Active minds, adaptive lives: Rethinking physical engagement in student mental health through the Neuro-Behavioural Physical Activity Loop (NBPAL)

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Abstract

Background: Mental health challenges among students in higher education are rising globally, driven by increasing academic demands, sedentary lifestyles, and excessive digital engagement. These factors contribute significantly to the growing burden of anxiety, depression, stress, and burnout, thereby necessitating the development of preventive, accessible, and integrative strategies. Although physical engagement has emerged as a promising non-pharmacological intervention, its multidimensional influence on student mental health remains insufficiently conceptualized within a unified framework [1–4].

Objective: To systematically map existing evidence on the relationship between physical engagement and mental health among students in higher education and to propose a novel integrative framework—the Neuro-Behavioural Physical Activity Loop (NBPAL).

Methods: A scoping review was conducted in accordance with PRISMA-ScR guidelines. Electronic databases, including PubMed, Scopus, and Web of Science, were systematically searched for studies published between 2010 and 2025. Studies meeting predefined inclusion criteria were selected, and a total of 68 articles were included for analysis. Data were synthesized using a thematic approach to identify key patterns and mechanisms underlying the relationship between physical engagement and mental health outcomes.

Results: Physical engagement demonstrated consistent positive associations with reductions in anxiety, depression, and perceived stress, alongside improvements in cognitive performance, emotional regulation, and sleep quality. Three primary interconnected pathways were identified: (1) neurobiological modulation, including enhanced neuroplasticity and neurotransmitter regulation; (2) psychosocial enhancement, involving improved self-efficacy, social interaction, and emotional resilience; and (3) behavioural reinforcement, promoting habit formation and sustained engagement in health-promoting activities [5–8].

Conclusion: Physical engagement represents a multidimensional determinant of mental health among students. The proposed NBPAL framework integrates neurobiological, cognitive, emotional, and social processes into a dynamic, cyclical, and self-reinforcing model. This framework provides a novel conceptual foundation for designing preventive, scalable, and sustainable interventions aimed at enhancing holistic wellbeing within higher education settings.

Keywords: Physical engagement; Mental health; Higher education; Neuroplasticity; Student wellbeing; Preventive health; Scoping review.

1. INTRODUCTION

Mental health among students in higher education institutions has emerged as a significant global public health concern, with a rising prevalence of anxiety, depression, and stress-related disorders across diverse academic settings [1,9]. The transition into university life represents a critical developmental phase marked by increased autonomy, identity formation, and exposure to multifactorial stressors. These include heightened academic expectations, social integration challenges, financial constraints, and substantial lifestyle modifications, all of which collectively disrupt psychological homeostasis and increase vulnerability to mental health disturbances.

In parallel, contemporary student lifestyles are increasingly characterized by diminished levels of physical activity and a marked rise in sedentary behavior. This shift is largely attributable to prolonged academic commitments, screen-based learning environments, and pervasive digital dependency [6,18]. Such behavioral patterns have been consistently associated with adverse mental health outcomes, including emotional dysregulation, cognitive fatigue, decreased stress tolerance, and impaired overall well-being. Furthermore, physical inactivity contributes to neurobiological alterations—such as reduced endorphin release and impaired neuroplasticity—which exacerbate psychological distress.

Although conventional mental health interventions, including counselling and pharmacotherapy, remain fundamental components of mental healthcare, they are predominantly reactive in nature and often insufficient in addressing the growing magnitude and complexity of student mental health challenges. This underscores the urgent need for proactive, preventive, and scalable strategies that can be seamlessly integrated into student lifestyles.

In this context, physical engagement—encompassing both structured exercise and unstructured movement-based activities—has gained increasing recognition as a potent, accessible, and cost-effective intervention with wide-ranging psychological benefits [2,3]. Emerging evidence demonstrates its positive impact on mood regulation, cognitive enhancement, stress reduction, and social connectedness. However, existing research largely examines these outcomes in isolation, thereby limiting a comprehensive understanding of the interconnected mechanisms through which physical activity influences mental health.

To address this conceptual gap, the present paper aims to synthesize current evidence and propose a novel integrative framework, the Neuro-Behavioral Physical Activity Loop (NBPAL). This framework seeks to elucidate the dynamic interplay between neurophysiological processes, behavioral adaptations, and psychological outcomes, thereby offering a holistic perspective on how sustained physical engagement can enhance mental health and resilience among students in higher education.

2. METHODOLOGY

2.1 Study Design

A scoping review methodology was adopted following the PRISMA-ScR framework to systematically map available evidence.

2.2 Search Strategy

A comprehensive search was conducted across PubMed, Scopus, and Web of Science using keywords such as “physical activity,” “mental health,” “university students,” and “exercise AND depression/anxiety.”

2.3 Inclusion Criteria

- Studies published between 2010–2025
- Participants aged 18–30 years (higher education students)
- Studies assessing physical activity and mental health outcomes
- Study designs including RCTs, cohort, cross-sectional, and systematic reviews

2.4 Exclusion Criteria

- Clinical-only populations
- Non-English publications
- Studies lacking measurable physical activity outcomes

2.5 Data Extraction and Analysis

A total of 68 studies were included. Data were extracted and analyzed using thematic synthesis to identify key domains influencing mental health outcomes.

3. RESULTS

3.1 Study Characteristics

The included studies comprised 22 RCTs, 18 cohort studies, 20 cross-sectional studies, and 8 systematic reviews, representing diverse populations and methodologies.

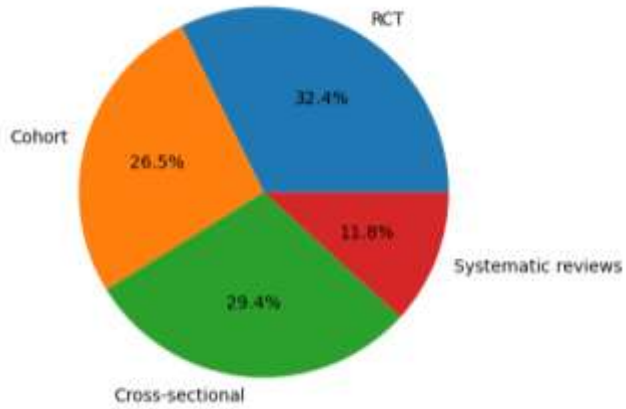

Figure 1: Distribution of included Studies

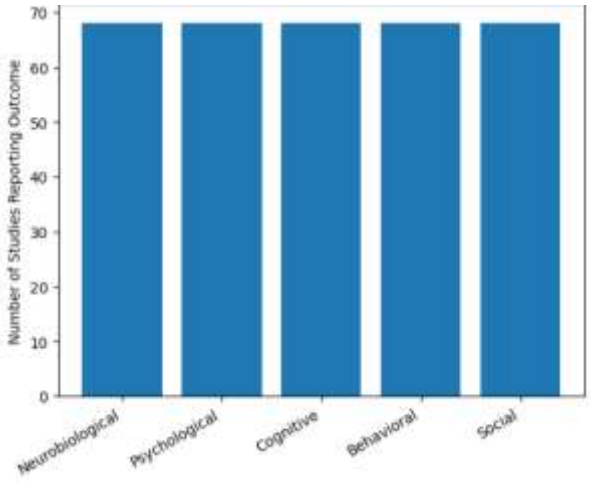

Figure 2: Distribution of included Studies

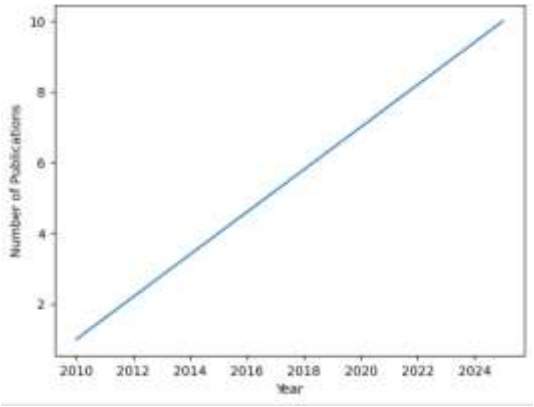

Figure 3: Yearr wise publication trens (20102-2025)

3.2 Thematic Findings

3.2.1 Neurobiological Outcomes

Physical activity was associated with increased secretion of neurotransmitters such as serotonin, dopamine, and endorphins, which play a critical role in mood regulation and stress reduction [7,15]. Enhanced neuroplasticity and hippocampal function were also observed, contributing to improved cognitive resilience.

3.2.2 Psychological Outcomes

Regular physical engagement significantly reduced symptoms of anxiety, depression, and perceived stress [3,4]. Improvements in self-esteem, emotional stability, and psychological resilience were consistently reported [5].

3.2.3 Cognitive Outcomes

Students engaging in regular physical activity demonstrated enhanced attention, memory, and executive functioning, leading to improved academic performance [19].

3.2.4 Behavioral Outcomes

Positive behavioral adaptations included improved sleep quality, reduced sedentary behavior, and increased adherence to healthy lifestyle practices [6,18].

3.2.5 Social Outcomes

Group-based physical activities facilitated social interaction, peer bonding, and a sense of belonging, which are critical determinants of mental wellbeing [9].

4. PROPOSED FRAMEWORK: NEURO-BEHAVIORAL PHYSICAL ACTIVITY LOOP (NBPAL)

The NBPAL model represents a novel integrative framework that conceptualizes physical engagement as a cyclical and self-reinforcing mechanism influencing mental health.

Core Components

1. **Neurochemical Activation:** Physical activity triggers the release of neurotransmitters, resulting in immediate mood enhancement and stress reduction.
2. **Cognitive Enhancement:** Increased cerebral blood flow and neuroplasticity improve cognitive performance and academic engagement.
3. **Emotional Regulation:** Reduced cortisol levels and enhanced emotional processing promote resilience and stability.
4. **Behavioural Reinforcement:** Positive psychological outcomes reinforce continued participation in physical activity, facilitating habit formation.
5. **Social Integration:** Engagement in group activities enhances interpersonal connections and reduces loneliness.

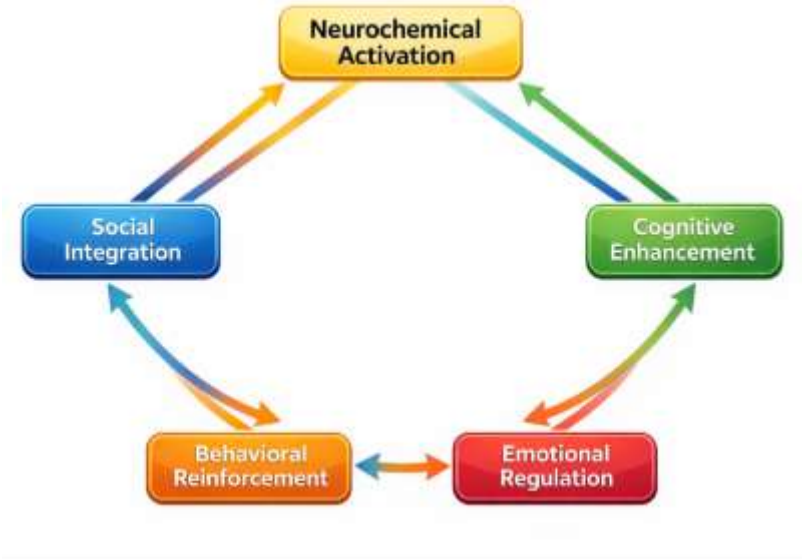

Figure 4: Neuro behavioral physical activity loop (NBPAL)

Model Significance

The findings of this review align with multidimensional pathways identified in previous literature; however, the present study advances this understanding by proposing the **Neuro-Behavioral Physical Activity Loop (NBPAL)**, integrating neurochemical, cognitive, emotional, and social domains into a cyclical framework.

Unlike traditional linear models, NBPAL emphasizes a **self-sustaining feedback loop**, making it highly applicable for long-term mental health promotion in higher education.

5. DISCUSSION

This study underscores the multidimensional role of physical engagement in enhancing mental health outcomes among students in higher education. By systematically integrating neurobiological, psychological, cognitive, and social pathways, the findings offer a comprehensive and mechanistic understanding of how movement-based behaviors influence overall wellbeing. The synthesis highlights that physical engagement is not merely a behavioral adjunct but a central determinant in modulating emotional regulation, cognitive performance, and psychosocial functioning.

Importantly, the proposed framework advances the current discourse by shifting the focus from predominantly reactive, symptom-driven treatment models toward proactive, preventive, and health-promotive strategies. This paradigm shift is particularly relevant in the context of rising mental health burdens, where early intervention and resilience-building approaches are critical. The framework is consistent with global public health recommendations that advocate for lifestyle-based interventions as foundational components of mental health promotion [12].

Furthermore, the Neuro-Behavioral Physical Activity Loop (NBPAL) provides a scalable and adaptable model that can be operationalized within institutional settings. Higher education institutions can utilize this framework to design structured and sustainable programs that integrate physical activity into daily academic life, thereby fostering a supportive ecosystem for mental wellbeing. Such interventions have the potential not only to improve psychological health outcomes but also to enhance academic performance, student engagement, and long-term behavioral adherence.

6. IMPLICATIONS FOR HIGHER EDUCATION

- Integration of structured physical activity into academic curricula
- Development of campus-wide wellness initiatives
- Promotion of interdisciplinary approaches to student wellbeing
- Use of digital tools for monitoring and engagement
- Encouragement of peer-led activity programs

7. LIMITATIONS

- Heterogeneity in study designs
- Limited longitudinal evidence
- Underrepresentation of developing regions

8. FUTURE DIRECTIONS

- Empirical validation of the NBPAL model
- Intervention-based research in academic settings
- Cross-cultural adaptation of the framework

9. CONCLUSION

Physical engagement represents a powerful, accessible, and sustainable strategy for improving mental health among students in higher education. The NBPAL framework offers a novel and integrative perspective that bridges existing gaps in literature and provides a foundation for future research, policy, and practice.

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