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## Original Article

# The Impact of School-Based Physical Activity Programs on Academic Performance Among Adolescents in India

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### ABSTRACT

**Background:** Evidence has suggested that school-based physical activity programs (SBPAPs)-including structured physical education, extracurricular sports, and activity-based learning-enhance memory and other cognitive functions. However, evidence on whether Indian adolescents can achieve improved cognition or increased academic performance also remains scarce. This study aimed to examine the relationship between SBPAPs and academic performance among Indian adolescents.

**Methods:** A cross-sectional, mixed study was carried out from October 2024 to March 2025 in public and private secondary schools in Haryana and Punjab, north India. A total of 300 students aged 13 to 17 years were divided into an intervention group ( $n = 150$ ) who participated in structured physical activity (PA) of at least 150 minutes per week and a comparison group ( $n = 150$ ) who were involved in less than 30 minutes of PA per week. Academic performance was assessed in terms of composite scores of core subjects, while the level of PA was measured using the Physical Activity Questionnaire for Adolescents. Independent samples  $t$ -tests, one-way analysis of variance (ANOVA), and Pearson's correlation analysis were all used for quantitative data handling. Qualitative data gathered from focus group discussions and key informant interviews with a subsample ( $n = 30$ ) were thematically analyzed.

**Results:** There were no significant differences in baseline demographics between the groups ( $p > 0.05$ ). Compared with the comparison group, the intervention group showed significantly higher academic scores (mean = 76.4%, SD = 7.8; mean = 70.6%, SD = 8.4) with a moderate-to-large effect size ( $t = 6.30, p < 0.001, d = 0.72$ ). A one-way ANOVA found that academic performance differed significantly among PA intensity levels ( $F(2,297) = 19.44, p < 0.001$ ). There was a moderate positive correlation between PA levels and academic achievement ( $r = 0.44, p < 0.01$ ). Qualitative findings corroborated quantitative data, showing that physically active students displayed improved concentration, emotional regulation, and academic motivation.

**Conclusions:** Partaking in structured SBPAPs significantly increases Indian adolescents' academic performance. These findings imply the necessity of including physical education in the academic curriculum as a low-cost, scalable method for supporting both cognitive growth and educational achievement.

**Key words:** Adolescents, academic performance, physical activity, school-based programs, India, cognitive function, mixed methods

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## INTRODUCTION

Adolescence is a key phase of development, with rapid physiological, psychological, and neurocognitive transformations shaping long-term educational and health trajectories. [1,2] The steadily increasing pressure of academic work and sedentary habits over the past few decades has drawn greater attention to the need for physical activity (PA). It is no longer just seen as a way of ensuring physical health, but is increasingly recognized for its contribution to intellectual and learning performance. [3,4]

School-based physical activity programs (SBPAPs)—which include organized physical education, extracurricular sports, and classroom education integrated with movement—are increasingly being advocated as effective interventions to foster educational environments and improve academic performance. [5,6] Biological studies on neurobiological and cognitive function suggest that continual PA activates neurogenesis, increases cerebral perfusion, and enhances neuroplasticity—all biological mechanisms linked directly to keener attention, better memory, and improved academic outcomes. [7,8]

However, education in India tends to prioritize exam preparation, often at the expense of physical education programs. This imbalance endures despite numerous studies showing that PA enhances concentration, supports cognitive problem-solving, and improves classroom engagement and performance in standardized tests among adolescents aged 12 to 18 years. [9,10] Moreover, with rising rates of mental health challenges and non-communicable diseases in this group, holistic approaches that promote both physical and cognitive well-being are urgently required. [11,12]

Remarkably, direct empirical studies examining the influence of in-school PA programs on academic achievement in Indian adolescents are rare. Previous inquiries have mostly focused on either physical or academic domains independently, with limited exploration in authentic school settings. Hence, the present study aims to evaluate the impact of SBPAPs on academic performance among adolescents in selected Indian schools to inform evidence-based educational policies and curricular reforms.

## MATERIALS AND METHODS

This study was conducted over 6 months (October 2024–March 2025) in selected public and private secondary schools in Punjab and Haryana, India. A cross-sectional, mixed-methods design was employed to assess the impact of SBPAPs on academic achievement. Quantitative methods were used to measure academic performance and PA intensity, while qualitative data captured students' lived experiences and perceptions.

## Study population and sampling

The study included 300 students aged 13 to 17 years enrolled in grades 8 to 11. A stratified purposive sampling method ensured representation across gender, school type (government vs. private), and location (urban vs. semi-urban). Participants were grouped based on SBPAP exposure:

**Intervention group (*n* = 150):** Engaged in structured PA  $\geq 150$  minutes/week (PE classes, sports clubs, movement-integrated curricula)

**Comparison group (*n* = 150):** Engaged in minimal PA  $\leq 30$  minutes/week.

Eligibility criteria included regular attendance, no physical or cognitive disabilities, and signed parental consent.

## Data collection instruments and procedure

### Quantitative component

Academic performance was measured through cumulative scores in Mathematics, Science, and Language Arts, obtained from school records for two academic terms. The Physical Activity Questionnaire for Adolescents (PAQ-A) was used to measure PA frequency and intensity over the previous 7 days. [13] Sociodemographic data were collected using a structured student profile questionnaire.

### Qualitative component

Focus group discussions (FGDs) and key informant interviews were conducted with a subsample of 30 students and selected teachers. Discussions explored student perceptions of PA, academic benefits, obstacles, and psychosocial effects. All interviews were conducted in local languages, recorded with permission, and transcribed verbatim.

## Ethical considerations

This study was approved by the Institutional Review Board (IRB) of Desh Bhagat University. Informed written consent was obtained from both students and their parents/guardians. Confidentiality and anonymity were strictly maintained.

## RESULTS

### Characteristics of the sample

### Statistical analysis and interpretation of baseline characteristics

**Table 1** presents the baseline demographic characteristics of participants in the intervention (*n* = 150) and comparison (*n* = 150) groups. Independent samples *t*-tests were used to compare continuous variables (e.g., age), while chi-square

**Table 1:** Participant demographics (*N* = 300).

Variable	Intervention group ( <i>n</i> = 150)	Comparison group ( <i>n</i> = 150)	<i>p</i> -value
Age (years)	15.2 $\pm$ 1.1	15.0 $\pm$ 1.3	0.284
Male (%)	51%	53%	0.742
Socioeconomic status (low-income %)	46%	48%	0.726

tests were employed for categorical variables (e.g., gender and socioeconomic status [SES]).

The mean age of participants in the intervention group was  $15.2 \pm 1.1$  years, while the comparison group reported a mean age of  $15.0 \pm 1.3$  years. The independent samples *t*-test yielded a *p*-value of 0.284, indicating that the age difference between the groups was not statistically significant. This suggests that both groups were comparable in terms of age at baseline.

The proportion of male participants in the intervention group was 51%, compared to 53% in the comparison group. The chi-square test produced a *p*-value of 0.742, demonstrating no significant difference in gender distribution between the groups. This reflects a balanced representation of males and females across study arms.

Participants from low-income households constituted 46% of the intervention group and 48% of the comparison group. The chi-square analysis revealed a *p*-value of 0.726, indicating no statistically significant difference in SES between the groups.

All demographic variables assessed—age, gender, and SES—exhibited *p*-values greater than 0.05, confirming the absence of significant baseline differences between the intervention and comparison groups. This establishes the demographic equivalence of the groups and supports the internal validity of subsequent comparisons on study outcomes. Hence, any differences observed in post-intervention measures can be more confidently attributed to the intervention rather than to confounding demographic variables.

### Statistical analysis and interpretation of Table 2

To evaluate the impact of the intervention on students' academic performance, an independent samples *t*-test was conducted comparing the mean scores of the intervention group and the comparison group.

The analysis revealed a statistically significant difference between the two groups,  $t(df) = 6.30$ ,  $p < 0.001$ . Students in the intervention group achieved a higher mean score ( $M = 76.4$ ,  $SD = 7.8$ ) compared to those in the comparison group ( $M = 70.6$ ,  $SD = 8.4$ ). The mean difference of 5.8 percentage points suggests that the intervention was associated with improved academic outcomes.

The computed Cohen's *d* value of 0.72 indicates a moderate to large effect size, implying that the observed difference is not only statistically significant but also educationally meaningful. [13] This suggests that the intervention had a substantive impact on enhancing academic performance. Overall, the findings from Table 2 provide compelling evidence that the intervention contributed to significantly better academic performance among participants. These results support the effectiveness of the intervention strategy and highlight its potential for broader implementation in similar educational contexts.

**Table 2:** Showing academic performance comparison between intervention and comparison groups.

Group	Mean score (%)	SD	t-value	p-value	Cohen's <i>d</i>
Intervention group	76.4	7.8	6.30	<0.001	0.72
Comparison group	70.6	8.4			

### One-way analysis of variance (ANOVA): Impact of PA intensity level

A one-way ANOVA was conducted to determine whether the intensity level of PA (categorized as low, moderate, and high based on PAQ-A tertiles) significantly affected academic performance (Table 3).

The one-way ANOVA was conducted to examine whether there were statistically significant differences in the dependent variable across the three groups under study.

The ANOVA results presented in the table indicate that there was a significant difference between the groups, as shown by the following statistics:

Between-group variability ( $SS = 2183.2$ ,  $df = 2$ ,  $MS = 1091.6$ ) reflects the variance attributable to the differences between the group means.

Within-group variability ( $SS = 16594.5$ ,  $df = 297$ ,  $MS = 55.88$ ) represents the variance within the individual groups.

The *F*-ratio of 19.44 ( $F(2, 297) = 19.44$ ) indicates the ratio of between-group variance to within-group variance.

The *p*-value is less than 0.001 ( $p < 0.001$ ), which is well below the conventional alpha level of 0.05.

Given this *p*-value, we reject the null hypothesis and conclude that there are statistically significant differences among the group means.

This suggests that the independent variable had a significant effect on the dependent variable, warranting further post hoc analysis to determine which specific groups differ from one another.

### Qualitative findings

Three core themes emerged from FGDs:

**Enhanced concentration and engagement:** Students noted improved focus post-exercise:

*"After PE, I feel fresh and can concentrate more in Maths class."*

**Stress reduction:** PA helped students manage anxiety:

*"Playing sports helps me calm down, especially before exams."*

**Table 3:** Showing one-way analysis of variance results: academic performance by PA level.

Source	SS	df	MS	F	p-value
Between groups	2183.2	2	1091.6	19.44	<0.001
Within groups	16594.5	297	55.88		
Total	18777.7	299			

**Academic confidence:** PA improved motivation and self-efficacy:

*"Because I'm active in sports, I feel more motivated and confident in my studies."*

These findings were corroborated by PE teachers and coordinators, who observed better attendance and classroom behavior among active students.

### Key findings

Adolescents who participated in SBPAPs had significantly higher academic performance than those who did not ( $p < 0.001$ ).

A moderate positive correlation ( $r = 0.44$ ) existed between PA level and academic achievement.

Qualitative data revealed improvements in focus, emotional regulation, and motivation among physically active students.

### DISCUSSION

This research examined the association between SBPAP and academic performance in Indian adolescents. The findings build upon a body of international evidence that demonstrates the diverse positive effects of PA on cognitive and academic outcomes among school-age populations. [14-16]

The results of quantitative analyses, including an independent sample *t*-test and one-way ANOVA, showed that students who were regularly physically active, especially students whose PA level was moderate to high, reported significantly higher academic scores than did students who were not regularly active. These results are in accordance with previous studies demonstrating the beneficial effects of PA on attention, executive function, memory, and classroom behavior. [7,8]. Aerobic PA intervention has been demonstrated to improve neurovascular structures, thus aiding in cognitive function, such as increasing cerebral blood flow, inducing higher concentrations of neurotrophic factors, such as brain-derived neurotrophic factor, and strengthening of neural connections—all mechanisms which are important for academic performance. [7]

Moreover, an independent association of PA with academic performance was also observed in the unadjusted regression analysis among school type, gender, and age. Specifically, school type was entered as an extra predictor, and students attending a private school performed a little better in academic results. This could be due to institutional variation (e.g., availability of exercise facilities, scheduled PA, and teacher/pupil interaction). [17]

Ironically, age and sex showed no effect on scores, indicating that the positive impact extends to students in these categories as well. This is consistent with earlier work suggesting that the cognitive and academic benefits of PA are generalizable across adolescent subpopulations. [5,15]

The quantitative findings were supported by qualitative results obtained through semi structured interviews. SBPAPs students reported better concentration, emotional regulation, and less academic stress, which enhances academic achievement. These results are consistent with the psychosocial model of

the effect of PA on academic achievement via improved self-efficacy, decreased anxiety, and better peer relationships. [18]

Notwithstanding these interesting results, various potential limitations are to be mentioned. The cross-sectional design of the study does not allow for concluding causality. The evidence linking PA and academic performance is convincing, but longitudinal research is required to establish the direction of effect. Additionally, the use of self-reported PA data, collected by the PAQ-A instrument, may involve bias in response. Furthermore, other relevant confounders, such as eating and sleeping habits, screen time, or parental involvement, were not assessed and might influence the results reported.

Yet the implications for Indian education and health policy are huge. In an educational environment that typically emphasizes academic achievement at the expense of physical education, the current study offers evidence supporting the inclusion of intentional PA during school. With the continued trend of increasing sedentary behavior, pressures on academics, and poor adolescent mental health, SBPAPs represent a feasible, affordable intervention targeting both health and educational outcomes.

### Suggestions for future research

To extend the present findings, future studies should use either longitudinal or experimental designs to determine the causality between PA and academic achievement. Objective assessments such as accelerometers may improve measurement precision. Additionally, investigations could explore a wider set of psychosocial and environmental variables to integrate the multiple mechanisms through which the PA-academic relationship operates. India-specific studies, including diverse socioeconomic, regional, and across-culture contexts, are also needed to inform equitable and inclusive policy reforms.

### CONCLUSIONS

Our work contributes considerable strength of evidence demonstrating the positive link between SBPAPs and AP among Indian adolescents. By employing both quantitative and qualitative analysis, the results show that schoolchildren who are engaged in high levels of moderate to vigorous physical activity—whether through PE, extracurricular sports, or integrated movement-based learning—outperform sedentary peers on academic achievement indicators.

Crucially, the authors argue that such cognitive and scholastic advantages are observed across both sexes, as well as age categorizations, highlighting the wide-reaching versatility of PA as a developmental asset in adolescence. Also, the qualitative testimonies of students supported these quantitative trends, with positive effects, including increased focus, decreased stress, and increased academic motivation, identified by students as perceived effects of routine PA engagement at school.

With increasing school load and (screen-based) sedentary behavior among the Indian youth, the implications of the findings are important from both the educational and public health policy perspectives. Structured-physical-activities as a part of the regular school curriculum are not just tools

to promote physical health, but an investment into the development of cognitive abilities and learning outcomes.

There are considerations (causality) that could not be addressed in the study due to its cross-sectional design. Longitudinal and experimental research in the future is required to study the potential causal mechanisms and intervening variables—ranging from psychosocial factors to neurocognitive mechanisms—that mediate between PA and academic outcomes. Policymakers, educators, and stakeholders should work together to ensure that physical education is not just an optional extra but an essential part of all-around development and academic performance of adolescents in India.

## AUTHORS' CONTRIBUTION

Each author has made a substantial contribution to the present work in one or more areas, including conception, study design, conduct, data collection, analysis, and interpretation. All authors have given final approval of the version to be published, agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

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## CONFLICT OF INTEREST

None.

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