DISCUSSION

The present study was undertaken with an objective of observing the effect of obesity on the physical performance variables, academic performance and self-esteem of school going adolescents of Punjab. In the present study, the three main groups were: girls group, boys group and combined girls and boys group. All of these groups were further sub-categorized into four weight categories, namely, underweight, normal weight, overweight and obese category.

5.1 Obesity prevalence

From the present study it could be inferred that the prevalence of overweight and obesity amongst the school going adolescents of Punjab, aged between 9-16 years was 39% and 42% respectively (girls and boys considered together). It might be assumed that out of every 10 children, 4 were obese with almost equal number of children were overweight. In girls, the prevalence of overweight and obesity was 37% and 40% respectively and in boys, the prevalence of overweight and obesity was 38% and 41% respectively. Though the prevalence rates were similar for girls and boys, but the boys had greater fatness as compared to the girls. Obesity epidemic is widespread globally and has reached alarming levels in the various parts of India as well. Among Indian adolescents, till date various researchers had demonstrated the prevalence rates ranging from 9-27.5% (for overweight) and 1 to 12.9% (for obesity) (Kapil et al., 2002; Chhatwal et al., 2004; Sidhu et al., 2006; Sharma et al., 2007; Bose et al., 2007). The prevalence rates reported by the present study are alarmingly high. Also it is noteworthy to mention that the present study reported prevalence rates as per current CDC guidelines, whereas other researchers had used varied BMI classification system to classify overweight and obesity. The overweight and obesity prevalence rates reported by the present study were similar to the global trends in overweight and obesity, with similar prevalence rates reported in Serbian boys and girls (overweight and obesity, 39%) (Ostojic et al., 2011), amongst school going children of Baltimore (overweight and obesity, 33%) (Jehn et al., 2006). As per OECD update 2012, Indian children aged 5-17 years had high prevalence rates of
overweight and obesity (18.3% girls and 20.6% boys). The highest prevalence rates of overweight and obesity amongst girls and boys were observed in Greece (37% and 45% respectively), followed by United States (35.9% and 35% respectively) and Spain (22.9% and 32.9% respectively).

The gender disparity in the occurrence of obesity might be accounted to development and maturation, difference in growth rates amongst boys and girls, numerable behavioral and environmental influences, amongst other factors. Wang (2002) suggested that early sexual maturation in girls was positively associated with overweight and obesity but negatively associated in case of boys.

5.2 Obesity and physical performance variables

5.2.1 Aerobic capacity, measured by VO$_{2}$max

The findings of the present study indicated that in boys, the aerobic capacity was the highest in the underweight category, followed by normal weight, overweight and the least amongst the obese boys (Table 4.18). Amongst all these weight categories, significant differences in the VO$_{2}$max were observed between all the weight categories except between the underweight and normal weight boys. In girls, the aerobic capacity reported was the highest in the normal weight, followed by overweight, underweight and the least amongst the obese girls (Table 4.17). However, no significant inter-group differences in the aerobic capacity were observed in any of the four weight categories. When between-group differences were searched significant differences (p<0.003-0.001) in aerobic capacity were noticed between underweight boys and overweight and obese boys; between normal weight boys and overweight and obese boys. However, in girls, no significant differences in the aerobic capacity were observed between any of the weight categories. On comparing the boys and the girls of the respective weight categories, the boys had significantly greater aerobic capacity than the girls in all the weight categories (i.e. underweight, normal weight, overweight and obese category).

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and aerobic capacity. In the combined girls and boys group, there was a significant inverse correlation between aerobic capacity and BMI.
Discussion

percentile ($r = -0.231$, $p < 0.001$), percent body fat ($r = -0.496$, $p < 0.001$) and waist circumference ($r = -0.329$, $p < 0.001$), for all the weight categories.

In the underweight category, significant inverse correlations were observed between aerobic capacity and BMI percentile ($r = -0.231$, $p < 0.001$) in the girls and boys combined group; aerobic capacity and percent body fat, in girls ($r = -0.459$, $p < 0.007$) and in the combined boys and girls ($r = -0.546$, $p < 0.001$) and between aerobic capacity and waist circumference, in girls ($r = -0.604$, $p < 0.001$) and in the girls and boys combined group ($r = -0.320$, $p < 0.002$). In the normal weight category, there was a negative correlation between the BMI percentile and the aerobic capacity in boys ($r = -0.215$, $p < 0.001$) and in the girls and boys combined group ($r = -0.187$, $p < 0.001$); but not in girls. In the overweight category, significant negative correlation between the BMI percentile and the aerobic capacity was observed only in boys ($r = -0.195$, $p < 0.021$). In the obese category, there was significant negative correlation between the BMI percentile and the aerobic capacity, in boys ($r = -0.394$, $p < 0.001$) and the combined girls and boys group ($r = -0.273$, $p < 0.001$), but not in girls.

The average VO$_2$max documented in the present for the combined girls and boys aged 9-16 years was $41.49 \text{ml.kg}^{-1} \text{min}^{-1} \pm 4.19$. This was slightly less in comparison with the VO$_2$max of children aged 8-12 years, with VO$_2$max ranging from 34-58 ml.kg.$^{-1} \text{min}^{-1}$ (Cooper et al., 1984; Washington, 1988; Duncan et al., 1996). The reasons for this difference could be attributed to racial factors, genetic influences and socio-economic status, etc. But the aerobic capacity values reported in the present study were similar to the findings of Leger et al. (1988) who documented VO$_2$max range (38-52 ml.kg.$^{-1} \text{min}^{-1}$) for adolescents (6-18 years of age). It was also worthy to mention that the aerobic capacity of boys (42.76 ml.kg.$^{-1} \text{min}^{-1}$) was greater than girls (39.14ml/kg/min). These gender differences in the aerobic capacity were similar to those reported previously (Krahenbuhl et al., 1985). Ascribing influences are age-linked morphological variations in the body along with physiologic alterations in the size of the heart and cardiac function during puberty in girls and boys (Rowland et al., 2000).

Overweight or obesity negatively affects the cardio-respiratory endurance of the individuals, thus resulting in decreased endurance performance. Yet there is paucity of
conclusive evidence explaining the effects of obesity on aerobic capacity. From the present study it might be inferred that body weight adversely influenced the cardiovascular endurance or the aerobic capacity. The findings of the study were in sync with the study conducted by several authors who had reported negative effect of body composition on physical fitness, including the PACER test (Lloyd et al., 2003) and Mile Run and Walk test (Cureton et al., 1975; Slaughter et al., 1977; Cureton et al., 1977 and 1995; Pate et al., 1989; Cureton et al., 1991; Rowland et al., 1999), all of which were used to measure the aerobic capacity. When expressed in the more traditional method relative to total mass (ml·kg⁻¹·min⁻¹ max), in the boys group, as well as in the combined girls and boys group, as the weight category increased aerobic capacity became significantly lower. This might be accounted to the large (and deliberate) discrepancy in total mass between the various weight categories.

Furthermore, it was imperative to draw associations of aerobic capacity with not just BMI but also with other strong indicators of adiposity. The findings of the present study indicated that VO₂max had significant negative correlation with BMI percentile as well as other indicators of obesity such as percent body fat, skinfold measurements and waist circumference. Ostojic et al. (2011) demonstrated significant negative correlations between aerobic capacity and percent body fat (r=-0.76, p<0.05) and waist circumference (r=-0.43, p<0.05) but not with BMI in Serbian boys and girls between 6-14 years of age. Klasson-Heggebo et al. (2006) studied on 4072 adolescents of 9-15 years old and reported curvilinear-graded inverse relationship between aerobic capacity and waist-circumference and between aerobic capacity and percent body fat. Similar findings were reported by other authors (Hager et al., 1995; Ekelund et al., 2001; Sirard et al., 2001). Apart from drawing correlations between aerobic capacity and BMI alone, ample research evidences indicated that anthropometric measurements including skinfold measurements (biceps, triceps, suprailiac and subscapular), percent body fat and waist-circumference should be regularly employed to predict fitness in children and adolescents and to assess the risk of obesity in them (Chen et al., 2002; Janssen et al., 2005; Hussey et al., 2007).
5.2.2 Trunk and lower body strength measured by 1 minute curl-up test

The findings of the present study indicated that, in boys, the curl-up score was the highest in the underweight category, followed by normal weight, overweight and the least amongst the obese boys (Table 4.18). Amongst all these weight categories, significant differences in the curl-up scores were observed between all the weight categories except between the underweight and normal weight boys. In girls, the results indicated that the curl-up score was the highest in the underweight category, followed by normal weight, overweight and the least amongst the obese girls (Table 4.17). Significant differences in the curl-up scores were observed between all the weight categories, except between the underweight and normal weight girls. In comparing the boys and the girls group of respective weight categories, the boys had significantly greater curl-up scores than the girls in all the weight categories (i.e. underweight, normal weight, overweight and obese categories).

One-way analysis of variance showed statistically significant between-group differences (p<0.001) of body weight in the curl-up scores both in boys and girls. The mean score for curl-up in underweight boys (28.71no.min⁻¹±9.56) was significantly different from overweight (23.30no.min⁻¹±10.10) and obese boys (18.72no.min⁻¹±10.82). Furthermore, the mean curl-up score of the normal weight boys (27.03no.min⁻¹±9.56) was significantly different from overweight (23.30no.min⁻¹±10.10) and obese boys (18.72no.min⁻¹±10.82). Similar were the observations in girls, the mean score for curl-up in underweight girls (23.15no.min⁻¹±10.73) was significantly different from overweight (17.66no.min⁻¹±10.28) and obese girls (10.04no.min⁻¹±8.34) and the mean curl-up score of the normal weight girls (21.44no.min⁻¹±9.88) was significantly different from overweight (17.66no.min⁻¹±10.28) and obese girls (10.04no.min⁻¹±8.34). Both the underweight and normal weight girls had significantly greater curl-up scores than their overweight and obese girl counterparts.

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and curl-up. Significantly negative correlations were observed between the BMI percentile and the curl-up scores (r = -0.275, p<0.001) in the girls and boys combined group, for all the weight categories. In the underweight category, there was no significant correlation between BMI percentile and curl-up scores.
in girls, boys or the combined girls and boys group. In the normal weight category, significantly negative correlations were noted between the BMI percentile and the curl-up scores in boys ($r=-0.188$, $p<0.001$) and in the girls and boys combined group ($r=-0.153$, $p<0.001$), but not in girls. In the overweight and obese category, there were no significant correlations between BMI percentile and curl-up scores in the girls, boys or combined girls and boys group.

There is dearth of conclusive evidence explaining the effects of obesity on lower extremity strength. From the findings of the present study it could be inferred that an individual’s weight adversely affected the curl-up capacity. Individuals with less weight performed better on 1 minute curl-up test as compared to individuals who were overweight or obese. It might be assumed that being overweight/obese lead to a greater waist circumference and greater abdominal muscle mass deposition in the abdomen, thus affecting the muscular endurance of the abdominals which in turn accounted for the poor test scores on 1 minute-curl up test.

5.2.3 Upper body strength, measured by 1 minute push-up test

The findings of the present study indicated that in boys, the push-up score was the highest in the underweight category, followed by normal weight, overweight and the least amongst obese boys (Table 4.18). Amongst all these weight categories, significant differences in the push-up scores were observed between all the weight categories. In girls, the results indicated that the push-up scores were the highest in the underweight category, followed by normal weight, overweight and the least amongst the obese girls (Table 4.17). Amongst all these weight categories, significant differences in the push-up scores were observed between all the weight categories, except between the underweight and normal weight girls. In boys, the mean score for push-up in underweight category (24.82 no.min$^{-1}$ ±11.42) was significantly different from overweight (14.87 no.min$^{-1}$ ±10.49) and obese categories (12.20 no.min$^{-1}$±9.34). Furthermore, the mean push-up scores of the normal weight category (20.85 no.min$^{-1}$±10.96) was significantly different from overweight (14.87 no.min$^{-1}$±10.49) and obese categories (12.20 no.min$^{-1}$±9.34) categories. Both the underweight and normal weight boys had significantly greater push-up scores than their overweight and obese boy counterparts. Similar were the
observed that the mean score for push-up in underweight category (24.15 no.min⁻¹±11.98) was significantly different (p<0.001) from overweight (13.69 no.min⁻¹±12.17) and obese categories (8.49 no.min⁻¹±10.63) and the mean push-up scores of the normal weight category (18.17 no.min⁻¹±13.24) was significantly different from overweight (13.69 no.min⁻¹±12.17) and obese categories (8.49 no.min⁻¹±10.63). Both the underweight and normal weight girls had significantly greater push-up scores than their overweight and obese girl counterparts.

In comparing the boys and the girls group of respective weight categories, the boys had significantly greater push-up scores than the girls in all the weight categories (i.e. underweight, normal weight, overweight and obese categories).

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and push-up scores. There was significantly negative correlation between the BMI percentile and the push-up scores (r = -0.347, p < 0.001) in the girls and boys combined group, for all the weight categories. In the underweight category, there was no correlation (p>0.05) between BMI percentile and the push-up scores in the girls, boys or combined girls and boys group. In the normal weight category, there was significantly negative correlation between the BMI percentile and the push-up scores in girls (r=-0.126, p<0.048), boys (r=-0.188, p<0.001) and in the girls and boys combined group (r=-0.169, p<0.001). In the overweight category, there was significantly negative correlation between the BMI percentile and the push-up scores in boys (r=-0.210, p<0.012) and in the girls and boys combined group (r=-0.199, p<0.002), but not in girls. In the obese category, there was no significant correlation (p>0.05) between BMI percentile and push-up scores in the girls, boys or combined girls and boys group.

There is deficiency of conclusive evidence elucidating the effects of obesity on upper extremity strength. From the findings of the present study, it might be inferred that being an overweight or obese adolescent adversely affected the upper-body muscular endurance. Underweight as well as normal weight children performed better in 1 minute push-up test as compared to overweight and obese children. The results of the present study were similar to those conducted previously reporting decreased abdominal as well as upper body strength (using curl-up and push-up tests.
respectively) in individuals with higher BMI (Deforche et al., 2003; Ortega et al., 2005; Tokmakidis et al., 2006; Mota et al., 2010). Steene-Johannessen et al. (2009) proposed muscular fitness (abdominal and upper body strength) as a subset/function of physical activity participation. Hence, by decreasing the sedentary time and increasing the physical activity levels and physical fitness levels (including muscular fitness, upper and lower body) may be a prerequisite to prevent excessive weight gain and risk of metabolic diseases (diabetes, cardio-vascular disease) amongst adolescents.

5.2.4 Flexibility

The findings of the present study indicated that in boys, flexibility was the least in the underweight, followed by obese, normal weight boys and the highest midst the overweight boys. Amongst all these weight categories, no significant differences in the flexibility scores were observed in any weight categories (Table 4.18). In girls, the results indicated that flexibility was the least in underweight, followed by overweight, obese and the highest in normal weight girls. No significant difference in flexibility was observed between any of the weight categories (Table 4.17).

When between-group differences were investigated, no significant effect of body weight was observed on flexibility in boys as well as in girls, implying the body weight had no significant effect on an individual’s flexibility.

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and flexibility. There was no significant correlation (p>0.05) between the BMI percentile and the flexibility in the girls and boys combined group, for all the weight categories. On comparing boys and girls of respective weight categories, girls had significantly greater flexibility scores than boys in all the weight categories (except the overweight group).

Some authors believed that in general, increased body fatness could increase the time consumed to perform activities and hence avert the attainment of optimum flexibility by the individual. From the present study it could be inferred that an individual’s weight had no effect on his/her flexibility.
5.3 Waist circumference measurement

The findings of the present study indicated that in boys, the waist circumference scores increased significantly from a lower BMI percentile category to a higher BMI percentile category, implying that the highest waist circumference values was recorded in the obese, followed by overweight, normal weight and the least recorded waist circumference measurement was observed in the underweight category (Table 4.18). In girls, a similar trend was also observed (Table 4.17). When between-group differences were investigated, significant (p<0.001) effect of body weight was observed on the waist circumference measurement in boys as well as in girls. In boys, the mean waist circumference in the underweight category (60cm±5.90) was significantly less from normal weight (70.27cm±7.78), overweight (82.04cm±8.12) and obese categories (93.70cm±13.83). Furthermore, the mean waist circumference of the normal weight category (70.27cm±7.78) was significantly less from overweight (82.04cm±8.12) and obese categories (93.70cm±13.83). Similar were the observations in girls, where the mean waist circumference in the underweight category (60.07cm±7.64) was significantly less from normal weight (69.44cm±8.21), overweight (78.31cm±7.04) and obese categories (87.93cm±10.29) and the mean waist circumference measurements of the normal weight girls (69.44cm±8.21) were statistically less from overweight (78.31cm±7.04) and obese categories (87.93cm±10.29).

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and waist circumference. There was significant positive correlation between the BMI percentile and waist circumference (r=−0.712, p<0.001) in the girls and boys combined group, for all the weight categories.

In the underweight category, a positive correlation (r=0.294, p<0.029) was observed only in boys. In the normal weight category, a positive correlation was observed in girls (r=0.558, p<0.001), in boys (r=0.629, p<0.001) and in the girls and boys combined group (r=0.588, p<0.001). In the overweight category, a positive correlation was observed in boys (r = 0.279, p<0.001) and in the girls and boys combined group (r=0.231, p<0.001). In the obese category, a positive correlation was observed in girls (r=0.468, p<0.001), boys (r=0.436, p<0.001) and in the girls and boys combined group (r=0.450, p<0.001).
In comparing the boys and the girls group of respective weight categories, the boys had significantly greater waist circumference than girls in the overweight and obese categories (but not in the underweight or normal weight categories).

The findings of the present study were in sync with the study conducted by Lean et al. (1995), who demonstrated that intra-abdominal fat mass had positive correlation with waist circumference. Flodmark et al. (1994), observed obese children of age group 12-14 years and demonstrated a positive association between an increasing waist circumference and an adverse atherogenic lipoprotein profile, implying that body fatness was positively associated with waist circumference scores. Waist circumference scores with respect to body weight were increasingly being employed to predict cardio-vascular risk in adolescents. Numerous studies conducted previously supported that there was a positive association between waist circumference and altered hemodynamic parameters.

5.4 Academic performance
5.4.1 Academic performance and obesity

The findings of the present study indicated that in boys, the overweight boys had the highest academic scores, followed by normal weight, obese boys and the least amongst the underweight boys (Table 4.18). Significant difference in the academic performance scores was observed only between underweight and overweight category. In girls, the results indicated that the academic score was the highest in the overweight girls, followed by underweight, normal weight and the least amongst the obese girls (Table 4.17). Significant difference in the academic scores was observed only between the overweight and normal weight girls. When between-group difference was investigated, no statistically significant effect of body weight was observed on the academic scores in boys and in girls, implying the body weight had no significant effect on an individual’s academic performance.

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and academic performance scores. No correlation was observed between the BMI percentile and the academic performance in the girls and boys combined group, for all the weight categories. On comparing the boys and the girls
group of respective weight categories, the girls had significantly greater academic performance scores than the boys in all the weight categories (except the obese category).

The results of the present study indicated that an individual’s body weight has no effect on an individual’s academic performance. Nevertheless, the results of the present study indicated that no cause-effect relationship existed between the two variables. Several landmark researches in the past had also reported similar findings (Gortmaker et al., 1993; Blanchflower, 1994; Li, 1995; Mo-Suwan et al., 1999; Cawley 2004; Robert and Chandra, 2004; Crosnoe and Muller, 2004; Datar et al., 2004; Datar et al., 2006; Sabia, 2007; Kaestner et al., 2009; Edwards et al., 2011; Abdelalim et al., 2012; Li and O'Connell, 2012). On the contrary, many studies conducted globally had demonstrated an inverse association between BMI and academic performance (Li, 1995; Campose et al., 1996; Laitinen et al., 2002; Mikkila et al., 2003; Sigfusdottir et al., 2007).

The in-congruency in the findings may be (1) due to dissimilar methodologies adopted used to assess and classify obesity, including weight and height measurement techniques, (Blanchflower et al., 1994; Mo-suwan et al., 1999; Dwyer et al., 2001; Tershakovec et al., 1994; Datar et al., 2004), (2) error in methodologies of reporting the academic performance scores, self-reported by children (Laitinen et al., 2002; Falkner et al., 2001; Mikkila et al., 2003; Crosnoe and Muller, 2004; Sigfusdottir et al., 2007) or errors in scores reported by parents (Krukowski et al., 2009; Kaestner et al., 2009; Carter et al., 2010), (3) result of varied techniques adopted to assess academic performance, including, various standardized test scores and IQ tests, (Campos et al; 1996; Carter et al. 2010; Abdelalim et al., 2012; Datar and Sturm, 2006; Judge et al., 2007; Castelli et al., 2007; Cottrell et al., 2007; Shore et al., 2008; Chomitz et al., 2009; Kaestner and Grossman, 2009; Roberts et al., 2010; Edwards et al., 2011; Wingfield et al., 2011; Li and O'Connell, 2012; Gable et al., 2012) and percent grading self-reported by students or parents (Falkner et al., 2001; Crosnoe and Muller, 2004; Sigfusdottir et al., 2007; Krukowski et al., 2009) or system of grading adopted by schools (Tershakovec et al., 1994; Li, 1995; Mo-suwan et al., 1999; Dwyer et al., 2001; Laitinen et al., 2002; Huang et al., 2006; Shore et al., 2008; Abdelalim et al., 2012) or (4) due to racial differences amongst the populations.
Furthermore, it is possible that the association between body weight and academic performance was facilitated by variables, socio-economic status not observed in the present study. Studies indicated that socio-economic status was a good indicator of academic achievement, with a high socio-economic status indicating a greater academic performance. High socio-economic status indicated a better quality of life and improved health. Hence, it could be inferred that high socio-economic status might lead to improved fitness levels and higher academic scores. Since, in the present study, socio-economic status was not taken into consideration, parallels may be difficult to draw between body weight and academic performance, when considered alone. Furthermore, with research it is well proven that correlation is not causality, implying that it is inappropriate to conclude that obesity leads to poor academic performance score. No rationale existed supporting the logic that one event (obesity) lead to another (poor academic performance). Although greater aerobic capacity per se did not directly enhance academic achievement; physical activities amongst other activities which were aimed to enhance the health of an individual also promoted mental capabilities and the intellectual capacity.

5.4.2 Academic performance and aerobic capacity (VO$_{2\text{max}}$)

Pearson product-moment correlation coefficients were computed to assess the relationship between aerobic capacity and academic performance. There was a positive correlation between academic performance and VO$_{2\text{max}}$ ($r=0.118$ and $p<0.001$) in the girls and boys combined group, for all the weight categories. When correlation between academic performance and VO$_{2\text{max}}$ was investigated, in the underweight category, there was no correlation between both variables in boys, girls or combined girls and boys group. In the normal weight category, there was a positive correlation between the two variables in girls ($r=0.183$, $p<0.004$), boys ($r=0.141$, $p<0.009$) and in the girls and boys combined group ($r=0.092$, $p<0.026$). In the overweight category, there was a positive correlation between the two variables in girls ($r=0.255$, $p<0.010$), boys ($r=0.191$, $p<0.023$) and in the girls and boys combined group ($r=0.136$, $p<0.035$). In the obese category, a positive correlation existed between the two variables in girls ($r=0.398$, $p<0.007$), boys ($r=0.377$, $p<0.001$) and in the girls and boys combined group ($r=0.357$, $p<0.001$).
Discussion

Hence, in all the weight categories (except underweight adolescents) VO$_2$\text{max} was positively correlated with academic performance.

The findings of the present study had reported consistent relationship between aerobic capacity and academic scores. Several researchers had reported consistent relations between academic performance and physical fitness (Castelli et al., 2007; Chomitz et al., 2009; Eveland-Sayers et al., 2009; Kwak et al., 2009; Wittberg et al., 2009). In these studies physical fitness encompasses (aerobic capacity, strength and endurance as well as flexibility, taken together). The findings of the present study was similar to the findings of Chomitz et al. (2009), who reported that the chances of clearing a standardized English test as well as a Math test increased by 24% and 38% respectively with increasing level of physical fitness. Comparable findings was reported by Lindsey et al. (2001) who demonstrated that in 2,992 school going adolescents of grades 3-8 of Mississippi (USA), when sex, race and socio-economic status were controlled, significant positive correlation was observed between physical fitness and standardized test scores in English and Math. Furthermore, the possibility of increased academic scores increased with the level of physical fitness of the adolescents. While cause-effect relationship or physiological rationalizations for the physical fitness-academic performance connect could not be stemmed from the present study. Previously conducted researches had reported enhanced cognitive functioning (in reaction time, response accuracy and concentration) with increased level of physical fitness in adults (Hillman et al., 2009) as well as in elementary school children and mid-school adolescents (Sibley and Etnier, 2003).

5.4.3 Academic performance and self-esteem

Pearson product-moment correlation coefficients were computed to assess the relationship between academic performance and self-esteem. There was a positive correlation between academic performance and self-esteem ($r=0.131$, p<0.001) in the girls and boys combined group, for all the weight categories. When correlation between academic performance and self-esteem was investigated amongst the four weight categories, the following observation was made. In the underweight category, no correlation was observed between academic performance and self-esteem in girls, boys or
combined girls and boys group. In the normal weight category, there was a positive correlation between academic performance and self-esteem in girls (r=0.170, p<0.008) and in the girls and boys combined group (r=0.130, p<0.002). In the overweight category, there was a positive correlation between academic performance and self-esteem in girls (r=0.318, p<0.002) and in the girls and boys combined group (r =0.187, p<0.004). In the obese category, no correlation was observed between academic performance and self-esteem in girls, boys or in the girls and boys combined group.

Hence, in the normal weight and overweight categories in girls and the girls and boys combined groups, academic performance was positively correlated with self-esteem, whereas, in the underweight and obese categories, no correlation was observed between academic performance and self-esteem.

There is ample body of evidence documenting relationship between self-esteem and academic performance. Enormous literature supported positive association between academic performance and self-esteem (Bankston and Zhou, 2002; Lockett and Harrell, 2003; Schmidt and Padilla, 2003). West et al. (1980) demonstrated positive correlation (p=0.18-0.50) between academic performance and self-esteem. Purky (1970) reported that self-esteem was associated with few constituents determining either academic success or verbal speaking skills and concluded that there was incessant relationship between self-esteem and academic performance. Reynolds (1988) reported that academic self-concept was positively correlated with grade point average (GPA) scores in collegiate students. Covington (1989) demonstrated that there was a corresponding increase in academic performance with increase in self-esteem of the individual and vice versa. He further stated that by manipulating self-esteem (positively) greater academic scores could be achieved. In another study, Carr et al. (1991) while observing motivational achievement in underperformers, demonstrated that self-esteem was an important determinant of reading awareness. Reasoner (2005) elucidated that there existed a universal concord among researchers supporting the fact that there was an intimate association between academic performance and self-esteem but considerable incongruities existed in the description/nature of this relationship. Few researchers urged that pupils achieving greater scores in schools did so to achieve positive self-esteem, whereas, other believed greater academic scores were by virtue of positive self-esteem.
On the contrary, there is ample research evidence documenting conflicting relationship between academic performance and self-esteem (ranging from negative to no relationship between the two variables). Yogev and Ilan (1987) and Van-Tuinen and Ramanaiah (1979) reported that self-esteem was not related to academic performance.

From the findings of the present study and the ample research evidences, it has been documented that a positive association between self-esteem and academic score existed in school going students but which variable lead to the other was a subject of detailed research and a difference in opinion on the relationship between self-esteem and academic performance might be attributed to dissimilarities in the notions and meaning of self-esteem and self-concept; and the resulting swappable use of these constructs as a single construct by researchers.

5.5 Obesity and self-esteem

The findings of the present study indicated that in boys, normal weight boys had the highest self-esteem scores, followed by underweight, overweight and the least self-esteem scores was observed in the obese boys (Table 4.18). No significant differences in the self-esteem score was observed between any of the weight categories. In girls, the results indicated that the self-esteem score was the highest in the underweight girls, followed by the overweight girls, normal weight girls and the least amongst the obese girls (Table 4.17). Significant differences was observed only between the underweight and obese girls, normal weight and obese girls and overweight and obese girls.

When between-group differences were investigated to observe the effect of body weight on self-esteem, statistically no significant effect was observed in boys. On the contrary, in girls, a significant effect (p<0.008) of body weight on self-esteem was observed. Post-hoc comparisons using the Bonferroni multiple comparison test indicated that self-esteem in obese girls (53.87 score±12.09) was significantly lower than underweight (62.63 score±10.27), normal weight (60.42 score±13.66) and overweight girls (61.30 score±13.19).

Pearson product-moment correlation coefficients were computed to assess the relationship between BMI percentile and self-esteem. There was no correlation between
the BMI percentile and the self-esteem in the girls and boys combined group. However, a positive correlation between BMI percentile and self-esteem in the combined girls and boys group, of obese weight category \((r=0.178, p<0.030)\) was observed. There was no significant correlation between BMI percentile and self-esteem in boys or in girls of the respective weight categories. Furthermore, on comparing the boys and the girls group of respective weight categories, no significant differences in the self-esteem score was observed in any of the weight categories.

From the findings of the present study, it might be inferred that as an individual’s body weight adversely affected his/her self-esteem, but the same was true only in the case of girls and not in boys. Since the studies which had documented an association between obesity and self-esteem, were longitudinal in nature and a cross-sectional study design sometimes failed to report the covariates associated with body weight and self-esteem. Hence, it may be possible that the design of the present study does not facilitate investigation of relationship between self-esteem and academic performance. On the contrary, several authors have reported positive association between obesity and self-esteem amongst adolescents (French et al., 1995; Wardle and Cooke, 2005; Wang et al., 2008). Many researchers had documented that teasing from friends and family members and social stigma associated with being fat might be contributing factors possibly leading to low self-esteem in obese adolescents (Cramer and Steinwert, 1998; Musher-Eizenman et al., 2004; Robinson, 2006).

Ambiguity in consensus existed on the role of gender in determining an individual’s self-esteem with studies reporting inconsistent results. While few researches reported greater self-esteem in females as compared to males of the same age group (Kearney-Cooke, 1999; Sotelo, 2000; Jacobs et al., 2002), other studies had failed to report any such trend (Mullis et al., 1992; Sotelo, 2000). The present study found that boys had a greater self-esteem than girls across all the weight categories. Similar findings were reported by Wang et al. (2009), who demonstrated that boys had a greater self-esteem than girls aged 10-11 years, and the same pattern was observed after a four year follow-up. It was postulated that in comparison to boys, girls evaluated their physique
and athletic capabilities more adversely, resulting in a low self-esteem (Vasta et al., 2009).

5.6 Strength of the study

1. To the best of our knowledge, the present study was the first of its kind to report normative values of various physical performance variables, academic scores and self-esteem scores of children aged 9-16 years belonging to different weight categories, namely, underweight, normal weight, overweight and obese.

2. The study was unique because it documented the relationship between various weight categories and physical performance variables, academic scores and self-esteem of the adolescents considering the BMI percentile.

3. The study also explored the relationship of aerobic capacity and academic performance as well as self-esteem of 1069 adolescents, which was considered a vast sample size to validate the findings.

4. A wide range of very recent references have been used to support or criticize the findings of the present study.

5. Additionally, the exclusive use of field tests for assessing the physical fitness, use of questionnaire to assess the self-esteem of the pupils, made the study design an ideal model for replication at school level to assess these parameters.

6. Use of field tests has a huge clinical significance as these tests (which are easy to administer and require little training to administer) can easily be performed in a school setting and can be included as a part of physical fitness assessment programs in schools. Hence, schools can offer comprehensive and prime sites to collect information regarding the levels of body fatness of the pupils as well as their physical fitness and psycho-social variables (self-esteem) to draft and institute specialized physical activity sessions for overweight and obese children.

5.7 Limitations of the study

1. Adjustments for maturity index were not made.

2. The study would benefit from inclusion of other variables such as maturity index, socio-economic status, which could enhance the outcomes.

3. A cross-sectional study design might not predict cause-effect relationships.