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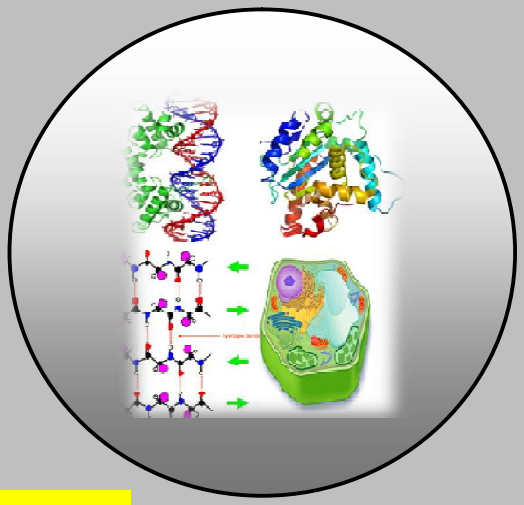

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RESEARCH PAPER

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Daily Physical Activity: The Link to Physical Fitness, Cognition and Academic Performance in Bengali (Indian) Adolescents of Rural and Urban Areas

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ABSTRACT

This study evaluated VO_2 Max (Maximal aerobic capacity) and academic score (as a marker of cognitive functions) in relation to increasing levels of daily physical activity (PA).It also investigated whether there was significant variability in VO_2 Max and academic score between the rural and urban areas. Male and female adolescents (N=600) of different age groups (Group I=13-14, Group II= 15-16 and Group III=17-18) were selected at random from different schools of rural and urban areas in West Bengal state, India. Using Physical Activity Questionnaire for Adolescents (PAQ –A) the subjects were divided into low, moderate and high PA categories. The VO_2 Max was assessed by Queens College Step Test and the academic score (% of total) was calculated from the mean of total marks of the last three years annual school examination. Mean, standard deviation, two level nested ANOVA, one way ANOVA, multiple comparison tests, t-tests, and Pearson's correlation coefficient was applied on the data as required. The results revealed that the VO_2 Max and academic scores of both male and female adolescents were significantly different among low, moderate and high PA levels. Rural-urban differences in VO_2 Max and academic score were inconsistent in both the genders in majority of cases. Higher VO_2 Max in boys than that of girls was noted. Academic score was higher in girls than that of boys in some cases. PA had significant ($p \leq 0.001$) positive correlation with VO_2 Max and academic score in boys and girls. Academic scores were positively influenced by VO_2 Max only in females. It was concluded that considerable amounts of regular physical activity must be incorporated in lifestyle of all adolescents in order to experience its beneficial effects on physical fitness, cognitive functions and academic performance.

Keywords: PA Level, Bengali Adolescents, VO_2 Max, Academic Score, Rural and Urban.

INTRODUCTION

Physical activity (PA) play an important role in determining physical fitness (Gutin et al. 2005; Ruiz et al. 2006; Hussey et al. 2007) and academic performance (Dwyer et al. 2001; Sibley and Etnier 2003; Tomporowski 2003a; Coe et al. 2006; Hillman et al. 2009) . Important relationship between fitness level and academic accomplishment exists (Chomitz et al. 2009). Recent times have marked the use of academic performance as measure of cognitive function (MacCabe et al., 2010; Tolppanen et al., 2012; Meo et al., 2013). PA improves cognitive functioning as evidenced by improved perception abilities, intelligence quotient (IQ) , verbal tests, arithmetic tests (Sibley and Etnier 2003) concentrating ability and memorizing power (Strong et al. 2005). Furthermore, increased blood supply to the brain, angiogenesis increasing oxygen saturation, improved communication through neurotransmitters like nor-adrenalin and serotonin, control of neurotropin may also be influenced positively by exercise to improve cognitive functioning (Ploughman et al. 2008). Simple PA such as walking on a treadmill for 20 minutes before academic tests improved cognitive control and resulted in better academic score among students (Hillman et al. 2009). Thus it may be deduced that cognitive function affects academic performance and hence academic performance may act as a marker of cognitive function. Studies have pointed the association of educational ability in early life with adverse health outcome in later life (Lawlor et al. 2008). So a better performance in academics may lead to both good carrier and good health in future. Likewise, better physical fitness has several benefits on health (Eisenmann et al. 2005; Hallal et al. 2006; Mesa et al. 2006). Negative impact on health, socioeconomic status, and educational achievement in adulthood may be the result of adverse affect of health in early life (Case et al. 2002; Case et al. 2005). Views exists that Maximal aerobic capacity (VO_2 Max) which is a measure physical work capacity and an indicator of cardio respiratory fitness, if found unsatisfactory may impact productivity of children and adolescents in strenuous physical work in adulthood (Spurr and Reina 1989).

Although studies on VO_2 Max exists on Bengali adolescents, no reports on links between PA, physical fitness and academic performance has been found in Bengali adolescents. Furthermore, physical activity as a determinant of physical fitness and academic performance has been investigated widely in studies of non Indian origin and there is a lacuna in this respect among Bengali adolescents. So the present study was undertaken to evaluate physical fitness (in terms of VO_2 Max) and academic performance (as a marker of cognitive function/control) in relation to daily physical activity levels (low, moderate, and high) in Bengali adolescent males and females of rural and urban areas. Gender differences and rural-urban differences of VO_2 Max and academic performance were evaluated in the different activity levels. This study also explored association of VO_2 Max and academic performance with age.

MATERIAL AND METHODS

For the present study healthy and disease free adolescents of both the genders of age group 13-18 years (N= 600) were selected randomly form different schools of urban and rural areas of Burdwan, Hooghly, and Howrah districts of West Bengal, India. The subjects were divided into three age groups (Age GR I=13-14 years, Age GR II= 15-16 years, and Age GR III=17-18 years). Each age group had two gender groups. The two genders component in each of the three age groups had 50 individuals from both rural and urban areas respectively. All subjects volunteered for the study. Informed consent was taken from all the subjects before including them in the study. The study was approved by the institutional human ethical committee.

The physical activity level scores were computed from the Physical Activity Questionnaire for Adolescents or PAQ-A (Kowalski et al. 1997a). On the basis of the score the subjects was divided into three categories – low (score ≤ 2), moderate (score >2 and ≤ 3), and high activity levels (score > 3). Physical fitness in terms of VO_2 Max and cognitive abilities in terms of academic score was evaluated.

Physical Activity Questionnaire for Adolescents (PAQ-A): Physical activity (PA) done in day to day life was assessed using the questionnaire. It consisted of eight questions. The first question asked about the number of times a specific physical activity (PA) was done. It was modified to include common practices of physical activities of the Bengali boys and girls, excluding the uncommon items. Participants had the different options, Viz., no activity , 1/2 times, 3/4 times, 5 /6 times and 7 times or greater, to choose from a particular PA. The second to seventh questions were asked about the time at which PA was done Viz., morning, after lunch, after school, evening and weekends. Here the participant had to select one response out of five .The eighth question was about the days of the week ,i.e., Monday to Sunday, in which PA was done. It had options that described the best PA done in that day. Scoring for these eight questions and computation of final PA score were done using the procedure described in the original questionnaire (Kowalski et al. 1997b).

Physical fitness: VO_2 Max (Maximal aerobic capacity) is a measure of cardiorespiratory fitness (Shephard et al 1968). It was determined in adolescents using Queens College Step Test (QCT). Earlier studies have also used the test in adolescent population (Chatterjee et al. 2001; Chatterjee et al. 2005; Parris 2006).In QCT the participant stepped up and down on a 16.25 inch (41 cm) bench for continuous 3 minutes by the help of rhythm generated by a metronome. Stepping pace for females was 22 steps/min, and for males it was 24 steps/min. Pulse rate was recorded from 5^{th} to 20^{th} seconds immediately after completion of the stepping. The resultant 15 second pulse was multiplied by 4 to get beats / min heart rate. After that, computation of VO_2 Max was done using the formula below.

Girls: VO_2 Max (ml/kg/min) = 65.81 – (0.1847 x heart rate: bpm).
Boys: VO_2 Max (ml/kg/min) = 111.33 - (0.42 x heart rate: bpm).

Cognitive function: Assessment of academic performance was done as a marker of cognitive function in line to earlier studies (MacCabe et al. 2010; Tolppanen et al. 2012; Meo et al. 2013). Marks obtained in all the individual academic subjects by the participant in the last three years annual examination of the school was assessed either from their report cards / school database / files. Marks of all the individual academic subjects were summed. Percentage (%) of the mean of the three years total marks was calculated to get the academic score (%) of an individual.

Statistical analysis: Mean and standard deviation of the study variables was determined. Two level nested ANOVA (Sokal and Rohlf 2001) was applied on overall sample and on the three separate age groups in both males and females. It was employed to determine 1) whether there was significant variation in the dependent variable among the three PA levels, 2) whether there was significant variation in the dependent variables between the subjects of rural and urban areas nested /contained within PA levels. Furthermore, one way ANOVA was carried out separately for rural and urban adolescents to find the significance of variation of the dependent variable between the three PA levels. Post- hoc Bonferrroni - multiple t- test was used following two level nested ANOVA while post- hoc Scheffe's test was carried out following one way ANOVA.

Moreover, t -test was used to find significance of gender variation and rural-urban variation in the dependent variable. Links between PA, physical fitness and academic score was assessed using Pearson's correlation coefficient and multiple regression analysis. A p value of $\leq$ 0.05 was considered statistically significant in all the analysis.

RESULTS

The mean and standard deviation values of the variables of all Bengali male and female adolescents studied have been presented in Table 1. Results revealed that there was an increase in VO_2 Max and academic scores with the increase in physical activity levels. Significant difference in VO_2 Max and academic scores was observed in three PA levels (low, moderate and high) in both gender groups. The VO_2 Max and academic scores were significantly different between male and female in different PA levels except for academic scores in moderate PA level. The VO_2 Max showed significantly higher values ($p \leq 0.05$) in males in all PA levels than that of female subjects. However, the academic scores of male adolescents were significantly lower ($p \leq 0.05$) in low and high PA levels than that of their female counterpart. Excepting academic scores of males, significant variability in VO_2 Max and academic scores was found between the areas (rural-urban) nested within the PA groups (evidenced by F statistic of subgroup in two level nested ANOVA in Table 1). A significant gender difference ($p \leq 0.05$) was observed in both VO_2 Max and academic score except in academic score of moderate PA level (Table 1).

Table 1. Variation of VO_2 Max and Academic Scores in different physical activity level male (M) and female (F).

Note: Nested within PA levels /groups are subgroups i.e. Regions (rural:R and urban:U).The means and standard deviations (SD) of two subgroups within each PA group has been presented and statistically treated in table 2).

Variables	Sex	Physical activity levels			Two-level nested ANOVA		Post-hoc Bonferroni-Multiple t- test
		Low Mean ± SD	Mod. Mean ± SD	High Mean ± SD	(F_G)	(F_{SG})	
VO_2 Max ml/kg/min	M	32.6 ± 6.05 #	41.7 ± 6.39 #	48.3 ± 6.82 #	18.51*	5.77***	L≠M, L≠H, M≠H
	F	29.4 ± 2.76 #	30.9 ± 4.28 #	40.1 ± 3.09 #	107.5***	2.51*	L≠M, L≠H, M≠H
Academic Score (%)	M	33.0 ± 9.39 #	47.8 ± 14.6	50.8 ± 14.1 #	23.4 **	1.19 ns	L≠M, L≠H
	F	38.4 ± 7.22 #	46.4 ± 11.9	60.4 ± 15.5 #	23.2 **	3.30*	L≠M, L≠H, M≠H

Males: low, n = 43, mod, n = 110, high, n = 147; Females: low, n= 52, mod, n =125, high, n =123

* $\leq$ 0.05; ** $\leq$ 0.01; *** $\leq$ 0.001, ns = not significant. (Note: G = group and SG =subgroup)

Significantly different means, P $\leq$ 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 column are significantly different by t -test ($p \leq 0.05$).

The rural and urban adolescents of both genders showed significant variation ($p \leq 0.001$) in VO_2 Max and academic score among three PA levels (Table 2).

Rural-urban differences in VO_2 Max and academic scores have been presented in Table 2. Significant rural-urban difference was noted in academic score of female only in case of moderate PA level, and in VO_2 Max of both the sexes at high PA level ($p \leq 0.05$). In other cases there was no significant difference in both the parameters between rural and urban subjects in three PA levels (Table 2). However, a general trend of higher (non-significantly) academic score was noted in urban adolescents than that of rural adolescents. Conversely, the values of VO_2 Max were comparatively lower in urban subjects in most of the PA levels of both the sexes.

Table 2: Mean, SD, and ANOVA of the subgroups (rural: R and urban: U) present within each PA group, irrespective of age group.

Variables	Sex	Region	Physical activity levels			One way ANOVA (F)	Post- hoc Scheffe 's test
			Low Mean ± SD	Mod. Mean ± SD	High Mean ± SD		
VO_2 Max ml/kg/min	M	R	34.8 ±7.18	41.1 ±6.84	50.2 ±5.28#	56.93***	L≠M, L≠H, M≠H
		U	31.8 ±5.46	42.5 ±5.71	46.2 ±7.64#	50.60***	L≠M, L≠H, M≠H
Academic Score (%)		R	29.3 ±5.89	46.8 ±14.67	51.5±16.63	11.18***	L≠M, L≠H
		U	33.5 ±9.69	50.3 ±15.22	50.1 ±14.22	18.07***	L≠M, L≠H
VO_2 Max ml/kg/min	F	R	29.8 ±3.35	31.4 ±5.27	39.4 ±3.29#	70.23***	L≠H, M≠H
		U	28.9± 1.91	30.4 ±2.76	40.8 ±2.76#	312.3***	L≠H, M≠H
Academic Score (%)		R	37.3 ±6.28	43.5±7.34#	58.9 ±13.5	56.02***	L≠M, L≠H, M≠H
		U	38.8 ±7.45	49.6±14.89#	61.7 ±14.53	28.07***	L≠M, L≠H, M≠H

Males R : low, n = 12, mod ,n = 63, high, n = 75 ; Males U :low ,n= 31, mod, n =47, high ,n =72
Females R: low, n = 27, mod, n = 66, high, n = 57; Females U: low, n= 25, mod, n =59, high, n =66
* < 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant

The PA groups having significantly different rural-urban subgroup are shown: Comparison (vertical column wise) among the same gender different region indicated by # in superscript are statistically different using t –test ($p \leq 0.05$).

In the three separate age groups (Table 3) VO_2 max was observed to vary significantly among PA levels in both males and female adolescents.VO_2 max was also varied significantly between rural and urban areas in all age groups of both the sexes, except in age group III. Significant differences in academic score among PA levels in all age groups, except in male subjects of age group III and in females of age group I, were found. Rural-urban difference of academic scores among different PA levels was observed only in case of males of group III and females of group I.

Furthermore, the descriptive statistics revealed that VO_2 Max of male adolescents showed an increase with age while in female subjects it was decreased or remained unchanged with the advancement of age. No clear trend in the change of academic score was noted with age (Table 3). From the evaluation of sex related difference it was found that significant variation ($p \leq 0.05$) in VO_2 Max was evident in all the comparison between two sexes in all the PA levels of the same age group (male VO_2 Max being higher than females), except among individuals of group I having low PA level and of age groups I and II with high level of PA. Conversely in case of academic performance significant difference was observed (females possessing better academic score than males) only in individuals of age group II with low PA level and age groups I, II, and III with high PA level ($p \leq 0.05$) (Table 3).

Table 3.Variation of VO_2 max and academic score in different PA levels according to age and sex.
Note: Nested within PA levels / groups are subgroups, i.e., areas (rural: R and urban: U).The means and standard deviations of two subgroups within each PA group for male and female has been presented and statistically treated in table 4 and 5).

Variables	Sex	Age GR	Physical activity levels			Two-level nested ANOVA		Post -hoc Bonferroni-Multiple t -test
			Low Mean ± SD	Mod. Mean ± SD	High Mean ± SD	(F_G)	(F_{SG})	
VO_2 Max (ml/kg/min)	M	I	31.1 ± 8.21	36.9± 6.12#	43.5 ± 6.50	13.2*	1.69 ns	L≠H, M≠H
		II	32.3 ± 4.33#	42.8 ± 4.96#	47.9 ± 6.25	12.20*	4.15**	L≠M, L≠H, M≠H
		III	34.4 ± 5.24#	46.5 ±3.82#	52.5 ±4.40#	52.34**	2.05 ns	L≠M, L≠H, M≠H
	F	I	30.6± 30.09	31.8 ±4.09#	41.5 ±2.89	27.79**	3.90**	L≠H, M≠H
		II	28.9± 2.19#	30.2 ±3.19#	40.39 ±2.91	55.82**	3.16*	L≠H, M≠H
		III	28.8 ±2.86#	30.7 ±5.13#	38.4 ±2.74#	24.49**	2.18 ns	L≠H, M≠H
Academic Score (%)	M	I	34.9 ±6.92	52.4 ±15.86	47.4 ±15.43#	8.50*	0.79 ns	L≠M, L≠H
		II	28.4 ±5.77#	44.5 ±13.45	52.8 ±16.50#	17.14*	0.98 ns	L≠M, L≠H, M≠H
		III	33.9 ±11.81	47.9 ±14.65	52.1 ±14.39#	2.91 ns	3.65**	
	F	I	37.8 ±5.30	47.1±14.89	60.2 ±14.42#	7.08 ns	2.66*	
		II	38.9 ±7.68#	48.8 ±11.88	59.9± 13.42#	13.76*	1.65 ns	L≠M, L≠H, M≠H
		III	37.1 ±7.27	43.7 ±7.44	61.1 ±14.75#	226.8***	0.17 ns	L≠M, L≠H, M≠H

Males I : low, n = 13, mod ,n = 40 , high, n = 47 ; Females I :low ,n= 15, mod, n =44, high ,n =41
Males II : low, n = 15, mod ,n = 41 , high, n = 44 ; Females II :low ,n= 19, mod, n =37, high ,n =44
Males III : low, n = 15, mod ,n = 29 , high, n = 56 ; Females III :low ,n= 18, mod, n =44, high ,n =3
* ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant. (Note:G = group and SG =subgroup)

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.

Comparison (vertical coloumn wise) among male Vs female of the same age group indicated by # in superscript are statistically different using t –test (p ≤ 0.05).

Separate analysis of variables in rural and urban adolescents of the three age group (I,II and III) respectively also found significant variation in VO_2 Max and academic score in the three PA levels among males (Table 4) and females (Table 5).

Table 4: Mean, SD, and ANOVA of VO_2 Max and academic scores of the subgroups (rural :R and urban: U) present within each PA group of adolescent males according to three age groups.

Variables	Age and Sex	Rural/ urban	Physical activity levels			One way ANOVA(F)	Post-hoc Scheffe's test
			Low Mean ± SD	Mod. Mean ± SD	High Mean ± SD		
VO_2 Max ml/kg/min	GR I M	R	32.4 ±7.96	36.6 ±6.44	45.7 ±5.61#	16.18***	L≠H, M≠H
		U	30.3 ±8.79	37.5± 5.80	41.6 ±6.74#	8.60***	L≠H
Academic Score (%)		R	30.9 ±4.49	51.9 ±16.03	50.4± 16.56	3.83*	L≠M
		U	37.5 ±7.19	52.9± 16.11	44.7 ±14.14	3.63*	L≠M
VO_2 Max ml/kg/min	GR II M	R	35.3 ±5.20	41.7 ±5.12#	50.5 ±2.27#	32.01***	L≠M, L≠H, M≠H
		U	31.1 ±3.61	45.0± 3.86#	46.2 ±7.47#	25.58***	L≠M, L≠H
Academic Score (%)		R	27.8 ±9.18	45.3 ±13.13	56.9 ±22.26	5.77**	L≠H
		U	28.6 ±4.61	42.7 ±14.51	49.9 ±10.50	15.00***	L≠M, L≠H
VO_2 Max ml/kg/min	GR III M	R	37.9± 9.25	48.0 ±4.55	52.9 ±4.14	17.89***	L≠M, L≠H, M≠H
		U	33.5 ±3.88	45.4 ±2.88	51.8 ±4.82	78.80***	L≠M, L≠H, M≠H
Academic Score (%)		R	28.6 ±3.56	40.3 ±12.98#	49.4 ±12.78	5.36**	L≠H
		U	35.3 ±12.85	53.4 ±13.59#	56.8± 16.00	8.88***	L≠M, L≠H

Males I R : low, n = 5, mod ,n = 23, high, n = 22; Males I U :low ,n= 8, mod, n =17, high ,n =25
Males II R : low, n = 4, mod ,n = 28 , high, n = 18 ; Males II U :low ,n= 11, mod, n =13, high ,n =26
Males III R : low, n = 5, mod ,n = 12, high, n = 33 ; Males III U :low ,n= 12, mod, n =17, high ,n =21
* ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant

Significantly different means ($p \leq 0.05$), by post- hoc Scheffe's test are shown in table.
The PA groups having significantly different rural-urban subgroup are shown: Comparison (vertical column wise) among same age group different site indicated by # in superscript is statistically different using t- test ($p \leq 0.05$).

Among male adolescents of the same age group (Table 4) there were significant rural-urban differences ($p \leq 0.05$) in VO_2 Max in case of moderate PA level of group II and in academic score in case of group III with moderate PA level. Significant rural-urban differences ($p \leq 0.05$) were also noted in VO_2 Max in the subjects of age group I and II with high PA level. However, overall tendency of results indicated that the VO_2 Max was comparatively higher among the rural male adolescents of different age groups than that of urban subjects, especially in low and high PA levels. The academic scores were relatively higher in all age groups among the urban male adolescents than that of their rural counterpart (Table 4).

Table 5. Mean, SD, and ANOVA of VO_2 Max and academic scores of the subgroups (rural :R and urban: U) present within each PA group of adolescent females according to three age groups.

Variables	Age and Sex	Rural/ urban	Physical activity levels			One way ANOVA (F)	Post-hoc Scheffe's test
			Low Mean ± SD	Mod. Mean ± SD	High Mean ± SD		
VO_2 Max ml/kg/min	GR I F	R	31.7 ±3.21$^{\#}$	32.9 ±4.53$^{\#}$	42.3 ±3.36	33.18***	L≠H, M≠H
		U	28.4 ±1.24$^{\#}$	30.31 ±2.99$^{\#}$	40.9 ±2.47	111.5***	L≠H, M≠H
Academic Score (%)		R	36.7 ±4.63	42.9 ±7.37$^{\#}$	55.9 ±11.5	18.48***	L≠H, M≠H
		U	40.2 ±6.33	52.1 ±19.69$^{\#}$	62.9± 15.65	4.82**	L≠H
VO_2 Max ml/kg/min	GR II F	R	28.3 ±2.08	29.6± 3.26	39.4 ±2.04$^{\#}$	96.53***	L≠H, M≠H
		U	29.3 ±2.26	30.9 ±3.07	41.6± 3.35$^{\#}$	85.8***	L≠H, M≠H
Academic Score (%)		R	40.3± 9.93	44.7 ±7.25$^{\#}$	59.4 ±14.04	12.57***	L≠H, M≠H
		U	38.2± 6.39	53.1± 14.31$^{\#}$	60.6± 12.95	12.50***	L≠M, L≠H
VO_2 Max ml/kg/min	GR III F	R	29.0± 3.59	31.1± 6.80	36.7 ±2.29$^{\#}$	8.93***	L≠H, M≠H
		U	28.7 ± 1.75	30.2 ±2.28	39.8 ±2.26$^{\#}$	127.4***	L≠H, M≠H
Academic Score (%)		R	35.7 ±3.99	43.2 ±7.60	60.9 ±14.69	23.65***	L≠H, M≠H
		U	38.9 ±10.06	44.3 ±7.41	61.2 ±15.15	15.71***	L≠H, M≠H

Females I R: low, n = 10, mod, n = 24, high, n = 16; Females I U low, n= 5, mod, n =20, high ,n =25
Females II R: low, n = 7, mod, n = 19, high, n = 24 ; Females II U :low ,n= 12, mod, n =18, high ,n =20
Females III R: low, n =10, mod, n = 23, high, n = 17 ; Females III U :low ,n= 8, mod,n =21, high ,n =21
* < 0.05; ** ≤ 0.01; *** ≤ 0.001, ns = not significant

Significantly different means ($p \leq 0.05$), by post- hoc Scheffe's test are shown in table.
The PA groups having significantly different rural-urban subgroup are shown: Comparison (vertical coloumn wise) among same age group different site indicated by # in superscript is statistically different using t –test ($p \leq 0.05$).

Rural-urban difference was observed in both VO_2 Max and academic scores of female subjects (Table 5). Results showed that there was general tendency of higher values of VO_2 Max and lower values of academic scores in rural female subjects than that of their urban counterpart. However, the results were not significantly different all the age groups and all activity levels. Significant difference in VO_2 Max was observed in case of age group I, which belonged to low PA level as well as moderate PA level and in case of age groups II and III within high PA level ($p \leq 0.05$). On the other hand significant differences in academic scores were observed in groups I and II, only in case of moderate PA level (Table 5).
Significant positive correlation ($p \leq 0.001$) was observed between physical activity level and VO_2 Max values in the overall sample of boys and girls. The physical activity level was also significantly ($p \leq 0.001$) correlated with VO_2 Max when computed separately for different age groups of male and female subjects. The degree of correlation was high in most of the cases (Table 6).
In the overall sample of males and females and in all the age groups, except age group I boys, significant positive correlation ($p \leq 0.001$) were seen between PA and academic performance (Table 6).

Table 6: Correlation coefficient of PA with VO_2 Max and Academic score (all subjects, rural and urban combined).

Variable	VO_2 Max ml/kg/min	Academic Score (%)
PA Score (Males: overall)	0.56***	0.34***
PA Score (Females: overall)	0.69***	0.53***
PA Score (Males: GR I)	0.48***	0.13 ns
PA Score (Females: GR I)	0.69***	0.51***
PA Score (Males: GR II)	0.57***	0.49***
PA Score (Females:GR II)	0.73***	0.48***
PA Score (Males: GR III)	0.74***	0.38***
PA Score (Females :GR III)	0.66***	0.61***

****$p \leq 0.001$, ns = not significant*

In males PA, area (rural or urban) and age (not academic score) possessed significant effect on VO_2 Max ($p \leq 0.01$) .The regression equation was: VO_2 Max=18.6+6.1 PA - 2.5 area +4.1 Age , (R^2 = 0.49).
PA and age showed significant ($p \leq 0.01$) positive effect on VO_2 Max of males .The regression equation was: VO_2 Max=17.5 + 6.3 PA + 4.1 Age (R^2=0.47).

In females except area all the predictor variables like PA, academic score and age was related significantly with VO_2 Max ($P \leq 0.01$). The Regression equation was: VO_2 Max=19.6+5.4PA+.05Academic Score - 0.98 Age, (R^2 = .51).

The PA had significant ($p \leq 0.01$) positive effect on VO_2 Max of females, while the age showed significant ($p \leq 0.01$) negative effect on VO_2 Max .The Regression equation was: VO_2 Max= 20.6 + 5.9 PA – 1.0 Age, (R^2 =0.50).

The academic score of boys was positively associated with physical activity ($p \leq 0.01$), but there was no association with VO_2 Max, rural-urban areas and age. The regression equation was: Academic score (%) =24.5+6.9 PA, (R^2 =.12).

Physical activity, VO_2 Max and areas (not age) demonstrated significant ($p \leq 0.01$) positive relation with academic score of girls. The regression equation was: academic score (%)=11.5+8.4 PA +0.44 VO2 Max +3.82 Area, (R^2 = .31).

DISCUSSION

The evaluation of VO_2 Max and academic score with variation of daily physical activity levels in adolescents boys and girls indicated that in majority of the cases the mean values of both VO_2 Max and academic score tended to increase as the PA level changed from lower level to higher level although some exceptions have also been found in some of the age groups of male and female subjects. The effects of PA leading to better VO_2 Max have been found in several earlier studies (Gutin et al. 2005; Ruiz et al. 2006; Hussey et al. 2007; Shaikh et al. 2011). Similarly, the positive or beneficial effect of PA on academic score has been reported previously (Dwyer et al. 2001; Sibley and Etnier 2003; Tomporowski 2003; Coe et al. 2006; Hillman et al. 2009) in other populations. Unlike the present study some other studies also lead to different findings, either negative correlation between PA and academic score (Tremblay et al. 2000) or no correlation (Daley et al. 2000).It is well established that physical training increases VO_2 Max (Pollock 1973). In the present study high PA level of adolescents served as their improved training profile leading to better VO_2 Max. The underlying cause of better VO_2 Max with increasing PA levels may be due to the fact that PA leads to better adjustment or adaptation of circulatory and respiratory systems to cope up with strenuous works and leading to the delivery of more oxygen to the working muscles in such situations. It has been pointed out that the supply of more oxygen to active muscles and tissues is a determinant of better VO_2 Max (Saltin and Rowell 1980). The averages of academic scores obtained by individuals in this study indicated better cognitive functions in adolescents with high PA levels. Knowledge of the mechanism of beneficial effect of PA on academic performance has also expanded. Physical activity may promote learning or education by helping in being alert, attentive, and motivating by gearing up and promoting binding of neurons with each other, which helps in preserving fresh data, by triggering maturation of freshly formed cells originating from stem cells in the hippocampal region (concerned with memory) of brain (Ratey and Hagerman 2008). Experiments with animal model have found physical activity to be a powerful stimulus in promoting neurogenesis which benefits cognitive abilities (Van Prag 2009). Views exist that physical activity promotes 'executive central command' hence mediate an increase in the ability related to memory, learning and related cognitive abilities (Kramer et al. 2006). In a recent study, PA, such as, walking lead to greater P3 amplitude and resulted in better academic test results (Hillman et al. 2009). P3 (P300) is produced when cognitive function related to attention resource allocation come into play (Donchin et al. 1988; Lang et al.1997).

Better academic score following increased PA levels in the present study may be due to such underlying mechanisms which benefit the brain and cognition as discussed above.

This is the only study to combine inclusion of healthy, Bengali (Indian) individuals of both sexes of age range of 13-18 years and graded PA levels (low, moderate, and high). This study presents the mean values of $V0_2$ max found in different PA levels, so that it can serve as a reference values/ data for future research on fitness. Large scale similar study may help future researchers to formulate a classification system of cardio respiratory fitness exclusively for Bengali (Indian) adolescents which is lacking presently. Furthermore, these may be helpful in devising training programs or holistic interventions to promote fitness, health, competitive ability and athletic skills among Bengali adolescents.

During adolescence VO_2 Max of boys is known to increase up to the age of 18 years while in adolescent girls it decreases with age (Borms 1986). It was clearly evident in the mean values of VO_2 Max of Bengali males and females. Increased muscle mass with age may have increased the VO_2 Max of boys. Higher body fat is one of the cause of low VO_2 Max in females (Moreno et al. 2006).In Bengali girls, increase in the amount of body fat with age during adolescence, along with lowering of physical activity levels may have resulted in the lowering of VO_2 Max. The means of academic score did not indicate any prominent trend with increasing age in the present study. Separate regression analysis on the overall sample of males and females failed to find any significant effect of age on cognition measured using academic sore. Earlier other authors have also concluded absence of any impact of physical developmental process during adolescent period on cognition (Orr et al .1988).

The evaluation of gender difference showed that the male adolescents possessed higher VO_2 Max than that of females, whereas the girls had better academic score than that of boys in most of the comparisons. Greater height and weight of boys than that of girls may be the reason of higher VO_2 Max in boys. Earlier some studies reported girls doing better in academics and some studies reported the reverse (Patil and Dash 1990; Vijayalaxmi and Natesan 1992; Kaur and Gill 1993). Hormones may also have a role in gender differences in academic score. Testosterone has been linked to cognition in boys in puberty and even it has small role in cognition of girls (Davison and Susman 2001). Furthermore, high levels of gonadal steroids in the luteal phase of menstrual cycle may favour better cognition in females (Hampson 1990). Some behavioural aspects of girls like greater willingness to gain knowledge and attentive nature in classroom (Arnot et al. 1998) may favour academic abilities. In male and females the relationship between PA and academic performance may be affected differently by determinants of social, physical and psychological maturity (Bailey 2006; Carlson 2008). Females are also known to possess better skills related to verbal tasks which include spatial and autobiographical skills and emotional memory (Andreano and Cahill, 2009). These may be the plausible reason behind variation of academic scores between boys and girls in the present study. Studies have pointed out that as the fitness levels of girls are generally lower than boys; girls may be more sensitive to PA or exercise in producing a greater physiological response leading to better performance in academics (Carlson 2008) in addition to better improvement in cardio respiratory fitness. The results of rural-urban difference in VO_2 Max and academic score showed that in many instances there were insignificant differences in VO_2 Max and academic score of the subjects between two areas. However, rural subjects had slightly higher VO_2 Max than that of urban subjects. The trends of higher VO_2 Max among rural subjects might be attributed to the comparatively higher daily activity level of rural boys and girls. Although there was no significant difference in academic scores between the adolescents of rural and urban areas in most of the cases,

Yet a trend of higher academic scores has been noticed among urban subjects having different PA levels. A previous study in Varanasi district, India, reported considerable variations in educational performance of rural and urban sector adolescents (Joshi and Srivastava 2000). Moreover, it may be pointed out that there are increased trends of good educational facilities in rural area, like urban areas, which might lead to fewer chances of significant rural urban differences of academic score among the adolescents. Furthermore, in contrast to rural environment, urban environment may promote or favour students cognitive behaviour (Obasi, 2010).This may be the reason of urban students scoring better in academics in the present study.

The correlation study revealed that the VO_2 Max was positively influenced by PA level among the adolescents of both the sexes. The academic performance of the boys was influenced positively by PA whereas in girls it was influenced positively by PA, and VO_2 Max. Presence of any useful or positive impact of enhanced cardio respiratory fitness on cognitive performance has been investigated in several studies among adults. Such studies are limited in young population (Etnier et al. 2006).A part of the present study will contribute to the knowledge in this area. Furthermore significant positive effects of PA on VO_2 Max and academic score are clearly evident in the present study. It may be concluded that the present study provides evidences in favour of positive links between PA, maximal aerobic capacity and academic performance (as a marker of cognitive function) and supports the findings of previous studies (Briss walter et al. 2002; Tomporowski 2003b; Etnier et al. 2006) on other populations. The outcome of the present study indicates a dose response relationship of PA with not only VO_2 Max but also with academic performance. This study showed significant increment in both VO_2 Max and academic score with increasing PA levels in Bengali adolescents. However, the determination of duration, frequency, intensity and mode of PA /exercise, which are needed to improve VO_2 Max and academic performance, is beyond the scope of this present study. Studies on dose response relationship of PA with academic score are highly recommended to uncover the unknown mechanisms by which PA improves academic performance (Singh et al. 2012)**.** Individuals with low cardiorespiratory fitness have a scope of improving VO_2 Max as studies have found them more sensitive to training or high PA (Benefice 1988) Thus based on insights obtained from the present study into the positive association of PA with fitness it is recommended that sedentary adolescents should implement strategies like life style modification to incorporate considerable habitual PA in day to day life or opportunities of exposure to exercise or training program must not be neglected by individuals to improve aerobic fitness. At the same time this will benefit cognitive abilities or functioning not only during adolescence as indicated by the evaluated academic score in the present study but also during the entire life time (Voss et al. 2011) and this is expected to result in a better academic profile of an individual .This study also found that distribution of rural- urban difference in VO_2 Max and academic score of adolescents were not uniform and VO_2 Max of males was found to be higher and no particular trend of gender difference in academics was found. Considering the limitations of the present study such as use of questionnaire instead of pedometers or other costly instruments to determine PA levels and use of academic score instead of intelligence quotient (IQ) tests for testing cognitive function ,further studies are needed to achieve a conclusive pattern.

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REFERENCES

Arnot, M., Gray, J., James, M. and Rudduck, J. 1998. Recent Research on Gender and Educational Performance, OFSTED research series. The Stationery Office, London.

Andreano, J. M, and Cahill, L. 2009. Sex influences on the eurobiology of learning and memory. *Learn. Mem*. 16: 248–266.

Borms, J. 1986. The child and exercise: an overview. *J. Sports Sci.* 4: 3-20.

Benefice, E. 1988. Physical fitness and body composition in relation to physical activity in prepubescent Senegalese children. *Am. J. Hum. Biol.* 10: 385-396.

Briss Walter, J., Collardeau, M. and Arcelin, R. 2002. Effects of acute physical exercise characteristics on cognitive performance. *Sports Med.* 32: 555-566.

Bailey, R. 2006. Physical education and sport in schools: a review of benefits and outcomes. *J. Sch. Health* 76: 397–401.

Chatterjee, S., Chatterjee, P. and Bandopadhyay, A .2001. Enumeration of validity for predicted VO2 max by Queen. College Step Test in Bengalee boys. *Indian J Physiol and Allied Sci.* 55(3): 123-127.

Case, A., Darren, L. and Christina, P. 2002. Economic status & health in childhood: The origin of gradient. *Am. Econ. Rev* .92(5), 1308-1334.

Case, A., Angela, F. and Christina, P. 2005. The lasting impact of childhood health and circumstance. *J. Health Econ.* 24:365-389.

Chatterjee, S., Chatterjee, P. and Bandyopadhyay, A . 2005. Cardiorespiratory fitness of obese boys. *Indian J. Physiol. Pharmacol* . 49(3):353-7.

Coe, D.P., Pivarnik, J.M., Womack, C. J., Reeves, M. J., Malena, R. M. 2006. Effect of physical education and activity levels on academic achievement of children. *Med. and Sci. Sports and Exer.* 38:1515-1519.

Carlson, S.A., Fulton, J. E., Lee, S. M., Maynard, L. M., Brown, D. R., Kohl, H.W. III and Dietz, W. H . 2008. Physical education and academic achievement in elementary school: data from the early childhood longitudinal study. *Am. J. Public Health.* 98 (4): 7221-727.

Chomitz, V.R. , Slining, M. M., McGowan, R .J., Mitchell, S .E., Dawson, G .F. and Hacker, K. A. 2009. Is There a Relationship Between Physical Fitness and Academic Achievement? Positive Results from Public School Children in Northeastern United States. *J. Sch. Health* 79: 30-37.

Donchin, E. and Coles, M. G. H. 1988. Is the P 300 component a manifestation of cognitive updating?. *Behav. Brain Sci*. 11:357-427.

Daley, A. J., Daley, A .J. and Ryan, J. 2000. Academic performance and participation in PA by secondary school adolescent's .*Percept. mot. skills.* 91:531-534.

Dwyer, T., Sallis, J.F., Blizzard, L., Lazarus, R., and Dean, K. 2001. Relation of Academic Performance to Physical Activity and Fitness in Children. *Pediatr. Exerc. Sci*. 13: 225–237.

Davison, K. K. and Susman, E. J. 2001 Are hormone levels and cognitive ability related during early adolescence?. *International J. Behav. Dev.* 25(5):416- 428.

Eisenmann, J .C., Wickel, E .E., Welk, G .J. and Blair, S .N. 2005. Relationship between adolescent fitness and fatness and cardiovascular disease risk factors in adulthood: the Aerobics Center Longitudinal Study (ACLS). *Am. Heart J.*149: 46–53.

Etnier, J.L., Nowell, P.M., Landers, D.M. and Sibley, B.A. 2006. A Meta regression to examine the relationship between aerobic fitness and cognitive performance. *Brain Res. Rev .* 52:119-130.

Gutin, B., Yin, Z., Humphries, M. C. and Barbeau, P. 2005. Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. *Am. J. Clin. Nutr* .81: 746–750.

Hampson, E. 1990. Variations in sex-related cognitive abilities across the menstrual cycle. *Brain Cogn.* 14 (1): 26-43.

Hallal, P. C., Victora, C.G., Azevedo, M. R. and Wells, J .C .2006. Adolescent physical activity and health: a systematic review. *Sports Med.* 36: 1019–1030.

Hussey, J., Bell, C., Bennett, K., O'Dwyer, J. and Gormley, J. 2007. Relationship between the intensity of physical activity, inactivity, cardio-respiratory fitness and body composition in 7–10-year-old Dublin children. *Br. J. Sports Med.* 41: 311–316.

Hillman, C. H., Pontifex, M. B., Raine, L.B., Castelli, D. M. , Hall, E. E and Kramer, A. F. 2009. The effect of acute treadmill walking on cognitive control and Academic achievement in preadolescent children. *Neuroscience* 159 (3): 1044-54.

Joshi, S. and Srivastava, R. 2000. Self esteem and academic achievement of adolescents. *J. Indian Academy of Appl. Psychol.* 35:33-99.

Kaur, R. and Gill, J. K .1993. Sex differences in academic achievement in different subjects of rural and urban students. *Indian Psychol. Rev.* 40 (1-2):20-24.

Kowalski, K. C., Crocker, P. R. E. and Faulkner, R. A. 1997a. Validation of the Physical activity questionnaire for older children. *Pediatr. Exerc. Sci.* 9: 174-186.

Kowalski, K. C., Crocker, P. R. E. , Kowalski, N.P. (1997 b). Physical activity questionnaire for adolescents. http://www.dapa-toolkit.mrc.ac.uk/documents/en/PAQ/PAQ_manual.pdf (Assessed October, 2010).

Kramer, A .F. , Erickson, K. I. and Colcombe, J . 2006. Exercise, cognition, and the aging brain. *J. Appl. Physiol.* 101: 1237-1242.

Lang, P. J., Bradley, M. M. and Cuthbert, B .N. 1997. Motivated attention: Affect, activation and action. In: Lang, P. J., Simons, R. F. and Balaban, M. T. (Eds.), Attention and Orienting: Sensor and motivational processes. Erlbaum, Mahwah NJ: 97-135.

Lawlor, D. A., David, B. G., Clark, H., McIntyre, S. and Leon, D. A. 2008. Association of childhood Intelligence with risk of coronary heart disease and stroke: findings from the Aberdeen children of the 1950s cohort study. *Eur. J. Epidemiol .* 23:695-706.

Moreno, L.A., Mesana, M. I., Gonzalez-Gross, M., Gil, C. M., Fleta, J., Warnberg, J., Ruiz, J. R., Sarría, A., Marcos, A. and Bueno, M. 2006. Anthropometric body fat composition reference values in Spanish adolescents. The AVENA Study. *Eur. J. Clin. Nutr.* 60: 191- 6.

Mesa, J .L., Ortega, F. B., Ruiz, J .R., Castillo, M .J., Hurtig-Wennlöf, A., Sjöström, M.and Gutiérrez, N. 2006.The importance of cardiorespiratory fitness for healthy metabolic traits in children and adolescents: the AVENA Study [notification]. *J. Public Health.* 14: 178–180.

Mac Cabe, J. H., Lambe. M. P., Cnattingius, S., Sham, P. C., David, A. S., Reichenberg, A., Murray , R. M. and Hultman, C. M. . 2010. Excellent school performance at age 16 and risk of adult bipolar disorder: national cohort study. *Br. J. Psychiatry* 196: 109–115.

Meo, S. A., Alkahlan, M. A., Al –Mubarak, M. A., Al-obayli, M .S. , Melaibary, B .A., Bin Dous, A .N. and Alhassoun, A .I. 2013 .Impact of type 1 diabetes mellitus on academic performance. *J. Int. Med. Res.* 41(3):855-858.

Orr, D .P., Brack, C. J.and Ingersoll, G. 1988. Pubertal maturation and cognitive maturity in adolescents. *J. Adolesc .Health Care.* 9(4):273-9.

Obasi, M. N. 2010. Urban-rural differential in teaching and learning of geography in Ahiazu Mbaise and Owerri municipal council in Imo State. *Report and Opinion* 2(9):33-44

Pollock, M. L. 1973. Quantification of endurance training programs. *Exer. and Sport Sci. Rev* . 1, 155-188.

Patil, P. and Dash, S. 1990 . Effects of grade, sex and achievement levels on intelligence, incidental memory and stroop scores. *Psychol. Studies.* 33(1):36-40.

Parris, A. 2006. Report on the levels of aerobic fitness of year 9 and year 10 students at Linwood College. http://www.laneresearch.co.nz/files//LANE-chapter7.pdf (Assessed August 2011)

Ploughman, M. 2008. Exercise is brain food: The effects of physical activity on cognitive function. *Dev. Neurorehabil.* 11(3):236–240.

Ratey, J. J. and Hagerman, E .2008. Spark: The revolutionary new science of exercise and the Brain. Little, Brown and Company, NY.

Ruiz, J. R., Rizzo, N. S, Hurtig-Wennlof, A., Ortega, F. B, Warnberg, J. and Sjostrom, M. 2006. Relations of total physical activity and intensity to fitness and fatness in children; the European Youth Heart Study. *Am. J. Clin. Nutr.* 84: 298–302.

Shephard, R.J., Allen, C., Benade, A. J., Davies, C.T., Di Prampero, P.E., Hedman, R., Merriman, J. E, Myhre, K. and Simmons, R . 1968. The maximum oxygen intake. An international reference standard of cardiorespiratory fitness. *Bull World Health Organ* 38: 757–764.

Saltin, B. and Rowell LB. 1980. Functional adaptations to physical activity and inactivity. *Fed. Proceed*. 1980; 39(5): 1506-13.

Spurr , G. B. and Reina, J. C. 1989. Maximum oxygen consumption in marginally malnourished Colombian boys and girls 6-16 years of age. *Am. J .Hum .Biol.* 1:11-19.

Sokal, R.R., Rohlf, F. J .2001. Biometry. Freeman, NY.

Sibley, B .A. and Etnier, J. L . 2003. The relationship between physical activity and cognition in children: a meta- analysis. *Pediatr. Exerc. Sci*.15:243-256.

Strong, W .B., Malina, R .M., Blimkie, C .R., Daniels, S .R., Dishman, R .K., Gutin, B., Hergenroeder, A .C., Must, A., Nixon, P .A., Pivarnik, J .M., Rowland, T., Trost, S. and Trudeau, F . 2005. Evidence based physical activity for school age youth. *J. Pediatr* .146: 732-737.

Shaikh, W .A., Patel, M .C. and Singh, S .K . 2011. Association of physical activity and physical fitness with blood pressure profile in Gujarati Indian adolescents. *Indian J. Physiol. Pharmacol.* 55 (4): 322–328.

Singh, A., Uijtdewilligen, L., Twisk, J.W., van Mechelen, W.and Chinapaw, M.J . 2012. Physical activity and performance at school a systematic review of the literature including a methodological quality assessment. *Arch. Pediatr. Adolesc. Med.* 166(1): 49-55.

Tremblay, M. S., Inman, J. W., and Willms, J. D. 2000. The relationship between physical activity, self-Esteem, and academic achievement in 12-year-old children. *Pediatr. Exerc. Sci*. 12:312-323.

Tomporowski, P. D. 2003a. Cognitive and behavioural responses to acute exercise in youths: a review. *Pediatr. Exerc. Sci.* 15:348–359.

Tomporowski, P. D. 2003 b.Effect of acute bouts of exercise on cognition. *Acta. Psychologica*. 112,297-324.

Tolppanen, A. M., Sayers, A., Fraser, W .D. and Lawlor, D. A. 2012. Association of serum 25-hydroxyvitamin D3 and D2 with academic performance in childhood: findings from a prospective birth cohort. *J. Epidemiol. Community Health* 66 (12): 1137-42.

Vijayalaxmi, O. and Natesan, H. 1992. Factors influencing academic achievement. *Res. Highlights*.2: 62.

Van Prag, H. 2009. Exercise and the brain: something to chew on. *Trends Neurosci*. 32(5): 283-290.
Voss, M.W., Nagamatsu, L.S., Liu-Ambrose, T. and Kramer, A.F.2011. Exercise, brain, and cognition across the life span. *J. Appl. Physiol*. 111(5): 1505-13.

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