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# Effects of Daily Life Physical Activity on Obesity Indices, Cardiorespiratory Fitness and Association of the Latter Two with Academic Performance in Bengali Adolescents of India

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**Abstract** This study examined the influence of daily life Physical Activity (PA ) on obesity parameters (BMI: Body Mass Index, WHR: Waist Hip Ratio, Body fat percentage) and cardiorespiratory fitness or CRF (PFI: Physical Fitness Index). The influence of the later two on academic performance was also documented. The study was conducted on 720 healthy Bengali adolescents involving 240 subjects from each of the three age groups ( Age group I: 13-14 yrs, Age group II:15-16 yrs, Age group III:17-18 yrs). Subjects of both the genders were chosen from urban and rural areas by random sampling method. Physical activity questionnaire for adolescents (PAQ-A) was used to classify adolescents into low, moderate and high PA levels. Obesity parameters and PFI was measured using standard techniques. Percentage (%) of the mean of the three years total marks of annual school examination was computed to get the academic score (%) of the participant. In most of the instances, obesity parameters were significantly ($p < 0.05$) varied among different PA levels. PFI also showed similar trend of results.It was seen that rural urban impact on obesity parameters may not always be necessarily present whereas in case of PFI it was consistently significant. Obesity parameters was found to have significant negative correlation ($p < 0.001$) with PA and academic performance. PFI possessed significant ($p < 0.001$) positive correlation with PA and academic performance.However, multiple regression analysis found that only body fat percentage independently and significantly predicted academic performance in both the genders. The present data highlighted the importance of practicing sufficient PA in daily life not only to keep check against increased body fat levels and prevent obesity but also to increase CRF. Additively, it indicated that higher levels of body fat and lower levels of CRF may possibly restrict performance in examination. PA induced lowering of body fat and improvements in CRF may be expected to bring about some positive changes in academic performance.

***Keywords:*** *Bengali adolescents, physical activity, obesity parameters, cardiorespiratory fitness, academic performance*

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## 1. Introduction

Several threats to health may be the consequence of being obese or overweight. These threats include, but are not limited to cardiovascular complications, hypertension, osteoporosis, diabetes, psychological disturbances like anxiety and depression.Obesity in an individual is characterised by the presence of excess amount of body fat [1]. Sophisticated methods like the use of dual-energy X-ray absorptiometry (DEXA), etc are available for direct measuring of body fat. Application of these methods are difficult in large scale studies [2]. However, there are indirect methods of determining body fat, which are based on the utilization of well known obesity parameters like BMI, WHR and Body fat % (estimated from skinfolds). These indirect methods are widely used in epidemiological studies and they well indicate whether the individual is carrying excessive body fat. Obesity may be noted not only in developed nations but also in developing nations [3]. In India, obesity had often found to coexist with undernourishment and it had been found to effect individuals of all age groups and socioeconomic status, particularly in an urban settlement [1]. Life style factors like over consumption of calories, due to dependency on

non home based diet, with no control on ingrediants and amounts, absence of sufficient PA in daily life, prolonged engagement in sedentary screen based activities had been associated with obesity [3]. Moreover, easy ascess to motor driven vehicles [1] had allowed cutting down of walking/ cycling to school increasing the susceptibility of childrens and adolescents to obesity.

The negative relationship between PA and obesity parameters are well documented in other populations by several earlier studies [4-11] which depects the importance of PA in weight management. A study on the subjects of Kolkata, West Bengal documented similar findings [12]. Similarly, there are studies that noted positive relationship between PA and cardiorspiratory fitness / CRF ( in terms of Physical fitness index/ PFI) [13,14]. Academic performance is known to reflect cognitive functions [15] and thus may act as a "proxy" for the same. Evidences had started to gather, which indicate that academic performance may posses negative relationship with obesity parameters [3,16,17,18] and a positive relationship with CRF [19,20]. In Bengali adolescent population of rural and urban areas, no empirical study has been conducted in context of these issues.

In view of these reports, this present study is intended to report the associations of daily life PA with obesity parameters and CRF as well as the association of the later two with academic performance in Bengali adolescents of both genders. The findings of the present study may support the implementation of adequate PA in daily life of adolescents to prevent obesity, improve CRF and academic performance.

## 2. Materials and Methods

A cross-sectional study was carried out among 720 (360: males and 360 females) Bengali (Indian) adolescents of age ranging from 13 to 18 years. The sample of adolescents were drawn by simple random sampling from West Bengal (Districts: Burdwan, Hooghly and Howrah), India. The samples of both the genders were selected from the following three age groups - group I: 13-14yrs, group II: 15-16 yrs, and group III: 17-18yrs. Each age group had 120 males and females respectively. Furthermore, samples for each of the three age groups were collected from rural and urban areas. Informed consent was obtained from the subjects to consider them as participants of the study. Permission from institutional human ethical committee were obtained for the study. Majority of the adolescents belonged to middle class strata of the society as per Kuppuswami scale [21].

The daily life PA of the sample was determined by PAQ-A [22] containing eight questions, which enquired about PA performed in a span of last 7 days. It may be mentioned that the validity of the instrument is good [23]. This present study was employed a modified version of this instrument, which was altered to add few common PA performed in Indian context. In addition, some uncommon physical activities, which were generally not performed by the Indian adolescents, were excluded. Final PA was computed according to the original version [22] and classification of adolescents into low, moderate and high PA level was done in the following way: Score $\leq 2$: low PA, Score $>2$ and $\leq 3$: moderate PA, Score $> 3$: high PA.

Body weight and height. Weight was determined using Human weighing machine. Height was measured using anthropometric rod.

Physical Fitness Index: PFI score was determined employing the procedure mentioned in the original Harvard Step test using the formula: PFI = (100 x test duration in seconds) / (2 x sum of heart beats in the recovery periods) [24].

### 2.1. Obesity Parameters/Indices

BMI was obtained by dividing weight in kilograms by height in squared meters. For the purpose of identification of overweight and obesity the cut off values of BMI set by the International Obesity Task Force (IOTF ) were used [25] (Cole etal ). Skin fold thickness were measured at the right tricep and calf using Holtain skin fold callipers.Computations of body fat % were done using tricep and calf skinfold equation [26] of Slaughter et al. The equations are as follows:

$$\text{Body fat\% for males} = 0.735(\text{triceps} + \text{calf skinfolds}) + 1.0$$

$$\text{Body fat\% for females} = 0.610(\text{triceps} + \text{calf skinfolds}) + 5.0$$

Waist circumference were measured just above the belly button. Geater trochanter were measured to get the hip circumference. Waist circumference was divided by hip circumference to get waist hip ratio (WHR).All the obesity parameters were measured in triplicate and their average were used in study.

### 2.2. "Proxy" Measure of Cognition

Academic performance may be altered by changes in cognition. In line to studies by other authors [27] and in continuation of the trend identified and utilised by our earlier study [15], academic performance was evaluated as an indicator of cognitive functions. The overall average marks scored in last three years annual school examination were obtained from files /report cards/ school data base.The mean of these three averages marks were computed. This was followed by calculation of the Percentage (%) of the obtained mean to derive academic score (%) of the subjects.

### 2.3. Statistical Evaluation

Means and standard deviation (SD) were computed for all the variables. Sex differences were tested using t- test. Two level nested ANOVA [28] showed whether or not all the obesity parameters and PFI significantly varied between low, moderate and high PA level. It also grossly indicated the presence or absence of subgroup variation i.e rural urban variation, nested within the PA levels. The variance between the PA levels in rural urban subgroups respectively were tested using one way ANOVA. Appropriate post hoc test were also employed following significant results of ANOVA. The exact location of rural urban difference within the subgroups were located employing t-tests. For finding the interrelationship between PA, PFI and obesity parameters Pearson's correlation coefficient were calculated to form a

correlation matrix. Association of PFI and Obesity parameters with academic score were tested both by Pearson's correlation coefficient and multiple regression analysis.

## 3. Results

The means and standard deviation (SD) of the selected obesity parameters and PFI of the overall samples of male and females are presented according to different PA levels in Table 1. It showed that BMI of males and PFI of both the genders insignificantly varied among the different PA levels. The BMI of females, WHR and Body fat % of both the sexes was significanty different between the PA levels. In cases of significant variation of the study variables among different PA levels, the post hoc test conformed that the three PA levels (low, moderate and high) was significanty different from each other.

The results of the F statistics of the subgroup revealed that variation of BMI, WHR, Body fat % and PFI was present among the rural and urban subgroups, contained within the PA levels, excepting WHR and Body fat % of males (Table1).

The prevalence of overweight and obesity in the sample studied showed that in the overall sample of boys, 9.4% were overweight and 1.94 % were obese. On the contrary, in the overall sample of girls, 22.5% were overweight and 0.83 % were obese.

**Table 1. Variation of selected Obesity parameters and PFI in different physical activity (PA) level male (M) and female (F)**

| Variables | Sex | Physical activity levels (Mean ± SD) | | | Two-level nested ANOVA | | Post hoc Bonferroni-Multiple t- test |
|---|---|---|---|---|---|---|---|
| | | Low(L) | Mod. (M) | High(H) | ($F_G$) | ($F_{SG}$) | |
| BMI (kg/m$^2$) | M | 21.4 ± 3.32 | 18.2 ± 3.87 | 17.5 # ± 4.11 | 3.94 ns (17.9) | 10.3***(11.1) | ---------- |
| | F | 21.6 ± 288 | 18.4 ± 3.58 | 16.3 # ± 3.25 | 12.2* (31.9) | 5.39***(4.7) | L≠M, L≠H, M≠H |
| WHR (cm) | M | 1.06 # ± 0.27 | 0.95 # ± 0.17 | 0.85 # ± 0.11 | 20.4** (22.3) | 1.79 ns(1.0) | L≠M, L≠H, M≠H |
| | F | 0.96 # ± 0.21 | 0.83 # ± 0.15 | 0.75 # ± 0.07 | 11.5*(29.1) | 5.00**(4.4) | L≠M, L≠H, M≠H |
| Body Fat(%) | M | 20.8 # ± 5.09 | 16.7# ± 4.12 | 13.3 # ± 4.11 | 53.9**(41.7) | 1.64 ns(0.61) | L≠M, L≠H, M≠H |
| | F | 24.2 # ± 3.43 | 21.3 # ± 3.27 | 19.1 # ± 3.26 | 12.4*(33.6) | 5.74 ***(4.9) | L≠M, L≠H, M≠H |
| PFI | M | 52.7 # ± 9.14 | 57.1 # ± 8.63 | 60.4 # ± 9.63 | 2.16 ns(8.27) | 10.9***(13.1) | ---------- |
| | F | 46.1 # ± 7.59 | 52.1 # ± 6.43 | 55.2 # ± 8.98 | 4.08 ns(19.4) | 10.9***(11.5) | ---------- |

Males: low, n = 118, mod, n = 114, high, n = 128 ; Females: low, n= 109, mod, n =130, high, n =121

* ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant. (*Note: G = group and SG =subgroup)Figures in bracket under F statistics shows variance component percentage.*

*Significantly different means, P ≤ 0.017 ( 0.05 /3) using post hoc Bonferroni corrected t-test following significant $F_G$ in nested anova are shown in the table.*

*Means of Male Vs Female indicated with # in superscript in the same coloumne are significantly different by t -test (p ≤ 0.05).*

The means and standard deviation of rural and urban adolescent males and females are presented according to different PA levels in Table 2. It was found that BMI, WHR, Body fat % and PFI significantly differed between the three PA levels.Post hoc test showed that in majority of the case the three PA levels differed from each other.

**Table 2. Mean, SD, and ANOVA of selected obesity parameter and PFI of the subgroups (rural :R and urban: U ) present within each PA group**

| Variables | Sex | Region | Physical activity levels (Mean ± SD) | | | One way ANOVA (F) | Post- hoc Scheffe 's test |
|---|---|---|---|---|---|---|---|
| | | | Low(L) | Mod. (M) | High(H) | | |
| BMI(kg/m$^2$) | M | R | 20.5 # ± 3.31 | 17.4 # ± 4.19 | 16.0 # ± 1.69 | 28.7***(31.6) | L≠M, L≠H |
| | | U | 22.3 # ± 3.11 | 19.1 # ± 3.26 | 18.8 # ± 5.12 | 14.6***(18.60 | L≠M, L≠H |
| | F | R | 20.6 # ± 3.91 | 17.8 # ± 3.33 | 15.8 ± 2.99 | 28.4***(31.4) | L≠M,L≠H, M≠H |
| | | U | 22.7 # ± 3.58 | 19.0 # ± 3.74 | 16.8 ± 3.42 | 39.3***(39) | L≠M, L≠H, M≠H |
| WHR(cm) | M | R | 1.04 ± 0.29 | 0.92 # ± 0.13 | 0.85 ± 0.06 | 16.1 ***(20.1) | L≠M, L≠H |
| | | U | 1.09 ± 0.26 | 0.98 # ± 0.21 | 0.86 ± 0.14 | 20.7 ***(24.8) | L≠M,L≠H, M≠H |
| | F | R | 0.91 # ± 0.14 | 0.81 ± 0.12 | 0.74 ± 0.08 | 33.8 ***(35.4) | L≠M,L≠H, M≠H |
| | | U | 1.01 # ± 0.26 | 0.85 ± 0.17 | 0.76 ± 0.07 | 29.2***(32) | L≠M,L≠H, M≠H |
| BodyFat (%) | M | R | 20.3 ± 3.56 | 16.1 ± 3.01 | 12.9 ± 3.42 | 70.8***(53.8) | L≠M,L≠H, M≠H |
| | | U | 21.3 ± 6.16 | 17.5 ± 5.10 | 13.6 ± 4.66 | 33.8***(35.5) | L≠M,L≠H, M≠H |
| | F | R | 23.7 # ± 3.21 | 20.3 # ± 2.77 | 18.6 ± 2.66 | 44.9***(42.3) | L≠M,L≠H, M≠H |
| | | U | 24.8 # ± 3.59 | 22.2 # ± 3.46 | 19.5 ± 3.69 | 31.7 ***(34) | L≠M,L≠H, M≠H |
| PFI | M | R | 54.5 # ± 9.38 | 59.3 # ± 7.40 | 64.0 # ± 7.89 | 19.6***(23.7) | L≠M,L≠H,M≠H |
| | | U | 51.1 # ± 8.80 | 54.3 # ± 9.44 | 57.1# ± 10.1 | 6.76***(8.8) | L≠H |
| | F | R | 47.5 # ± 6.76 | 53.6 # ± 4.81 | 58.1# ± 4.92 | 41.1***(40) | L≠M,L≠H,M≠H |
| | | U | 44.4 # ± 7.01 | 50.2 # ± 6.57 | 52.6 # ± 10.9 | 14.7***(18.7) | L≠M,L≠H |

Males R: low, n = 56, mod, n = 63, high, n = 61 ; Males U: low, n= 62, mod, n =51, high, n =67

Females R: low, n = 57, mod, n = 66, high, n = 57 ; Females U: low, n= 52, mod, n =64, high, n =64

* ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant

*The variance component percentage are shown within parentheses under significant F statistics.*

*The PA groups having significantly different rural-urban subgroup are shown: Comparison ( vertical coloumn wise) among same gender different region indicated by # in superscript are statistically different using t -test(p ≤ 0.05).*

At different PA levels, BMI seemed to varry between rural urban adolescents, excepting in the case of high PA level females.Handful of instances of significant rural urban difference was present in case of WHR and Body

fat % viz. WHR of moderate PA level males, and low PA level females, Body fat % of low and moderate PA level females. At all the PA levels, significant rural urban differences in PFI was present in both sexes.

*Correlation Matrix:* It is presented in Table 3. PA was found to possess significant negative correlation with all the obesity parameters in both the genders. It also showed that PA was positively and significantly correlated with PFI in both males and females. It was observed that PA possessed a higher degree of correlation coefficient with BMI of females and Body fat % of males than that of other cases. In general the degree of correlation was comparatively higher in females than that of males.

BMI had a significant positive correlation with WHR and Body fat % in males and females. WHR also possessed significant positive correlation with body fat % in both sexes. PFI was significantly and negatively correlated with obesity parameters in both male and females.

**Table 3. Interrelationship between PA, obesity parameters and PFI**

| a. Correlation Matrix for males (n=360) | | | | | |
|---|---|---|---|---|---|
| Variables | PA | BMI | WHR | Body Fat % | PFI |
| PA | - | | | | |
| BMI | -.34 *** | - | | | |
| WHR | -.39 *** | .20*** | - | | |
| Body fat % | -.52 *** | .25*** | .12** | - | |
| PFI | .29 *** | -.19*** | -.26*** | -.23*** | - |
| b. Correlation Matrix for females (n=360) | | | | | |
| Variables | PA | BMI | WHR | Body Fat % | PFI |
| PA | - | | | | |
| BMI | -.52*** | - | | | |
| WHR | -.50 *** | .37*** | - | | |
| Body fat % | -.53 *** | .59*** | .33*** | - | |
| PFI | .41*** | -.33*** | -.27*** | -34*** | - |

* ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant

*Academic Score of the subjects:*

The mean academic score of males (M=43.7, SD=16.2) was found to be significantly ($p < 0.05$) lower than that of females (M=48.8, SD=14.6).

*Association of Obesity parameters and Cardiorespiratory fitness (PFI) with academic score*

A significant negative correlation between BMI and academic score in boys ($r = -.17$, $p < 0.001$), and girls ($r = -.29$, $p < 0.001$) was noted. It may be pointed out that the degree of correlation was higher in girls than that of boys. The academic score was also significantly and negatively correlated with WHR in boys ($r = -.20$, $p < 0.001$) and girls ($r = -.21$, $p < 0.001$). Similarly, significant negative correlation ($p<0.001$) was noted between Body fat % and academic score in both boys and girls. On the other hand there was a significant positive correlation ($p < 0.001$) between PFI and academic score in both the genders.

**Table 4. Multiple regression analysis of Academic score with selected obesity parameters and Cardiorespiratory fitness (PFI)**

| | Male(n= 360) | | Female(n= 360 ) | |
|---|---|---|---|---|
| $R^2$ | 12 % | | 13 % | |
| Variables | B (regression weights) | P | B (regression weights) | P |
| BMI ($kg/m^2$) | -0.30 | > 0.05 | -0.47 | ≤ 0.05 |
| WHR (cm) | -10.2 | ≤ 0.01 | -6.68 | > 0.05 |
| Body Fat (%) | -0.69 | ≤ 0.001 | -0.67 | ≤ 0.01 |
| PFI | 0.13 | > 0.05 | 0.14 | > 0.05 |

After controlling for the other variables using multiple regression analysis, the following were found: In both the genders, the Body fat % had significant negative regression weights, indicating adolescents with lower body fat % were expected to have higher academic score, BMI possesed similar significant negative regression weights in females whereas WHR showed significant negative regression weights only in case of males. PFI was not significantly associated with academic score in males and females (Table 4).

## 4. Discussion

Earlier studies on adolescents and even adult populations reported decrement in BMI, WHR and fat % on being exposed to sufficient PA [4-11]. The findings of the present study confirmed the finding of these earlier studies in the present population (Bengali). It has been known that WHR gets lowered along with lowering of weight in individuals showing preponderance of adiposity in the abdomen [29,30,31]. The present study showed that PA may modify WHR in Bengali adolescents. This indicated that PA may mobilize fats from abdomen and thereby affect regional distribution of fats [32]. The findings of the present study on BMI, WHR and fat % implied that daily life PA may be helpful in weight management/ prevention of obesity. The effects of exercise /PA in regulating body weight are well accepted [33,34]. PA may be regarded to be one of the most important factors influencing obesity. Studies had noted that inactivity caused obesity although no accompanying more intake of energy through diet was present [35,36,37]. Thus every adolescent should adopt strategies to maintain sufficient PA in daily life in order to restrict obesity. Unlike the present study, reports of increase in weight, BMI, and other variables related to physical development following exercise or PA exists in the literature [38,39,40,41]. Thus it is evident that the effect of PA /exercise on body composition may differ among studies. These differences among studies may be attributed to be due to differences in methodology of estimation of body composition, duration and mode PA / exercise performed by the population [42]. Moreover, varried dietary practices by the population considered by these studies may also contributed to the differences among these studies. An earlier study [43] found that BMI of Bengali adolescents belonging to middle class strata of the society was much below than those belong to prosperous strata of the society. In light of this particular earlier finding, lower prevalence of obesity, found in the present study was not surprising.

The effects of PA leading to better PFI scores (cardiorespiratory fitness), as observed in the present study have been reported by many earlier studies [13,14]. Regular PA is known to improve PFI by improving recovery heart rate [44]. The efficient delivery and use of oxygen by the muscles and tissues (which in turn may lead to lower resting heart rate, higher stroke volume, higher arteriovenous $O_2$ difference and lower respiratory minute ventilation ) [45] may be facilitated by exercise induced angiogenesis [46,47,48,49,50]. The improvement in PFI, on exposure to increasing levels of PA in the present study may be attributed to such physiological benefits of PA.

The higher BMI, WHR in boys and higher body fat % in girls in the present study is in line to a study on other population [51]. Earlier, Indian studies have also found BMI of male adolescents to be higher than females [52]. WHR is a measure of abdominal fat distribution [53]. Higher WHR in Bengali males in the present study suggest higher dominance of abdominal fats in males in comparison to Bengali females. This observation on WHR of Bengali males is supported by the fact that males show fat deposition especially in the truncal region. This includes subcutaneous and intra abdominal fat deposition [54]. Higher resting heart rate and more body fat in females may add to the differences in PFI values between male and females. Similar to our findings an earlier study on adult male and females using modified Harvard Step Test, found that the mean PFI score of females was lower than that of males [55]. This present study and even an earlier study [56] had shown that males with higher PFI showed lower amount of body fat. This indicated that body fat may influence PFI and since females show higher body fat than males, lower PFI values among females may be expected. Furthermore, earlier studies have noted that post exercise recovery heart rate of males drops back at a normal range earlier than females [57]. In addition females are known to be less physically active than males. Lower PFI in females in contrast to males in the present study may be due to above probable reasons.

Body fat levels may be influenced by dietary food habits. It may be that the dietary intakes of both rural and urban adolescents involved in the study were not much different from each other. This may had contributed to the inconsistency in rural urban differences, in context to obesity parameters. However, the PFI score was found to be consistently and significantly lower in urban individuals. This was in line to an earlier study [45]. This may be attributed to the comparatively lower daily physical activity level of urban boys and girls, in contrast to their rural counterpart.

In the present study, the observed positive relationship of BMI with other obesity parameters viz. WHR and body fat % was more pronounced in adolescent girls than that of the boys. These observations were in conformity with earlier studies on other population in which similar findings were obtained [58,59]. These findings of the present study implied that BMI to some extinct may be a better predictor of adiposity in girls than boys. Future studies need to conform this particular finding. The results of the present study also showed that higher PFI scores may be associated with lower values of obesity parameters. This implied that greater physiological fitness may lower the susceptibility of adolescents to develop obesity. Daily life PA is of much importance in achieving greater PFI as elucidated by the results of the present study. Increased adiposity may lower utilization of oxygen per unit of body mass. This may restrict proper functioning of heart especially during physical activities or exercises [60]. Thus on the basis of the present study it may be said that low PA level may result in higher mean values of BMI, WHR and body fat % which may be may be detrimental to cardiorespiratory fitness. Increased cardiorespiratory fitness (measured in terms of $VO_2$ Max) had been found to lower body fat % [60], BMI and WHR [61]. In light of these earlier studies and results of the present study it may be said that cardiorespiratory fitness whether measured in terms of either PFI or $VO_2$ Max may be expected to demonstrate a negative relationship with obesity parameters.

Academic scores of females in the present study was higher than that of males. This is in line to our previous study, performed with a different sample size of Bengali adolescents [15]. A number of studies [3,16,17,18] on other population reported that obese individuals were performing poorly in academics. This present study is possibly the first study on Bengali adolescents to report significant negative impact of BMI, WHR and Body fat % on academic performance in a sample of health, mostly non obese individuals. The findings were not surprising since individuals with more body fat may lack attentiveness and proper executive functions like flexibility in mental tasks [62]. However, some contradictory reports of no effect of excessive body fat on academic performance also exists in the literature [18,63]. In the present study, although initially it appeared from the correlation study that academic performance of girls may be little bit more adversely affected by increased obesity parameters, multiple regression analysis conformed the absence of any such trend. It showed no drastic differences in the effects of obesity parameters on academic performance between male and females. Consistent with a recent study [3] on Punjabi adolescents multiple regression analysis showed that BMI may have profound negative influence on academic performance of girls whereas it may not adversely affect academic performance in boys. An earlier study also found that BMI may not adversely influence cognition [64]. In elderly adults increased WHR had been found to be associated with impairment in cognitive ability [65,66]. The findings of the present study provided evidences that similar relationship between WHR and cognition may exists in adolescents. Furthermore, in the present study body fat % (rather than other obesity parameters) emerged as the most marked negative predictor of academic performance in both the genders. In the present study, multiple regression analysis showed lower explained variance in both boys and girls. This indicated that the various obesity parameters although not greatly but to a limited extinct may influence academic performance of Bengali adolescents.

Several explanations may be put forward to explain the negative relationship of obesity parameters with academic performance. Poor academic performance induced psychological disturbances may trigger excessive eating resulting in increased values of obesity parameters. Unfavourable attitude of teachers towards individuals with more body weight may lead to the assignment of lower marks/grades to them by teachers. Lack of discipline in personal life may prevent an individual from devoting time to both PA and academic tasks [67]. This in turn may increase their susceptibility to obesity and obtaining of poor grades in examinations. In individuals with higher BMI the amount of blood that is to be normally distributed to the brain gets distributed to other parts of the body. This compromised supply of blood to brain in individuals with higher BMI may lead to compromised academic performance or cognition. Lower self-esteem in overweight / obese individuals had also been linked to poor academic results [68].

Action of Leptin on brain affects synaptic plasticity and helps in removal of beta –amyloid which is thought to be

beneficial for cognition. Raised leptin concentration in individuals with more body fat may hamper transportation of leptin across the blood brain barrier and may lead to the development of resistance to leptin. These events may result in the attenuation of the beneficial funcitions of leptin on brain. Thus persons with more body fat may show impaired cognition [69] and hence a negative influence of excessive body fat on academic performance will not be surprising and may be expected.

Greater cardiorespiratory fitness may promote executive control of working memory, attentive abilities, adjustment of cognitive skills, faster reaction time, activation of circuitry related to frontal and parietal regions of the brain, accuracies in response by individuals, memories related to arbitrary associations (relational memory), better hippocampal contribution to develop memories [70]. It may thus be expected that these physiological benefits in individuals who have good cardiorespiratory fitness, in conjunction with healthy body composition to some extinct may positively affect academic performance.

However, in the present study, positive relationship of lower magnitude was found to be present between cardiorespiratory fitness (PFI) and academic performance using correlation study. Moreover, multiple regression analysis found no independent associations between PFI and academic performance (a suppressor effect). Unlike some earlier studies on other population [19,20], the evidence obtained by the present study in support of the presence of positive impact of cardiorespiratory fitness on academics was fairly weak. Additively, literature had pointed out that depending on the technique or methodology of determination of cardiorespiratory fitness, the findings on the impact of the later on academic performance may vary [71]. Therefore further studies are needed to reach a definite conclusion regarding the association between CRF and academic performance in Bengali adolescents.

## 5. Conclusion

The findings documented herein found negative association of obesity parameters, viz., BMI, WHR and body fat % with PA. This provided evidences to support the fact that sufficient daily life PA may effectively prevent obesity. It may be said that obese adolescents may be able to lose weight owing to the implementation of adequate PA in their daily life. This present study confirmed that, increased cardiorespiratory fitness may be observed due to increment in PA. The results showed that increase in WHR and Body fat % may occur with increase in BMI, whereas decrease in BMI, WHR, Body fat % may take place due to increase in cardiorespiratory fitness. Poor performance in academics was linked to the presence of higher values of BMI, WHR and body fat %. Conversely, it was noted that greater cardiorespiratory fitness to a limited extent may be associated with better academic performance. Based on the findings of the present study, it may be said that sufficient PA in daily life may alter obesity parameters and cardiorespiratory fitness towards a healthy level which may positively influence academic performance by modulating cognition. The importance of daily life PA should not be restricted to only anti obesity campaign, instead its beneficial implications in relation to overall fitness and cognition should be promoted across all populations.

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