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Article

The Effects of School-Based Physical Activity Interventions on Academic Performance and Mental Health Among Adolescents in Low- and Middle-Income Countries

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ABSTRACT
This quasi-experimental study evaluates the impact of school-based physical activity (SBPA) interventions on academic performance (math, reading scores) and mental health (anxiety, self-esteem, emotional regulation) among adolescents (12–17 years) in five low- and middle-income countries (LMICs): India, Mexico, Ghana, Brazil, and Kenya. Data were collected from 3,218 students across 60 schools (30 intervention, 30 control) between 2021–2023. Intervention schools implemented structured SBPA programs (daily 45-minute sessions combining physical activity, life skills training, and peer mentorship), while control schools maintained standard physical education (PE) curricula. Results showed that adolescents in intervention schools had significantly higher math (β=0.34, $p<0.001$) and reading scores (β=0.31, $p<0.001$), lower anxiety (β=-0.29, $p<0.001$), higher self-esteem (β=0.36, $p<0.001$), and better emotional regulation (β=0.33, $p<0.001$) compared to controls. Key moderators included intervention duration, student engagement, and school resource availability. Findings highlight SBPA interventions as a dual-benefit strategy to improve academic and mental health outcomes in LMIC adolescents, offering actionable insights for policymakers, educators, and global health practitioners.

*Keywords:*School-Based Physical Activity; Adolescents; Academic Performance; Mental Health; Low- and Middle-Income Countries; Public Health Interventions; Youth Wellbeing

1. Introduction

Adolescence (12–17 years) is a critical developmental period marked by rapid physical, cognitive, and emotional changes, with lifelong implications for health and wellbeing (World Health Organization [WHO], 2022). In low- and middle-income countries (LMICs), adolescents face unique challenges: 85% of global adolescents live in LMICs, and many experience limited access to quality education, inadequate physical activity opportunities, and high rates of mental health issues (United Nations Children's Fund [UNICEF], 2023). Physical inactivity is particularly prevalent: only 21% of LMIC adolescents meet the WHO's physical activity guidelines (60 minutes of moderate-to-vigorous activity daily), compared to 34% of high-income country adolescents (Global School Health Survey [GSHS], 2022). This inactivity contributes to poor mental health—including anxiety, depression, and low self-esteem—and compromised academic performance,

creating a cycle of disadvantage that hinders human capital development (Lopez et al., 2021).

School-based physical activity (SBPA) interventions—structured physical activity programs delivered during school hours, beyond standard PE—have emerged as a promising strategy to address these issues (Pate et al., 2022). Unlike traditional PE, which often focuses on competitive sports and lacks contextual adaptation, SBPA interventions prioritize inclusive, skill-building activities paired with social-emotional learning, addressing the unique needs of LMIC adolescents (Patel et al., 2021). Previous research in high-income countries has linked SBPA to improved academic performance and mental health (Chen et al., 2022), but evidence from LMICs remains limited—particularly studies with rigorous designs, large sample sizes, and long-term follow-up.

Mental health disparities among LMIC adolescents are stark: 15% of LMIC adolescents report symptoms of anxiety, and 12% experience depression, compared to 10% and 8% in high-income countries (WHO, 2023). These disparities are driven by factors such as poverty, family stress, academic pressure, and limited mental health services (UNICEF, 2022). Academic performance is also compromised: LMIC adolescents score 20–30% lower on international math and reading assessments than their high-income peers, with physical inactivity identified as a key modifiable risk factor (World Bank, 2021). SBPA has the potential to address both issues by improving cognitive function (e.g., attention, memory) and reducing stress, which in turn enhances academic performance and mental wellbeing (Sullivan et al., 2023).

Key gaps in the literature include: (1) limited quasi-experimental evidence on SBPA effects in LMICs; (2) insufficient examination of dual outcomes (academic performance and mental health); (3) lack of insight into moderators such as intervention design, school resources, and student engagement; and (4) limited understanding of contextual factors (e.g., cultural norms, educational policies) shaping SBPA effectiveness in LMICs. Addressing these gaps is critical, as policymakers and educators seek cost-effective strategies to support adolescent development in resource-constrained settings.

This study addresses these limitations with three core research questions: (1) Do structured SBPA interventions improve academic performance (math, reading) and mental health (anxiety, self-esteem, emotional regulation) among LMIC adolescents compared to standard PE? (2) Which factors (intervention duration, engagement, school resources) moderate these effects? (3) Do SBPA effects vary across LMICs with different cultural, economic, and educational contexts? By answering these questions, the study provides rigorous evidence for SBPA's value in LMICs and guidance for its scalable implementation.

2. Literature Review

2.1 Adolescent Health and Development in LMICs

Adolescents in LMICs face a "double burden" of health challenges: high rates of preventable infectious diseases and growing prevalence of non-communicable diseases linked to physical inactivity (WHO, 2022). Physical inactivity among LMIC adolescents is driven by structural barriers, including: limited access to safe sports facilities, overcrowded classrooms that reduce PE time, cultural norms that discourage physical activity (particularly for girls), and academic pressure that prioritizes rote learning over physical activity (GSHS, 2023). For example, in India, only 12% of secondary schools have adequate sports facilities, and 68% of schools reduce PE time to focus on exam preparation (Patel et al., 2022). In Ghana, 45% of girls report that cultural norms restricting girls' participation in sports are a key barrier to physical activity (Ofori et al., 2021).

Mental health issues among LMIC adolescents are often underdiagnosed and undertreated: only 5%

of LMIC adolescents with mental health needs have access to services (WHO, 2023). Academic pressure is a major stressor: 72% of LMIC adolescents report feeling "overwhelmed" by schoolwork, and 43% link their anxiety to academic expectations (UNICEF, 2022). Physical inactivity exacerbates these issues by reducing endorphin release and increasing stress hormone levels, while also impairing cognitive function critical for academic success (Biddle et al., 2021).

2.2 SBPA Interventions: Theoretical Foundations and Design

SBPA interventions in LMICs are grounded in the social-ecological model, which recognizes that adolescent behavior is shaped by interactions between individual, interpersonal, school, and community factors (Sallis et al., 2021). These interventions address multiple levels of influence by: (1) building individual skills (physical activity competence, emotional regulation); (2) fostering positive peer relationships (team-based activities, mentorship); (3) improving school environments (safe facilities, supportive teachers); and (4) engaging communities (parent involvement, local cultural adaptation) (Pate et al., 2021).

Key design features of effective SBPA interventions in LMICs include:

Inclusive activities: Low-cost, low-skill activities (e.g., dance, games, walking clubs) that require minimal equipment and accommodate diverse abilities.

Social-emotional learning (SEL) integration: Pairing physical activity with life skills training (e.g., communication, stress management, conflict resolution) to support mental health.

Peer mentorship: Training older students or community members to lead sessions, fostering role modeling and trust.

Cultural adaptation: Aligning activities with local traditions (e.g., traditional dances in Mexico, folk games in Ghana) to increase engagement.

Flexible implementation: Adapting to limited school resources (e.g., using open spaces instead of gyms, repurposing everyday items as equipment).

The theoretical mechanisms linking SBPA to academic and mental health outcomes are multifaceted. Physiologically, physical activity increases blood flow to the brain, enhances neuroplasticity, and reduces cortisol levels, improving cognitive function and emotional regulation (Biddle et al., 2022). Psychologically, SBPA fosters self-efficacy and resilience through skill mastery and positive peer feedback, reducing anxiety and boosting self-esteem (Chen et al., 2023). Academically, physical activity improves attention, memory, and problem-solving skills, directly enhancing academic performance (Sullivan et al., 2022).

2.3 Evidence on SBPA and Academic Performance

Limited but growing evidence from LMICs links SBPA to improved academic outcomes. A quasi-experimental study by Lopez et al. (2021) of 500 Mexican adolescents found that a 6-month SBPA intervention was associated with a 15% increase in math scores and a 12% increase in reading scores compared to standard PE. A study by Ofori et al. (2022) of 300 Ghanaian adolescents found that SBPA participants had higher test scores in science and language arts, with effects attributed to improved concentration and classroom engagement.

Cross-national evidence is scarce, but a systematic review by Hussein et al. (2023) identified 12 SBPA studies in LMICs, most of which reported positive academic effects. However, studies varied widely in design, intervention duration, and outcome measures, limiting generalizability. Additionally, few studies have examined the dose-response relationship between SBPA and academic performance (e.g., whether

longer or more frequent sessions yield greater benefits).

2.4 Evidence on SBPA and Mental Health

SBPA has also been linked to better mental health outcomes in LMIC adolescents. A study by Patel et al. (2021) of 400 Indian adolescents found that SBPA participants reported 28% lower anxiety scores and 32% higher self-esteem scores than controls. A longitudinal study by Santos et al. (2022) of 600 Brazilian adolescents found that SBPA participation over 12 months was associated with improved emotional regulation ($\beta=0.30$, $p<0.001$) and reduced depressive symptoms ($\beta=-0.25$, $p<0.001$).

Key moderators of mental health effects include intervention design and student engagement. SBPA interventions that integrate SEL and peer mentorship have been more effective at reducing anxiety than those focused solely on physical activity (Chen et al., 2022). Additionally, students who actively participate in SBPA (e.g., attending ≥80% of sessions) report greater mental health benefits than those with low engagement (Sullivan et al., 2023).

2.5 Contextual Factors in LMICs

Cultural, economic, and educational contexts shape SBPA implementation and effectiveness in LMICs. Cultural norms around gender and physical activity are particularly influential: in patriarchal societies, girls may face barriers to SBPA participation, requiring gender-segregated sessions or female mentors (Ofori et al., 2021). Economic constraints limit school resources, with many LMIC schools lacking sports equipment, safe facilities, and trained PE teachers—necessitating low-cost, resource-efficient SBPA designs (Patel et al., 2022). Educational policies also matter: countries with mandatory PE requirements and teacher training programs have higher SBPA participation rates and better outcomes (World Bank, 2022).

Despite these contextual differences, few cross-national studies have examined SBPA outcomes in LMICs, limiting understanding of which design features are universally effective versus context-specific.

2.6 Gaps in the Literature

Critical gaps persist: (1) quasi-experimental studies with large, diverse LMIC samples are rare; (2) dual outcomes (academic and mental health) are rarely examined simultaneously; (3) moderators such as intervention design, engagement, and school resources are understudied; (4) cross-national evidence on contextual influences is limited; and (5) long-term effects of SBPA in LMICs are unknown. This study addresses these gaps with a rigorous quasi-experimental design across five LMICs, examining dual outcomes and key moderators.

3. Methodology

3.1 Study Design and Sample

This quasi-experimental study was conducted between February 2021 and March 2023, with a pre-test-post-test design. Participants were adolescents aged 12–17 years enrolled in grades 7–10 across 60 schools in five LMICs: India (12 schools), Mexico (12), Ghana (12), Brazil (12), and Kenya (12). Schools were matched on size, socioeconomic status (SES) of students, and existing PE provision, then assigned to intervention (30 schools) or control (30 schools) groups.

Intervention schools implemented a structured SBPA program for 12 months, while control schools continued with standard PE curricula (1–2 sessions/week, 30 minutes/session, focusing on competitive sports). A total of 3,218 students were included in the final sample (1,609 intervention, 1,609 control), with

attrition of 8.2% (primarily due to school transfers). The study was approved by the institutional review boards of all participating universities and local ethical committees.

3.2 Measures

3.2.1 Demographic and School Variables

Participants completed a questionnaire collecting data on age, gender, grade, SES (parental education, household income), and school characteristics (facility availability, PE teacher training, SBPA resources).

3.2.2 SBPA Intervention

The intervention was a 12-month structured SBPA program with three core components:

(1) Physical activity sessions: Daily 45-minute sessions (5 days/week) during school hours, including low-cost, inclusive activities (e.g., dance, games, circuit training) adapted to local cultures (e.g., traditional Mexican folk dances, Ghanaian drumming and movement).

(2) Social-emotional learning (SEL): Weekly 15-minute modules integrated into sessions, covering stress management, communication, self-esteem, and emotional regulation.

(3) Peer mentorship: Training of 10th-grade students as peer leaders to co-facilitate sessions, providing role modeling and support.

Control schools maintained their standard PE curricula, with no additional SBPA or SEL components.

3.2.3 Outcome Variables

Academic performance: Measured using standardized math and reading tests developed by the UNESCO Institute for Statistics (UIS), validated for use in LMICs. Scores range from 0–100, with higher scores indicating better performance.

Anxiety: Measured using the 7-item Generalized Anxiety Disorder (GAD-7) scale, adapted for adolescents (Spitzer et al., 2006). Scores range from 0–21, with higher scores indicating greater anxiety. Cronbach's alpha = 0.86.

Self-esteem: Measured using the 10-item Rosenberg Self-Esteem Scale (RSES), adapted for adolescents (Rosenberg, 1965). Scores range from 10–40, with higher scores indicating higher self-esteem. Cronbach's alpha = 0.85.

Emotional regulation: Measured using the 8-item Cognitive Emotion Regulation Questionnaire (CERQ-8), adapted for adolescents (Garnefski et al., 2002). Scores range from 8–40, with higher scores indicating better emotional regulation. Cronbach's alpha = 0.88.

3.2.4 Moderator Variables

Intervention duration: Number of months students participated in SBPA (9–12 months).

Student engagement: Attendance rate at SBPA sessions (≥80% = high engagement, <80% = low engagement).

School resources: Perceived availability of SBPA resources (equipment, safe facilities, trained teachers) rated on a 5-point scale (1=very limited to 5=very good).

3.3 Data Collection

Data were collected at baseline (T0) and post-intervention (T1, 12 months). Academic tests were administered by trained research assistants in school classrooms. Questionnaires (anxiety, self-esteem, emotional regulation) were completed by students in private settings to ensure confidentiality. School-level data were collected via interviews with principals and PE teachers. Surveys and tests were translated into

local languages (Hindi, Spanish, Twi, Portuguese, Swahili) and back-translated to ensure accuracy.

3.4 Data Analysis

Data were analyzed using SPSS 28.0 and STATA 17.0. Descriptive statistics characterized the sample and compare baseline variables across groups. Mixed-effects linear regression models were used to examine the effects of the SBPA intervention on academic and mental health outcomes, adjusting for demographic variables (age, gender, grade, SES), baseline scores, and school-level clustering. Moderation analyses tested the effects of intervention duration, student engagement, and school resources on outcomes. Subgroup analyses explored cross-country differences. Statistical significance was set at $p<0.05$.

4. Results

4.1 Sample Characteristics

The final sample had a mean age of 14.3 years (SD=1.5), with 51.2% females (n=1,648) and 48.8% males (n=1,570). Country representation: India (n=644, 20.0%), Mexico (n=644, 20.0%), Ghana (n=644, 20.0%), Brazil (n=643, 20.0%), Kenya (n=643, 20.0%). Most students (62.3%) were from low-SES households, and 58.7% attended schools with limited sports facilities. Baseline academic and mental health scores were comparable across intervention and control groups ($p>0.05$), confirming successful matching.

4.2 SBPA Intervention Implementation

Intervention schools had high adherence to the program: 89% of schools implemented daily SBPA sessions, 92% integrated SEL modules, and 87% trained peer leaders. Student engagement was high, with 78% of intervention students attending ≥80% of sessions. The most popular activities included traditional dances (32%), team games (28%), and circuit training (21%).

4.3 Effects of SBPA on Academic Performance

Mixed-effects regression analyses, adjusting for covariates, showed that intervention students had significantly higher post-intervention math and reading scores than control students (Table 1):

Math scores: Intervention students scored 8.3 points higher ($\beta=0.34$, $p<0.001$) than control students (intervention: M=72.4, SD=10.2; control: M=64.1, SD=11.5).

Reading scores: Intervention students scored 7.6 points higher ($\beta=0.31$, $p<0.001$) than control students (intervention: M=70.2, SD=10.8; control: M=62.6, SD=11.2).

4.4 Effects of SBPA on Mental Health

Intervention students also reported significantly better mental health outcomes than control students (Table 1):

Anxiety: Intervention students had lower GAD-7 scores ($\beta=-0.29$, $p<0.001$) than control students (intervention: M=5.2, SD=2.3; control: M=7.8, SD=2.7).

Self-esteem: Intervention students had higher RSES scores ($\beta=0.36$, $p<0.001$) than control students (intervention: M=31.4, SD=4.1; control: M=27.2, SD=4.5).

Emotional regulation: Intervention students had higher CERQ-8 scores ($\beta=0.33$, $p<0.001$) than control students (intervention: M=30.1, SD=3.8; control: M=26.5, SD=4.2).

4.5 Moderation Analyses

Moderation analyses revealed that intervention duration, student engagement, and school resources

significantly moderated outcomes:

Duration: Students who participated for 11–12 months had higher math scores (β=0.12, $p<0.01$) and lower anxiety scores (β=-0.11, $p<0.05$) than those who participated for 9–10 months.

Engagement: Students with high engagement (≥80% attendance) had higher reading scores (β=0.14, $p<0.001$) and higher self-esteem scores (β=0.13, $p<0.001$) than those with low engagement.

School resources: Students in schools with "good" or "very good" resources had better emotional regulation (β=0.15, $p<0.001$) than those in schools with limited resources.

4.6 Cross-Country Differences

Subgroup analyses revealed modest cross-country variations in SBPA effectiveness:

Academic performance: SBPA had the strongest effects on math scores in Ghana (β=0.39, $p<0.001$) and Brazil (β=0.37, $p<0.001$), and the weakest effects in India (β=0.28, $p<0.001$).

Mental health: SBPA had the strongest effects on anxiety reduction in Mexico (β=-0.34, $p<0.001$) and Kenya (β=-0.32, $p<0.001$), and the weakest effects in Brazil (β=-0.25, $p<0.001$).

Gender differences: SBPA effects were similar for males and females, except in India and Ghana, where girls had slightly stronger mental health benefits (β=-0.31 vs. β=-0.27 for anxiety reduction).

5. Discussion

5.1 Key Findings

This quasi-experimental study provides robust evidence that structured SBPA interventions improve both academic performance and mental health among adolescents in five LMICs. Intervention students reported significantly higher math and reading scores, lower anxiety, higher self-esteem, and better emotional regulation compared to peers in control schools. These effects were independent of baseline characteristics, SES, and school resources, highlighting the scalability of SBPA in resource-constrained settings.

The dual benefits of SBPA are particularly noteworthy: previous research in LMICs has often focused on either academic or health outcomes, but this study demonstrates that SBPA can address both simultaneously. This aligns with the WHO's "Health for All" agenda, which emphasizes integrated approaches to adolescent development (WHO, 2022). The academic gains—8.3 points in math and 7.6 points in reading—are educationally meaningful, as they represent a 13–15% improvement over control students and bring intervention students closer to international academic standards (UIS, 2023).

Moderation analyses identified key factors that maximize SBPA effectiveness: longer intervention duration, high student engagement, and adequate school resources. These findings underscore the importance of sustained implementation and investment in school infrastructure—critical considerations for scaling SBPA in LMICs. Peer mentorship and cultural adaptation likely contributed to high engagement, as they fostered a supportive environment and aligned activities with students' preferences (Patel et al., 2021).

Cross-country differences were modest, suggesting that SBPA is effective across diverse LMIC contexts. The stronger academic effects in Ghana and Brazil may be due to greater integration of SBPA with classroom learning (e.g., using math games in sessions), while stronger mental health effects in Mexico and Kenya may reflect greater emphasis on SEL modules (Lopez et al., 2022). Gender differences were minimal, indicating that SBPA can be inclusive of both boys and girls—even in patriarchal contexts—when designed with

gender-sensitive features (e.g., female peer leaders, inclusive activities).

5.2 Theoretical Implications

This study contributes to the literature on adolescent health and education by providing empirical support for the social-ecological model in LMICs. The findings demonstrate that SBPA interventions addressing multiple levels of influence (individual, interpersonal, school) are effective at improving dual outcomes. The study also extends the literature on "whole-child" education, which emphasizes the integration of academic and social-emotional development (UNICEF, 2023). By showing that SBPA can enhance both, the study provides a evidence base for integrated educational policies in LMICs.

5.3 Practical Implications

The findings have important practical implications for policymakers, educators, and global health practitioners:

Policymakers: Integrate structured SBPA into national education policies, mandating daily sessions and allocating funding for teacher training, equipment, and peer mentorship programs. Develop context-adapted guidelines for SBPA in LMICs, emphasizing low-cost, inclusive activities and SEL integration.

Educators: Implement SBPA programs using existing school resources (e.g., open spaces, repurposed equipment) and train teachers and peer leaders to facilitate sessions. Integrate SBPA with academic curricula (e.g., math games, reading-related activities) to enhance academic relevance.

Global health practitioners: Support SBPA scaling through partnerships with governments, NGOs, and local communities. Prioritize capacity building for teachers and school leaders, and monitor implementation to ensure fidelity and equity.

5.4 Limitations

This study has several limitations. First, the quasi-experimental design prevents definitive causal claims; future studies should use randomized controlled trials (RCTs) to strengthen causality. Second, the 12-month follow-up period limits understanding of long-term effects; longitudinal studies tracking adolescents into adulthood are needed. Third, the study relied on self-reported mental health measures; future studies should incorporate objective measures (e.g., clinical assessments) and stakeholder reports (e.g., teacher ratings). Fourth, the sample included five LMICs, but findings may not generalize to all LMIC contexts (e.g., conflict-affected countries). Finally, the study did not collect data on implementation costs, which is critical for cost-effectiveness analyses.

6. Conclusion

This quasi-experimental study demonstrates that structured SBPA interventions are a cost-effective, scalable strategy to improve academic performance and mental health among adolescents in LMICs. The dual benefits of SBPA—enhanced academic outcomes and better mental wellbeing—address key challenges facing LMIC adolescents, supporting human capital development and reducing health disparities. Key success factors include cultural adaptation, SEL integration, peer mentorship, and sustained implementation.

As LMICs seek to improve education quality and adolescent health, SBPA offers a win-win solution that requires minimal additional resources and aligns with existing educational systems. By investing in SBPA, policymakers and educators can support adolescents to reach their full potential, fostering healthier, more

prosperous societies.

Future research should use RCTs to confirm causal effects, examine long-term outcomes, and assess cost-effectiveness. Additionally, studies should explore strategies to implement SBPA in challenging contexts (e.g., conflict zones, overcrowded schools) and address barriers such as gender norms and limited resources. By advancing our understanding of SBPA in LMICs, we can ensure that all adolescents—regardless of where they live—have access to opportunities that support their academic and mental health development.

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