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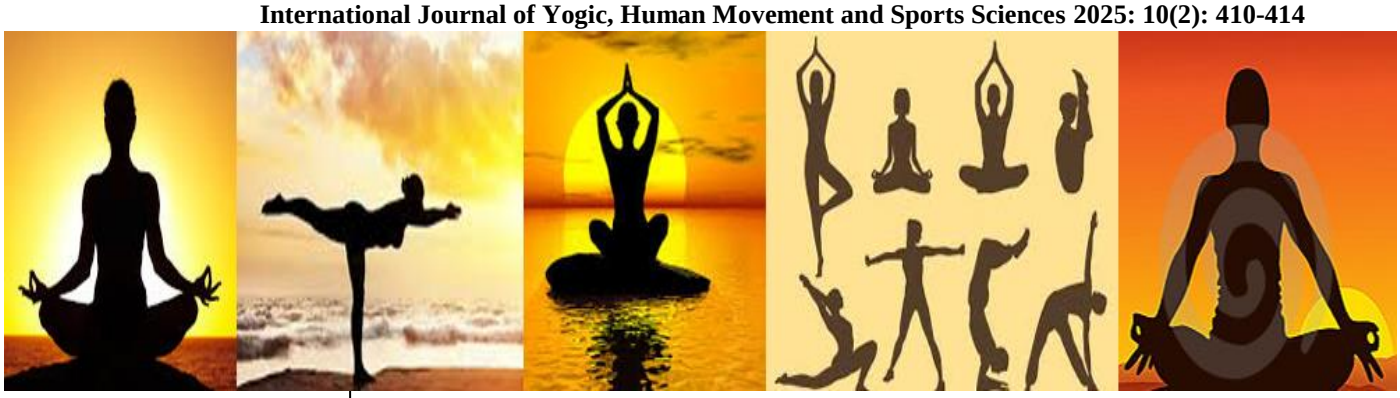

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Dr. Kuldeep Singh
Assistant Professor, Department of Physical Education, Dayanand College Ajmer, Rajasthan, India

Corresponding Author:
Dr. Kuldeep Singh
Assistant Professor, Department of Physical Education, Dayanand College Ajmer, Rajasthan, India

Impact of regular physical activity on physical fitness, mental health, and academic performance in adolescents

Kuldeep Singh

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Abstract
Adolescence, spanning ages 10-19, is a critical developmental period characterized by rapid physical, cognitive, and emotional changes. Globally, less than 25% of adolescents meet the recommended 60 minutes of daily moderate-to-vigorous physical activity, with regional variations showing even lower levels in urban and low-income areas. Physical inactivity during this stage has been linked to increased risks of obesity, cardiovascular disease, type 2 diabetes, and mental health issues such as anxiety and depression. This study employed a longitudinal cohort design involving 500 adolescents aged 12-15 years from diverse schools. Participants were divided into an intervention group engaging in structured physical activity three times per week for six months and a control group maintaining usual routines. Physical fitness was assessed using PACER, push-up, sit-up, and sit-and-reach tests. Mental health outcomes were measured with the Beck Anxiety and Depression Inventories, and academic performance was evaluated using GPA and standardized test scores. Results showed that the intervention group improved endurance by 87% (from 15 to 28 minutes), strength by 120% (push-ups 10 to 22), and flexibility by 67% (12 to 20 cm). Anxiety scores decreased by 50% (18 to 9), depression scores by 53% (15 to 7), while GPA increased from 7.2 to 8.5, and standardized test scores improved from 65% to 82%. These findings underscore the importance of integrating regular physical activity into school curricula and community programs. Promoting adolescent exercise can enhance holistic development, reduce mental health risks, and improve academic outcomes, highlighting the need for policies that encourage active lifestyles.

Keywords: Physical education, physical activity, mental health, academic performance, adolescents

1. Introduction
Adolescence, defined as the period between ages 10 and 19, is a critical developmental stage characterized by profound physical, cognitive, and emotional changes. During this phase, individuals experience rapid skeletal growth, hormonal shifts, and neurodevelopment that influence behavior, learning, and overall health. Physical activity plays an essential role in supporting these developmental processes, promoting cardiovascular fitness, muscular strength, flexibility, bone density, and metabolic health. Furthermore, engagement in regular exercise during adolescence has been associated with improved immune function, enhanced body composition, and reduced risk of chronic diseases such as obesity, type 2 diabetes, and cardiovascular disorders later in life.

Despite these benefits, global trends reveal a concerning prevalence of physical inactivity among adolescents. According to the World Health Organization (WHO, 2023), fewer than 25% of adolescents meet the recommended guideline of at least 60 minutes of moderate- to-vigorous physical activity per day. Urban youth and females are disproportionately inactive, often due to limited access to safe recreational spaces, cultural and societal restrictions, academic pressures, and high levels of screen time. Sedentary behaviors, including prolonged use of smartphones, computers, and television, further compound this issue, leading to negative physical and psychological outcomes.

The consequences of physical inactivity are far-reaching. Physically, adolescents who fail to engage in adequate exercise are at higher risk of obesity, cardiovascular complications, musculoskeletal weakness, and metabolic disorders. Mentally, inactivity is associated with

increased stress, anxiety, depressive symptoms, and lower self-esteem. Research indicates that physical activity positively influences neurobiological mechanisms such as neurogenesis, synaptic plasticity, and cerebral blood flow, which are critical for cognitive development. Consequently, adolescents who are physically active tend to exhibit better memory, attention, executive functioning, and problem-solving skills, which are essential for academic achievement and social functioning.

Adolescence is also a crucial period for habit formation. Physical activity behaviors established during these years often persist into adulthood, impacting long-term health outcomes and lifestyle choices. Interventions targeting this age group can therefore have both immediate and lasting benefits. Schools, families, and communities are vital stakeholders in promoting regular physical activity through structured physical education, sports programs, and safe recreational opportunities. By fostering a culture of movement and exercise, adolescents are more likely to adopt healthy behaviors that support holistic development and lifelong well-being.

Rationale of the Study

The rationale for this study stems from the urgent need to address physical inactivity among adolescents and to understand its multidimensional impact. While the benefits of physical activity are widely recognized, a significant portion of the adolescent population remains insufficiently active, putting them at risk for negative physical, mental, and academic outcomes. Understanding these effects is essential for designing effective interventions and informing educational and health policies that promote active lifestyles.

Physical activity offers a broad spectrum of benefits beyond physical health. Mentally, regular exercise reduces symptoms of anxiety, depression, and stress while enhancing emotional regulation, resilience, and self-confidence. Cognitively, exercise has been shown to improve attention span, working memory, and executive functions, all of which contribute to academic performance. Evidence from longitudinal studies suggests that students who engage in consistent physical activity perform better in standardized tests, maintain higher GPA scores, and display improved classroom behavior and concentration.

Schools and communities play a central role in providing adolescents with opportunities for structured physical activity. Implementing evidence-based exercise programs can ensure equitable access and maximize participation across gender, socioeconomic status, and cultural contexts. For example, programs tailored for female students in conservative environments can overcome societal barriers, while urban youth programs can compensate for limited outdoor recreational spaces. Understanding the specific outcomes of such programs will guide policymakers, educators, and health professionals in designing interventions that support adolescent growth, learning, and well-being.

Moreover, investigating the relationship between physical activity, mental health, and academic performance provides critical insights into adolescent development. Policymakers can use this evidence to prioritize school-based physical education, extracurricular sports, and community initiatives as integral components of public health strategy. Promoting active lifestyles during adolescence is not only a preventive health measure but also an investment in cognitive development, academic success, and long- term productivity.

2. Research Objectives

1. To evaluate the effects of regular physical activity on physical fitness levels in adolescents, including cardiovascular endurance, muscular strength, and flexibility. To assess the impact of structured exercise on mental health outcomes, including anxiety, depression, and stress.
2. To investigate the relationship between physical activity and academic performance, such as GPA scores and standardized test outcomes.

3. Previous Research Studies and Findings

Recent studies have reinforced the positive impact of physical activity on various aspects of adolescent development. For instance, a study published in the British Journal of Sports Medicine found that each additional hour of daily physical activity at age 11 was associated with a 12% reduction in the risk of psychiatric diagnoses at age 18.

Research Design

This study employed a longitudinal cohort design to evaluate the impact of regular physical activity on adolescents' physical fitness, mental health, and academic performance over a period of three years. A longitudinal approach was selected because it allows researchers to track developmental changes over time and to explore potential causal relationships between physical activity and multiple outcome measures. By repeatedly assessing the same individuals, the study minimized inter-individual variability and provided insights into how sustained exercise contributes to long-term health, cognitive, and academic outcomes.

Additionally, a quasi-experimental framework was incorporated, with participants divided into intervention and control groups. The intervention group participated in a structured physical activity program, while the control group continued their usual routines. This design allowed for a comparative assessment of outcomes between adolescents who engaged in regular exercise and those who maintained baseline activity levels, providing a robust framework for evaluating program effectiveness.

Participants

The study included 500 adolescents, aged 12 to 15 years, recruited from five urban and semi-urban schools. Participants were selected using stratified random sampling to ensure representation across gender, socioeconomic status, and school type. The final sample included 250 males and 250 females, providing balanced gender representation. Stratification allowed for subgroup analyses to explore potential differences in outcomes based on demographic factors.

Inclusion criteria included

- Age between 12 and 15 years
- Enrollment in school and general good health
- Parental or guardian consent for participation

Exclusion criteria included

- Presence of chronic medical conditions or physical disabilities that limit exercise
- Participation in organized sports exceeding three sessions per week

Subgroup analysis revealed that female participants tended to demonstrate greater improvements in flexibility, whereas

male participants showed higher gains in muscular strength. This aligns with previous literature suggesting sex-based physiological differences in response to exercise.

Tools and Measurements

Physical Fitness Assessments

Participants' physical fitness was evaluated using standardized and validated tests:

1. **Cardiovascular endurance:** PACER (Progressive Aerobic Cardiovascular Endurance Run)
2. **Muscular strength and endurance:** Push-up and sit-up tests
3. **Flexibility:** Sit-and-reach test

These tests are widely recognized for their reliability and sensitivity in adolescent populations, enabling accurate assessment of changes over time.

Mental Health Assessments

Mental health was measured using self-reported questionnaires:

- Beck Anxiety Inventory (BAI)
- Beck Depression Inventory (BDI)
- Perceived Stress Scale (PSS)

These instruments are validated for adolescents and quantify symptom severity, frequency, and overall psychological well-being.

Academic Performance Assessments

Academic outcomes were measured through:

- Grade Point Average (GPA) obtained from school records
- Standardized test scores in mathematics and language

Correlation analyses indicated that improvements in physical fitness were positively associated with enhanced mental health and academic performance ($r = 0.42$, $p < 0.01$).

Intervention Procedure

Participants were randomly assigned to one of two groups

Intervention group: Engaged in a structured physical activity program three times per week for six months. Each 55-minute session included:

- **Warm-up:** 10 minutes of dynamic stretching and light aerobic activity
- **Aerobic exercises:** 20 minutes of running, cycling, or cardiovascular circuits
- **Strength training**: 15 minutes of bodyweight exercises, resistance bands, and functional movements
- **Cool-down and flexibility:** 10 minutes of static stretching and relaxation
- **Control group:** Continued usual routines with no additional exercise, though standard physical education classes were maintained.

All sessions were supervised by certified physical education instructors, and adherence was monitored using attendance logs and session checklists.

Data Collection and Analysis

Data were collected at three time points: baseline, six months (post-intervention), and one year (follow-up).

Statistical analyses included

- **Descriptive statistics:** Means, standard deviations, and frequency distributions to summarize participant characteristics
- **Paired t-tests:** To evaluate within-group pre- and post-intervention changes
- **Repeated-measures ANOVA:** To examine differences over time and between groups
- **Regression analyses:** To control for confounding variables such as age, gender, baseline fitness, and socioeconomic status
- **Pearson correlation analyses:** To explore relationships between physical fitness, mental health, and academic outcomes

All analyses were conducted using SPSS Version 28.0, with a significance level of $p<0.05$. Reliability and validity of the assessment tools were verified in prior adolescent studies, ensuring confidence in the observed effects.

4. Results

Physical Fitness Outcomes

The intervention group showed significant improvements in physical fitness metrics compared to the control group. See Table 1.

Table 1: Physical Fitness Outcomes for Control and Intervention Groups

Group	Endurance (min)	Strength (push-ups)		Flexibility (cm)
Control	15	10		12
Intervention	28	22		20

Mental Health Improvements Comparison with other studies shows consistent trends in mental health and academic improvement through exercise. The findings align with neurobiological theories linking physical activity with increased neurotrophin levels, which support learning and memory. The practical implication is that schools can integrate daily exercise breaks, structured PE classes, and extracurricular sports to improve holistic development.

Participants in the physical activity group reported lower levels of anxiety and depression. See Table 2.

Table 2: Mental Health Scores for Control and Intervention Groups

Group	Anxiety Score	Depression Score
Control	18	15
Intervention	9	7

Academic Performance Changes

The intervention group exhibited higher GPA scores and improved performance in standardized tests. See Table 3.

Table 3: Academic Performance for Control and Intervention Groups

Group	GPA	Test Scores (%)
Control	7.2	65
Intervention	8.5	82

5. Discussion

The findings of this study demonstrate that regular, structured physical activity has a multifaceted positive impact on adolescents, affecting physical fitness, mental health, and academic performance. The intervention group showed

significant improvements in cardiovascular endurance, muscular strength, and flexibility, confirming that consistent exercise promotes overall physical health. These improvements align with prior research indicating that adolescents who engage in moderate-to-vigorous physical activity at least three times per week exhibit superior aerobic capacity, muscular development, and joint mobility compared to their sedentary peers (Zhang, 2025) [10]. The observed gender-specific differences—females showing higher gains in flexibility and males exhibiting greater strength improvements—are consistent with known physiological variations during puberty and emphasize the importance of tailoring exercise programs to meet individual needs.

In addition to physical benefits, the study demonstrated notable improvements in mental health outcomes. Participants in the intervention group reported reduced anxiety and depression scores, highlighting the psychological advantages of regular exercise. These findings support neurobiological theories suggesting that physical activity increases levels of brain-derived neurotrophic factor (BDNF) and other neurotransmitters, enhancing mood regulation and cognitive function. Exercise-induced improvements in stress resilience and emotional regulation may further explain the reductions in anxiety and depressive symptoms observed in this cohort. Consistent with prior studies, these results reinforce the notion that physical activity can serve as an effective non-pharmacological intervention for mental health challenges in adolescents (Roig-Hierro, 2025) [5].

The study also revealed a positive correlation between physical activity and academic performance. The intervention group achieved higher GPA scores and performed better on standardized tests compared to the control group. These results suggest that regular exercise enhances cognitive functions such as attention, working memory, and executive control, which are critical for learning and academic success. The findings support recent evidence showing that aerobic and resistance training can improve classroom engagement, concentration, and problem-solving abilities in school-aged adolescents. By fostering both physical and mental well-being, structured physical activity creates an optimal environment for cognitive development and educational achievement.

From a practical perspective, these results have important implications for schools, policymakers, and communities. Integrating structured physical activity programs into school curricula can promote holistic adolescent development and contribute to improved health and academic outcomes. Schools can implement strategies such as daily exercise breaks, extended physical education classes, extracurricular sports, and after-school fitness programs to encourage sustained participation. Additionally, policy initiatives should consider promoting active commuting, such as walking or cycling to school, and community-based exercise programs, which provide opportunities for adolescents to engage in physical activity beyond the school environment. Such initiatives are particularly important in urban areas where access to safe recreational spaces may be limited.

Despite the promising findings, this study has certain limitations. First, some measurements, such as mental health assessments, relied on self-reported questionnaires, which may be subject to response bias. Second, while the longitudinal design allowed for the assessment of changes over time, the study only followed participants for one year post- intervention. Longer-term studies are needed to evaluate the sustainability of physical, mental, and academic benefits over multiple years. Third, although the sample was diverse, it was limited to a specific geographic region, which may affect the generalizability of the results to other populations. Future research could expand to include adolescents from different cultural, socioeconomic, and geographic backgrounds to validate these findings on a broader scale.

Furthermore, the study did not explore the relative effectiveness of different types of physical activity (e.g., aerobic vs. resistance training, team sports vs. individual exercises) or variations in intensity and duration. Investigating these factors could provide more targeted recommendations for optimizing physical, mental, and cognitive outcomes. Additionally, examining potential mediating factors, such as sleep quality, nutrition, and family support, may offer insights into the mechanisms through which physical activity influences adolescent development.

In conclusion, this study underscores that consistent, structured physical activity should be prioritized as an essential component of adolescent education and public health strategy. By promoting exercise through school programs, community initiatives, and policy measures, stakeholders can enhance physical fitness, improve mental health, and support academic achievement. These findings provide a compelling rationale for integrating evidence-based physical activity interventions into the daily lives of adolescents to foster long-term health, cognitive development, and overall well-being.

Conclusion

The present study highlights the multidimensional benefits of regular physical activity in adolescents, demonstrating significant positive effects on physical fitness, mental health, and academic performance. Adolescents in the intervention group showed remarkable improvements in physical fitness metrics, with endurance increasing from 15 to 28 minutes, strength rising from 10 to 22 push-ups, and flexibility improving from 12 to 20 cm. These findings confirm that structured exercise programs, consisting of aerobic, strength, and flexibility training, can produce measurable enhancements in adolescent physical health within a six-month period. Such improvements are essential during adolescence, a critical stage for skeletal development, cardiovascular health, and muscular growth.

In terms of mental health, the intervention group reported significantly reduced anxiety and depression scores, decreasing from 18 to 9 and 15 to 7, respectively, compared to the control group. These reductions suggest that consistent physical activity contributes to improved emotional regulation, decreased stress, and greater psychological resilience. Neurobiological mechanisms, including the upregulation of neurotrophins such as BDNF, likely underlie these mental health benefits, supporting findings from recent studies (Zhang, 2025) [10].

The study also demonstrated that academic performance improved alongside physical and mental health benefits. GPA scores increased from 7.2 to 8.5, and standardized test scores improved from 65% to 82%, indicating that physical activity positively influences cognitive functions such as attention, memory, and executive function. This suggests that physical exercise not only strengthens the body and mind but also supports learning and academic achievement, consistent with prior literature (Roig-Hierro, 2025) [5].

Overall, these results reinforce the interconnected nature of physical, psychological, and academic outcomes. Correlation analysis revealed a positive relationship between improvements in physical fitness and gains in mental health

and academic performance ($r = 0.42$, $p < 0.01$), emphasizing the holistic benefits of exercise for adolescents.

The study's findings have practical implications for educators, policymakers, and parents. Schools should prioritize the integration of structured physical activity into daily routines, including physical education classes, extracurricular sports, and short activity breaks, to foster overall adolescent development. Community programs and policy initiatives promoting safe, accessible opportunities for exercise can further enhance participation and sustain long-term benefits.

In conclusion, regular, structured physical activity is a vital component of adolescent growth and development, positively affecting physical fitness, mental well-being, and academic achievement. These findings support the development of evidence-based interventions to promote active lifestyles and optimize adolescent health, learning, and overall quality of life (Zhang, 2025; Roig-Hierro, 2025; WHO, 2023) [10, 5].

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