SUMMARY

AND CONCLUSION
Scientific advances have helped tackle communicable and infectious diseases to a large extent, but prevalence of non-communicable diseases is on the rise. Overweight and obesity are increasing in all age groups and in all countries of the world. Along with overweight and obesity, co-morbidities have also increased in children. Type 2 diabetes mellitus, hypertension and poor fitness are all associated with obesity. Therefore, childhood obesity can be said to be a public health issue of concern. The rise in the prevalence of overweight and obesity is associated with changes in food habits and physical activity (Corbin, 2000). Technological advances have introduced several other forms of entertainment like video games, internet and many such; this may make children sedentary and compromise their fitness. While there are some reports on prevalence of childhood obesity in India, few have focused on physical fitness and its association with nutritional status. Therefore, this study was undertaken to assess nutritional status of primary school children between 6-9 years of age, from different socioeconomic backgrounds and to determine whether their nutritional status and dietary patterns influenced physical fitness. Anthropometric measurements were measured for 3600 children. Physical activity and dietary patterns were studied on a subsample of 1500 children and fitness tests for cardio-respiratory endurance, flexibility and strength were conducted on 354 children. The study included 39.5% children from the low SES group, 25.2% from lower middle SES group, 31.0% from the upper middle group and 4.2% children from the upper SES group.
Anthropometric Measurements and Nutritional Status: Height and weight were measured and BMI was calculated. Older children were taller than the younger age group children which is a normal trend of growth. HAZ score which was negative for younger children increased with age and was positive in older children. Height percentiles which were less than the median also improved and were closer to the median for the older age group. A small percentage of children were stunted (HAZ score <-3SD) - 2% boys in the 6 – 7 year group and 0.2% 7 – 8 year old group. A slightly higher percentage of girls (3.1% and 0.4% in the 6 – 7 and 7-8 year group respectively) were stunted. Stunting was not observed in boys or girls in the 8 – 9 year old group.

With weight children showed a trend similar to that of height in relation to age. Boys in all the three age groups had significantly higher weights than girls. However, a small percentage of children in all age groups were underweight (6 – 7 year age group- 1.9%, 7 – 8 year age - 0.5% and 8 – 9 year group - 0.1%).

Mean BMI also increased with age. The mean BMI Z score improved with age, going from a negative value of -0.524 for the youngest group (6-7 years), to a slightly lower negative value (-0.23) in the 7-8 year old and a positive value for the oldest children in the study. Similarly, BMI percentile improved with age, although there was no difference was observed between the two sexes.
Children were classified as underweight, normal, overweight and obese using the Cole’s (2000) standards. In the present study, 24.4% children were underweight, 14.7% were overweight and 7.5% children were obese. A little more than half (53.4%) had normal weight. It is of concern that almost one-fourth children were underweight and another one-fourth overweight + obese. The percentage of underweight children decreased as age increased. Among boys, 10-15% of boys were overweight, with the percentage gradually increasing with age. Among girls, a much higher percentage of girls in the 8-9 years age group were overweight compared to the two younger age groups. Also, prevalence of overweight, among the 8-9 year olds was almost one and half times more among girls than boys. When BMI Z scores were calculated, it was observed that most of the children (84.6%) were in the normal weight category, 0.2% children were thin, 10.6% were overweight and 4.6% were obese.

Comparison of distributions in different nutritional status categories by BMI Z-scores and Cole’s standards showed that with Cole’s classification more children were identified as underweight, overweight and obese as compared to the WHO Z score classification which identified most children to have normal weight. All children who were ‘thin’ based on Z score category were also underweight based on Cole’s standards. However, one-fourth who were normal as per Z-score were classified as underweight using Cole’s classification. Almost 8% children who were normal according to Z-score were overweight by Cole’s classification. Three-fourths of the children (73.9%) were identified
as overweight by both the criteria. According to Cole’s classification, the children who were obese (26.1%) fell in the overweight category per the WHO cut-offs. Thus, there are differences between the two standards in identification of underweight, overweight and obese children. Children who are underweight need to be cared for to achieve normal weight and for those who are overweight and obese, it is important to prevent development of obesity-related disorders. If most children are identified as normal, they may be left out of programmes involved in improving nutritional status.

For skinfold measurements and body fat, as nutritional status improved, skinfold measurements and percent body fat increased. As age increased, percent body fat increased significantly. In the present study, the sum of skin fold was 13.5 mm and percent body fat ranged from 4.83 - 29.38 among boys and 3.82 - 26.95 in girls. There are no standards for body fat in children. Comparison of body fat with the standards of Lohmann and Going (2006), from USA showed that, children had body fat below the 50th percentile. Mean triceps and subscapular measurements were also lower than the CDC standards.

There was a significant positive correlation between BMI and percent body fat ($r = 0.922; p= 0.000$) in this study. The mean triceps and sub-scapular measurement increased with age. As nutritional status improved (based on Cole’s classification and BMI Z-score) mean skinfold measurements and body fat also improved significantly. A statistically
significant difference was seen between the two sexes for percent body fat. Boys had a higher percent body fat (mean = 13.3 ± 4.4) compared to girls (mean = 12.5 ± 4.1).

Comparison between SES categories, showed that mean heights and weights differed significantly between the low, lower middle and upper middle SES groups, but there was no significant difference between upper middle and upper SES groups. BMI differed significantly different only between the low SES and the other three groups. All skin fold measurements and percent body fat were significantly lower in the low SES group was compared to the other three SES groups.

Distribution of children in BMI categories showed that a higher percentage of underweight children were from the low SES group, followed by the lower middle SES group. The upper middle SES group had the highest percentage of normal weight children and the highest percentage of overweight children was in the upper SES group. The percentage of obese children in the upper income group was only marginally higher than the upper middle income group. One-tenth of the children in the low SES category were obese and almost one-fourth were overweight and obese compared to one-third of the children from the upper SES families.

Thus it can be said that overweight and obesity is not a disorder only seen in the upper income groups and it is of concern that it is prevalent even in the low SES strata. Also, as
the percentage of underweight children is highest in this SES category, the study suggests that the dual problem of malnutrition needs to be tackled seriously. Thus strategies and intervention for prevention of overweight and obesity should be aimed at all socioeconomic groups.

The mean skinfold measurements and body fat at all sites in children belonging to the low SES group were significantly lower as compared to children in the other SES groups. Thus it can be said that as socioeconomic condition improves, skinfold measurements and body fat increase. Height increased with increasing SES, with the upper middle and upper SES group children having mean values closer to the 60th percentile. The mean Z scores also improved from negative values to positive values suggesting that nutritious foods which are affordable to the higher income groups help to maintain normal nutritional status. Based on WAZ scores and BMI Z-scores, the highest percentage of children was in the normal Z score category. Eighteen percent children of the low SES group were in the obese of Z-score category.

Children of mothers who worked had higher mean height, height percentile, HAZ score as well as higher mean subscapular skinfold and suprailiac skinfold thicknesses. Additional income by working mothers may increase the purchasing power of families. Working mothers may also be better educated and aware of healthy choices which could help them to choose nutritious foods. More children were normal or overweight when
mothers were working. Further, it was observed that a higher percentage underweight children were from families with $\geq 8$ members.

*Physical activity and Anthropometry:* Physical activity participation was examined by asking the children frequency per week and duration of playing different activities/sports. All children played games at least in the school recess, however none of the children attempted specific exercises. Among the 1500 children, 97% of the 8-9 year olds, 95% of the 7-8 year old and 92.1% of the 6-7 year old children reported that they played regularly. Boys were involved in games like cricket and football that involved running, whereas girls played more sedentary games like doll play or board games. Play station and computer games were also popular among boys and older children but not among girls and younger children.

A higher percentage of obese and overweight children reported a higher frequency and longer duration for physical activity compared to other children. Underweight children spent 33% less time on physical activity than normal weight children. The benefits of physical activity were reflected in the mean values of anthropometric measurements, which were significantly higher for the children who were most active.

Comparison of socioeconomic groups indicated that children from upper middle SES spent the highest mean duration of time on four activities (running, cricket, cycling and
football), whereas children of the low SES group spent least amount of time on these games. Children from the lower SES do not get adequate opportunities, probably due to lack of adequate facilities which promote physical activity.

Children in the present study did not watch TV for a very long duration. Overweight children watched TV for significantly lower duration and underweight children watched TV for the longest duration. Out of the 1500 children, 76.7% children attended tuition class, with the percentage increasing from the youngest to the oldest age group. Also, overweight and obese children spent less time on tuitions compared to underweight children.

Duration of sleep did not differ between the BMI categories or between the two sexes. There was no association between hours of sleep and body weight or BMI. A significant negative correlation between sleep and TV viewing was observed, which suggested that when children slept more, they watched TV for a shorter time and vice versa ($r = -0.294$, $p=0.000$).

The American Academy of Pediatrics (2003) recommended that children should have a minimum of 60 minutes of activity per day. Mean time spent in active games by children in the present study was 172 minutes per week or 25 minutes per day. Participation of
children in active games was less which gives cause for concern in terms of physical
fitness and risk of obesity and non-communicable diseases in the long run.

*Physical Fitness:* The present study examined fitness parameters of 354 children. The
tests used were modified Harvard’s Step Test for cardio-respiratory endurance, Sit and
Reach Test for flexibility and Grip Strength test for muscular strength. The mean PFI
score of the children was 25.2. All children had poor fitness as none of them had a score
≥ 39 which is the standard given by Brouha and Ball (1952). Poor flexibility and grip
strength too was reflected by the low mean score for both these tests. The score for Sit
and Reach test was at the 25th percentile of the AAHPERD standards. Some children had
a very poor score of grip strength- as low as 0 for 5.6% of children. Boys and girls
differed only in grip strength, with boys having greater grip strength than girls. Mean
scores for PFI and Sit and Reach test and number of steps climbed by children were
significantly higher in the oldest age group (8-9 years) compared to the two younger age
groups. Grip strength was the lowest for children in the 6-7 year age group than the 7-8
year and the 8-9 year age groups, respectively. PFI and grip strength increased as age
increased. For all the three fitness tests more than 50% of the children had scores below
the median or the 50th percentile, with more than 60 % of the children falling in the poor
flexibility category.
Children who had good fitness scores had lower biceps and suprailiac skinfold thickness. However, percent body fat in the highest quartile of PFI was significantly higher than the lower three quartiles of PFI score. A significant correlation between body fat and fitness parameters was observed. Physical fitness index and number of steps climbed were positively correlated with percent body fat ($r = 0.117, p=0.028; r=0.154, p=0.004$) respectively. The correlation was positive with grip strength ($r=0.468; p=0.000$), whereas there was a negative between body fat and the flexibility test ($r = -0.496, p=0.000$). Therefore it can be said that higher the body fat, lower was the flexibility. Cardio-respiratory activities need energy for performing without getting tired. Therefore, children with higher body fat may have had higher PFI scores. Thin children with low body fat on the other hand may have got tired earlier and therefore their PFI scores were lower compared to the overweight and obese children. Abdominal fat may prevent children from bending completely and reaching out. Therefore the flexibility scores of children were incomplete.

Obesity affects fitness and this was observed in the present study as well. Performance of normal weight children was best in the Step test and the Sit and Reach test. Grip strength was poorest in underweight children. It was significantly lower in the children with low BMI compared to overweight or obese children. However, grip strength did not differ between normal and overweight or obese children. For flexibility, children who had
normal and low BMI had significantly better flexibility than overweight or obese children.

PFI was the lowest for children from low SES families. There was a significant positive correlation between SES and PFI ($r=$ 0.322, $p=0.000$), suggesting that as SES improved the PFI score increased. Similar trends were observed for grip strength, which improved significantly as socioeconomic status improved. There was a significant positive correlation between SES and grip strength ($r=0.246$, $p=0.000$). This may be because children from upper SES families get better opportunities to learn and practice fitness activities, whereas children belonging to low SES backgrounds may lack adequate facilities and/or opportunities to perform fitness activities.

In the present study, children spent a lot of time on tuitions (median= 10 hours). Good PFI and grip strength scores were seen in children who spent less than ten hours per week on tuitions. Flexibility was not affected by the time spent on tuitions. Similar trends were obtained for PFI and Sit and Reach scores when children watched TV for less than 2.5 hours per week. Lack of sleep may lead to fatigue, sleepiness during the day and low activity levels due to tiredness. This may be the reason why children who slept more, had significantly higher PFI scores as well as higher scores for grip strength. Duration of sleep did not influence flexibility.
The mean PFI and grip strength were significantly higher for children who spent between 240-840 minutes per week in active games, compared to those who spent less time. Time spent on physically active games was significantly and positively correlated with PFI, number of steps and grip strength but not flexibility scores.

*Dietary Patterns*: Dietary patterns have changed due to socioeconomic transition particularly in developing countries. So that consumption of fats, sugar and salt has increased. Attention has now turned from undernutrition in children to overweight and obesity. The present study examined dietary patterns in relation to anthropometry and physical fitness. Comparison of the food consumption in terms of number of portions/week with the recommendations given by NIN (2010) for various foods indicated that consumption of all foods was much lower than the recommendations.

Rice and wheat were daily staples; however, millets were not consumed by children at all. Cereals consumption was less than 50%, for pulses, it was only one-third the recommendations. All children, young and old had a low pulse intake- the mean intake of being 5.1 ± 2.2 portions per week. The intake seems to be less than one portion per day, suggesting that protein intake may not be adequate. Consumption of vegetables was only 1/4th and fruits were less than half the recommended number of servings. Snacks and sweets were highly popular followed by beverages and biscuits. Vegetables were not consumed by 11.6% of the children and fruits were not consumed by one-third of the
children. Pulses were not consumed by 2.6% of the children. The mean total number of portions consumed was highest in the oldest age group for cereals, pulses, beverages and Chinese food whereas, consumption of fruits, snacks, sweets, biscuits, fast foods and non-vegetarian foods was highest in the youngest children.

The physical fitness index score and grip strength was higher in children who had a high cereal intake. However, Sit and Reach test score for flexibility was higher when children had a lower cereal intake. Cereals being sources of energy, may provide the necessary energy for children to have better scores for PFI and grip strength as both of these tests require energy for performance.

Although, most children consumed vegetables, the variety of vegetables was poor. Children consumed/preferred potatoes frequently. Leafy vegetables were not consumed by the children in any age group. Similar observations were made for fruits, where three-fourths of the children consumed only bananas. Fitness parameters other than Sit and Reach test were not influenced by vegetable intake. These foods are rich in fibre, hence a higher intake may help to have low body fat and better flexibility.

All children consumed snacks which included fried snacks like batata wada and samosa. The most favorite and regularly consumed snack was wada pav that was also available in the canteen. Children in the age group of 6-7 years ate in the canteen more often than the
older children. Also, all children frequently consumed instant noodles. Popular dry snacks frequently consumed were banana wafers, potato wafers, Kurkure, chakli and sev. Number of portions of snacks consumed influenced weight, skinfold measurements and body fat. Those who consumed less number of portions of snacks had lower weight, BMI, all skin fold thicknesses and body fat. Children with a high snack intake had poor PFI scores and better flexibility as indicated by the Sit and Reach scores. No clear trend was seen for grip strength.

Mean beverage consumption by children was 12.0 ± 4.4 portions per week with higher percentage of older children consuming them than younger children. Milk intake was positively associated with mean anthropometric measurements. BMI, body fat and skinfold thickness were also higher in children consuming more milk. Also, children occasionally consumed aerated soft drinks, fruit juices and sugar cane juice. Beverage intake did not affect fitness parameters except PFI which was higher only for children who consumed more than 12 portions of beverages per week. More number of portions of milk was associated with high PFI score and grip strength but poor flexibility score. This may be due to higher body fat due to a high milk intake.

Consumption of sweets (sweet preparations, ice creams and chocolates grouped together) was not high, the mean intake being 1.6 ± 1.9 portions per week. Almost all children (99.1%) consumed sweets. Chocolate ice cream and strawberry ice cream were
favourites. Chocolates/toffees/eclairs were consumed by half the children. Consumption of traditional sweets was restricted to specific festivals. Children in the youngest age group consumed more sweets than older children. The observations for association between fitness parameters and sweet intake were similar to that of snacks, though the sweet intake was not as high as the snack intake. A higher sweet intake was associated with better grip strength but poor Sit and Reach scores. In spite of low sweet consumption, children who had more sweets intake had higher weight, BMI, skin fold thicknesses and body fat.

Consumption of biscuits was very high in the children; between half a portion to maximum of twenty portions per week. Weight, BMI, triceps, biceps and percent body fat were highest in children who had a high biscuit consumption. Younger children and girls of all age groups had higher biscuit consumption. Biscuit consumption did not influence grip strength and Sit and Reach scores. However, PFI scores were highest for those whose biscuit consumption was lowest. One-fourth of the children ate Chinese food and ‘other fast foods.’ Foods such as pizza, burger, subway, fried chicken and doughnuts were popular foods and consumed by children at least once a week. More than 60% of the children consumed non-vegetarian foods, generally twice or thrice a week only. Eggs were frequently included in their diet, followed by chicken and much less frequently meat. Body weight, BMI, all skinfold measurements and body fat were significantly higher in children who consumed these foods more often.
Not all children consumed breakfast and perhaps not daily, as the mean number of portions of breakfast consumed was 5.4 ± 3.2 portions per week. Breakfast was consumed by a higher percentage of 6-7 year old children compared to the older age groups. Bread was the most common breakfast food since it is a convenience food available in several varieties which attract children. Number of portions of breakfast/week was positively associated with mean weight, triceps, biceps, sub scapular, supra iliac and body fat. However, breakfast consumption did not seem to affect fitness parameters other than grip strength which was higher for children who consumed breakfast regularly.

Based on the results of the study, following conclusions can be drawn:

- **Prevalence of overweight and obesity** was observed in children of all age groups, irrespective of the socioeconomic status. However, a substantial percentage of children were underweight. Given the consequences of both undernutrition and overnutrition, this dual burden of malnutrition needs to be tackled urgently.

- **Physical activity levels** were low, thus children were sedentary. Long hours spent on tuitions and sedentary games contributed to the low levels of activity and increased the risk of overweight and obesity.

- **The diets were poor**, with relatively low intake of vegetables and fruits and higher intake of energy dense including biscuits, snacks and sweets. This pattern in combination with low physical activity would contribute to weight gain.
• Physical fitness scores were poor and were influenced by nutritional status, diet and physical activity. This indicates that physical fitness can be achieved by paying adequate and appropriate attention to diet-related and physical activity-related behaviours.

Prevalence of overweight and obesity in all socioeconomic categories matches the prevalence of overweight in developed countries, which is of concern. Results of this study highlight the need to prevent undernutrition, as well as overweight and obesity in children. The physical activity of children in the primary school age group needs to be improved. The emphasis on tuitions and classes should be moderated to increase leisure time which can be spent in active games/sports. Conscious efforts should be made in time management for children to be active and less sedentary. Exercise is necessary to achieve and maintain good health and should therefore be an integral part of the daily routine of children. Eating habits and behaviors related to physical fitness are learnt and established in childhood and continue later in life. It is necessary to inculcate appropriate and healthy lifestyle habits in children, in order to help them achieve good health, wellness and fitness. Assessment of maternal knowledge of nutrition and child feeding practices was not in the scope of this study but merits attention if child health is to be ensured.
Therefore strategies for preventing obesity in children should consider the environmental conditions affecting children from all strata of society and need to be addressed through a multi-pronged approach.

**Recommendations for further research:**

- Fitness study with a larger sample of children from both sexes and across socioeconomic groups wherein other fitness parameters are examined.
- Study influence of selected foods on fitness and selected biochemical markers.
- Study of physical fitness and academic performance.
- Interventional studies to improve food choices and consumption, body composition and physical fitness.

**Limitations of the study:**

- Nutrient intakes were not examined.
- 24 hour dietary recall was not studied.
- 24 hour physical activity not studied.
- Fitness tests were conducted only on 354 subjects.
- Any previous illness of children was not noted.
- Selection of participants in the study on physical fitness was done by the teachers and was not in the investigator’s control.
In case of obesity, it is best to follow- "an ounce of prevention is worth a pound of cure". Healthy behaviours related to food, physical activity and fitness can and should be established during the formative years. Prevention of childhood obesity is crucial in order to help children have good quality of life and avoid chronic degenerative diseases later in life.