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THE ROLE OF PHYSICAL ACTIVITY IN ATTENTION CONTROL AMONG UNIVERSITY STUDENTS: A NARRATIVE REVIEW

Aghogho Joy Arawore[1]
Fabrícia Nascimento de Oliveira[2]
João Mário Pessoa Júnior[3]
Sâmea Valensca Alves Barros[4]
André Duarte Lucena[5]

ABSTRACT: Attention control is a core executive function essential for learning, academic performance, and daily cognitive functioning, particularly among university students who are frequently exposed to high cognitive demands, stress, and sedentary behavior. Physical activity has been increasingly recognized as a potential strategy to enhance attentional processes; however, the mechanisms and consistency of its effects across studies remain fragmented. This narrative review aims to examine the role of physical activity in attention control among university students, with a focus on underlying cognitive and neurobiological mechanisms. A structured narrative review was conducted using peer-reviewed articles indexed in PubMed and SciELO, following predefined inclusion and exclusion criteria. Studies investigating physical activity, exercise, or sedentary behavior in relation to attention control, executive function, or cognitive performance in young adults and university students were included. A total of 10 studies met the eligibility criteria and were thematically analyzed. Findings indicate that both acute and chronic physical activity are associated with improvements in attention control, including selective attention, sustained attention, and inhibitory control. These effects are supported by multiple neurobiological mechanisms, including increased cerebral blood flow, enhanced neuroplasticity through brain-derived neurotrophic factor (BDNF), modulation of dopamine and norepinephrine systems, reduced neuroinflammation, and improved stress regulation via the hypothalamic-pituitary-adrenal (HPA) axis. Evidence also suggests that moderate-intensity aerobic exercise is particularly effective in optimizing attentional performance. In conclusion, physical activity plays a significant role in enhancing attention control in university students through integrated neurocognitive and physiological pathways. Incorporating regular physical activity into daily routines represents a practical and evidence-based strategy to support cognitive performance, reduce attentional deficits, and promote academic success in this population.

Keywords: Physical activity. Attention control. University students.

[1] Master's Student, Universidade Federal Rural do Semi-Árido.
[2] Professor, Universidade Federal Rural do Semi-Árido.
[3] Professor, Universidade Federal Rural do Semi-Árido, Brazil.
[4] Co-supervisor, Universidade Federal Rural do Semi-Árido.
[5] Supervisor, Universidade Federal Rural do Semi-Árido.

RESUMO: O controle da atenção é uma função executiva central essencial para a aprendizagem, o desempenho acadêmico e o funcionamento cognitivo diário, particularmente entre estudantes universitários que são frequentemente expostos a altas demandas cognitivas, estresse e comportamento sedentário. A atividade física tem sido cada vez mais reconhecida como uma estratégia potencial para melhorar os processos atencionais; no entanto, os mecanismos e a consistência de seus efeitos entre os estudos permanecem fragmentados. Esta revisão narrativa tem como objetivo examinar o papel da atividade física no controle da atenção entre estudantes universitários, com foco nos mecanismos cognitivos e neurobiológicos subjacentes. Foi conduzida uma revisão narrativa estruturada utilizando artigos revisados por pares indexados no PubMed e SciELO, seguindo critérios predefinidos de inclusão e exclusão. Foram incluídos estudos que investigaram atividade física, exercício ou comportamento sedentário em relação ao controle da atenção, função executiva ou desempenho cognitivo em adultos jovens e estudantes universitários. Um total de 10 estudos atendeu aos critérios de elegibilidade e foi analisado tematicamente. Os resultados indicam que tanto a atividade física aguda quanto a crônica estão associadas a melhorias no controle da atenção, incluindo atenção seletiva, atenção sustentada e controle inibitório. Esses efeitos são sustentados por múltiplos mecanismos neurobiológicos, incluindo aumento do fluxo sanguíneo cerebral, aprimoramento da neuroplasticidade por meio do fator neurotrófico derivado do cérebro (BDNF), modulação dos sistemas de dopamina e norepinefrina, redução da neuroinflamação e melhora da regulação do estresse por meio do eixo hipotálamo-hipófise-adrenal (HPA). As evidências também sugerem que exercícios aeróbicos de intensidade moderada são particularmente eficazes na otimização do desempenho atencional. Em conclusão, a atividade física desempenha um papel significativo na melhora do controle da atenção em estudantes universitários por meio de vias neurocognitivas e fisiológicas integradas. A incorporação regular de atividade física nas rotinas diárias representa uma estratégia prática e baseada em evidências para apoiar o desempenho cognitivo, reduzir déficits atencionais e promover o sucesso acadêmico nessa população.

Palavras-chave: Atividade física. Controle da atenção. Estudantes universitários.

INTRODUCTION

Attention control is a fundamental component of cognitive functioning, enabling individuals to selectively focus on relevant stimuli while inhibiting distractions. It is a core aspect of executive function and is primarily regulated by a network of brain regions, including the prefrontal cortex and anterior cingulate cortex, which coordinate top-down control of attention and behavior(Widge et al., 2019; Cipolotti et al., 2025). These neural systems support allows individuals to efficiently allocate cognitive resources in goal-directed tasks (Guzmán-Muñoz et al., 2025). In young adults, particularly university students, effective attention control is essential for managing complex cognitive demands such as learning, problem-solving, and information processing.

However, growing evidence suggests that attention-related difficulties are increasingly prevalent among young adults. Studies indicate that approximately 30–50% of university

students report significant difficulties in maintaining sustained attention during academic tasks (Gallen et al., 2023; Lee et al., 2025). Additionally, the widespread use of digital devices has been shown to negatively impact attentional capacity, with individuals checking their smartphones an average of 85 times per day, contributing to frequent attentional shifts and reduced focus (Andrews et al., 2015). These patterns are further increased by academic stress and mental health challenges, as nearly one in three university students report high levels of stress and cognitive overload, which are associated with impaired executive functioning and attentional control (Gong et al., 2023).

Sedentary behavior is another major contributing factor to declining cognitive performance. Globally, it is estimated that over 80% of young adults do not meet the recommended levels of physical activity (World Health Organization, 2021). Physical inactivity has been linked not only to adverse physical health outcomes but also to poorer cognitive functioning, including deficits in attention and executive control (Buckley et al., 2014). The increasing prevalence of sedentary lifestyles among students, characterized by prolonged sitting and reduced physical engagement, raises concerns about its long-term impact on brain health and cognitive efficiency.

Physical activity has emerged as a promising and accessible strategy for enhancing cognitive performance. Defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985), physical activity has been consistently associated with improvements in brain structure and function. Empirical evidence suggests that individuals who engage in regular physical activity demonstrate better attentional performance and up to 20–30% improvements in executive function tasks compared to sedentary individuals (Tian et al., 2023; Hoffmann et al., 2021). These benefits are thought to be mediated through physiological mechanisms such as increased cerebral blood flow, enhanced neuroplasticity, and the upregulation of neurotrophic factors.

In young adults, both acute and chronic exercise have been shown to positively influence

attention control. Acute bouts of moderate-intensity exercise have been associated with immediate improvements in attention and processing speed, while long-term physical activity interventions contribute to sustained cognitive benefits (Hoffmann et al., 2021). Despite these promising findings, there remains a need to synthesize current evidence and better understand

the mechanisms through which physical activity influences attention control in this population.

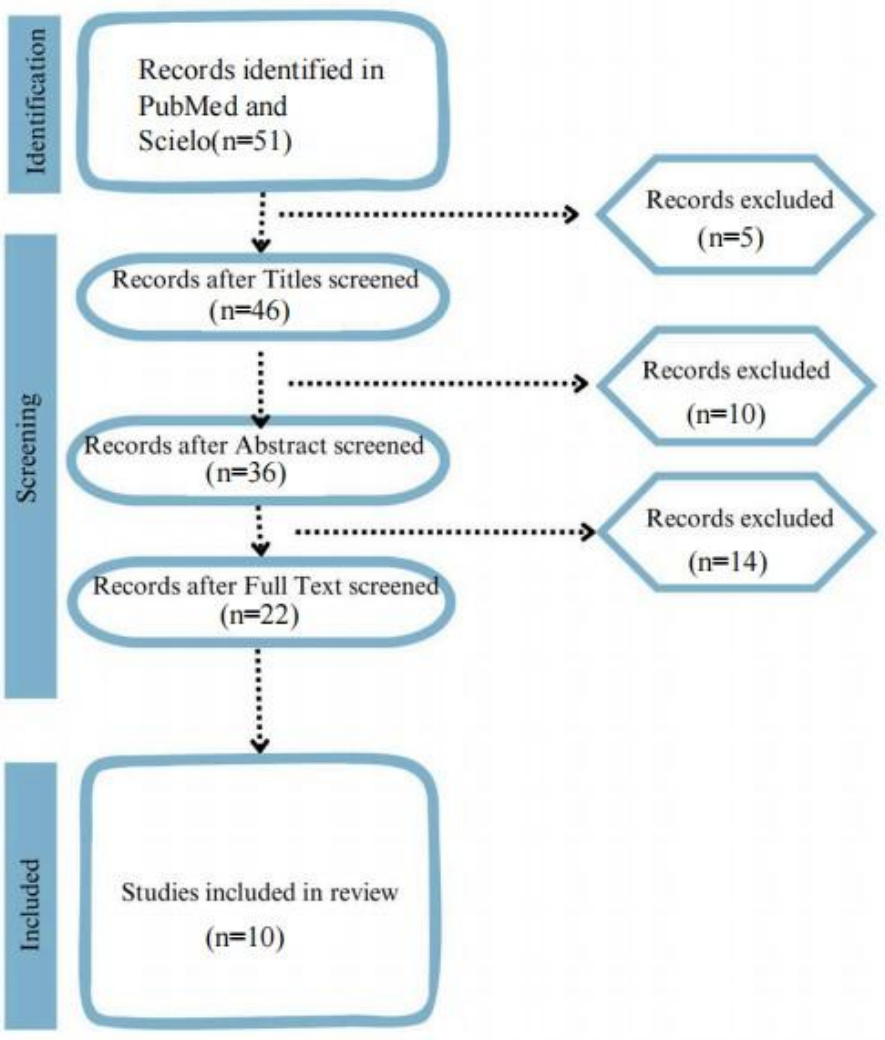
Therefore, the aim of this narrative review is to examine the role of physical activity in attention control among young adults. Specifically, this review explores the cognitive and neurobiological mechanisms underlying this relationship, evaluates existing empirical evidence, and discusses the implications for enhancing cognitive performance and mental well-being in university populations.

METHODOLOGY

This study adopted a structured narrative literature review design to examine the role of physical activity in attention control among university students. A systematic search of peer-reviewed articles indexed in PubMed and Scielo was conducted to identify relevant literature. Prior to conducting the search, clear inclusion and exclusion criteria were established to ensure methodological consistency and relevance. Studies were included if they: (1) involved university students or young adults, (2) examined physical activity, exercise, or sedentary behavior as the primary variable, (3) assessed attention control, executive function, or cognitive performance outcomes, (4) provided empirical or theoretical contributions relevant to neurocognitive mechanisms, (5) consisted of original research, systematic reviews, meta-analyses, or theoretical papers, (6) were published between January 2000 and December 2025, and (7) were written in English. Studies focusing exclusively on clinical populations were excluded unless their findings were directly applicable to healthy cognitive functioning.

The literature search was conducted using predefined keywords and Boolean operators to ensure a comprehensive and focused retrieval of studies. The search strategy included the following terms:(("physical activity"[Title/Abstract] OR "exercise"[Title/Abstract] OR "aerobic exercise"[Title/Abstract] OR "resistance training"[Title/Abstract] OR "sedentary behavior"[Title/Abstract]) AND ("attention control"[Title/Abstract] OR "executive function"[Title/Abstract] OR "sustained attention"[Title/Abstract] OR "cognitive performance"[Title/Abstract]) AND ("university students"[Title/Abstract] OR "young adults"[Title/Abstract])). Following the search process, all retrieved records were screened for eligibility based on titles and abstracts, and relevant full-text articles were assessed in accordance with the predefined criteria.

Figure 1: Identified Studies via data-base



RESULTS

The included studies were organized using thematic analysis and grouped according to their focus on the role of physical activity in attention control and related executive functions among university students. This approach allowed for a structured synthesis of the literature, highlighting consistent patterns as well as variability in how physical activity influences attentional processes such as selective attention, inhibitory control, and cognitive flexibility. From the initial search, 51 records were identified, of which 10 met the inclusion criteria and were selected for review.

The characteristics of the physical activity interventions and the attention-related cognitive outcomes are summarized in Table 2.

Author, year	Design	Sample	Physical Activity / Task	Attention / Cognitive Measure	Key Findings (Attention Control)
Du et al. (2023)	Data mining (12-week longitudinal; CHAID decision tree)	2,219 undergraduates (Mean ≈ 19 years)	App-tracked running (frequency, duration, speed, distance, regularity)	Academic performance (continuous course scores)	Higher performance linked to greater exercise regularity and moderate activity. Best results with ~1 session/week and 16–25 min duration. Intensity less relevant than consistency.
Tsuk et al. (2019)	Counterbalanced repeated-measures experimental design (acute exercise intervention)	40 physical education students (Mean age ≈ 25.7 years)	Single 30-min sessions: moderate aerobic exercise vs resistance exercise vs control (rest)	Stroop task (attention) + Go/No-Go + executive function tests	Resistance exercise significantly improved attention scores vs control. Aerobic exercise showed non-significant improvement in attention but improved executive function. Control showed no change.
Yanagisawa et al. (2009)	Acute within-subject crossover (EX vs CTL, pre/post), fNIRS	20 healthy young adults (~21.5 yrs)	Moderate cycling (50% VO_2peak, ~30 min) vs rest	Color–word Stroop task (RT, accuracy), oxy-Hb (DLPFC activity)	Improved Stroop reaction time after exercise; increased left DLPFC activation; behavioral–neural link confirmed

Hoffmann et al. (2021)	Systematic Review & Meta-analysis (RCTs)	547 adults (50–80+ years), 9 studies	Aerobic PA (walking, cycling, swimming, 40–60 min, 1–3x/week, 3–12 months) vs control	Memory (word recall, spatial tasks) & Executive function (Stroop, WCST)	Large effect on memory (g=0.80); small effect on executive function (g=0.37)
Tian et al. (2023)	Systematic Review & Meta-analysis (RCTs)	752 sedentary individuals (14–75 years), 13 studies	Physical activity interventions (varied aerobic exercise; 20–60 min; 2–4x/week;	Executive function: inhibitory control, working memory, cognitive	Small–moderate effect on EF (SMD = 0.24); strongest for inhibitory control (0.38); no effect on cognitive flexibility
			≤12 to >12 weeks) vs control	flexibility (Stroop, WM tasks)	
Chang et al. (2025)	Meta-review (30 meta-analyses)	18,347 participants (383 studies across ages)	Acute exercise (single bouts; varied intensity/duration/type) vs control	Attention, executive function, memory, processing speed	Small–moderate improvement in cognition (SMD = 0.33); attention (0.37), EF (0.36), memory (0.23); strongest post-exercise
Deliens et al. (2015)	Qualitative study (focus group discussions; inductive thematic analysis)	46 university students (17 male, 29 female; mean age 20.7 ± 1.6 years)	Physical activity and sedentary behaviour explored (no experimental intervention)	Determinants of physical activity and sedentary behaviour (individual, social, physical environment, macro	Physical activity and sedentary behaviour influenced by enjoyment, self-discipline, time constraints, social support, parental influence,

				environment, university characteristics)	cost, accessibility, academic pressure, and university lifestyle factors
Alexander & Machado (2024)	Randomized Controlled Trial (6 weeks)	32 university students (18–28 years)	Running intervention (30 min, 3x/week) vs control	Pro/Anti task (inhibitory control), spatial & verbal working memory, PANAS	No significant effects on attention control, cognition, or affect. No fitness improvements. Some non-significant benefits for outdoor running; mixed enjoyment effects
Dvořák (2024)	Correlational cross-sectional study	107 university students (19–52 years)	No intervention (natural academic variation)	Stroop Test (inhibitory control + error rates)	Weak, non-significant correlation between Stroop effect and academic performance. Significant weak relationship between Stroop errors and grade averages (fewer errors = higher grades). No link with failure rate

Buckley et al. (2014)	review	Evidence synthesized from multiple studies (humans across lifespan; no single sample)	Physical activity & sedentary behavior; self-regulation and cognitive control tasks (e.g., Go/No-Go, Stroop, task-switching, cognitive training paradigms)	Executive functions: attention control, inhibition, working memory, cognitive flexibility; neural measures (PFC, ACC, DMN, reward networks)	Cognitive control (especially inhibition, attentional control, and working memory) supports physical activity adherence; lower executive function linked to sedentary behavior; bidirectional link between exercise and cognition; prefrontal networks (dlPFC, ACC) regulate goal-directed behavior and suppress competing sedentary/reward impulses

Table 2: This table summarizes the main studies included in the review.

ATTENTION CONTROL

Attention control refers to the ability to regulate and direct cognitive resources toward task-relevant information while suppressing irrelevant or distracting stimuli. It is a central component of executive function and is essential for adaptive, goal-directed behavior (Diamond, 2013). This cognitive process enables individuals to maintain focus, shift attention when necessary, and inhibit automatic or competing responses, thereby supporting efficient information processing in complex environments.

From a cognitive perspective, attention control is commonly divided into three key components: selective attention, sustained attention, and executive attention. Selective attention involves the ability to focus on specific stimuli while ignoring irrelevant information, which is crucial in environments with multiple competing inputs (Hobbiss & Lavie, 2024).

Sustained attention, also known as vigilance, refers to the ability to maintain focus over extended periods, a capacity that is especially important in academic and performance-based contexts (Oken, Salinsky, & Elsas, 2006). Executive attention, on the other hand, is responsible for conflict monitoring and cognitive control, allowing individuals to resolve interference and regulate thoughts and actions (Mackie, Van Dam, & Fan, 2013).

Neurobiologically, attention control is supported by an interconnected network of brain regions, primarily involving the prefrontal cortex, anterior cingulate cortex, and parietal regions. The prefrontal cortex plays a critical role in top-down regulation, enabling individuals to consciously direct attention in accordance with goals (Rossi et al., 2009). The anterior cingulate cortex is involved in conflict detection and error monitoring, facilitating adjustments in cognitive control when competing information is present (Cipolotti et al., 2025). Additionally, the parietal cortex contributes to attentional orientation and spatial awareness, supporting the allocation of attentional resources (Corbetta and Shulman, 2002, Szczepanski et al., 2010).

Attention control is also closely linked to neurotransmitter systems, particularly dopamine and norepinephrine, which modulate alertness, motivation, and cognitive flexibility. Dopaminergic activity within the prefrontal cortex has been associated with improved working memory and attentional regulation, while norepinephrine plays a key role in maintaining arousal and vigilance (Clark & Noudoost, 2014). Dysregulation of these neurochemical systems can lead to impairments in attention control, highlighting the biological basis of this cognitive function.

In young adults, attention control is especially important due to the high cognitive demands associated with academic and social environments. However, this population is also vulnerable to attentional disruptions caused by stress, multitasking, and excessive digital media use. Impairments in attention control have been linked to reduced academic performance, increased mental fatigue, and decreased productivity (Dvorak, 2024). Therefore, understanding the mechanisms and components of attention control is essential for identifying strategies to enhance cognitive performance in this group.

4.1 Physical Activity and Attention Control

Physical activity enhances attention control through a set of interrelated neurobiological mechanisms that directly influence brain structure, neurochemistry, and cognitive regulation.

These mechanisms include the upregulation of neurotrophic factors, modulation of neurotransmitter systems, reduction of neuroinflammation, and regulation of stress physiology. Together, these processes optimize the functioning of neural circuits underlying attention, particularly within the prefrontal cortex and associated networks (Phillips & Fahimi, 2018)

4.1.1 Vascular changes

One of the primary mechanisms through which physical activity enhances brain function is the increase in cerebral blood flow. During exercise, elevated heart rate and vascular activity lead to greater oxygen and nutrient delivery to the brain, particularly to regions involved in executive control such as the prefrontal cortex (Lucas et al., 2012). This improved perfusion supports neuronal metabolism and enhances the efficiency of neural processing, thereby facilitating attentional performance and cognitive speed.

4.1.2 Neuroplasticity

In addition to vascular changes, physical activity promotes neuroplasticity, the brain's ability to adapt structurally and functionally in response to experience. Exercise has been shown to stimulate neurogenesis, synaptogenesis, and angiogenesis, particularly within brain regions associated with learning and memory (Cotman & Berchtold, 2002; Hötting & Röder, 2013). A key mechanism underlying these effects is the increased expression of brain-derived neurotrophic factor (BDNF), a protein that supports neuronal survival, growth, and synaptic plasticity, including long-term potentiation. Physical activity consistently elevates BDNF levels, especially in brain regions involved in learning and executive control. Increased BDNF enhances synaptic strength and connectivity within prefrontal and hippocampal circuits, thereby improving the brain's ability to sustain attention, process information efficiently, and adapt to changing cognitive demands (Ding, Ying, & Gómez-Pinilla, 2011). Overall, this neuroplastic enhancement provides a structural and functional basis for improvements in cognitive performance, including attention and executive control.

4.1.3 Neurotransmitter

Physical activity enhances attention control through coordinated modulation of multiple neurotransmitter systems, including catecholaminergic (dopamine and

norepinephrine), serotonergic, and cholinergic pathways, which collectively regulate prefrontal cortex function and large-scale brain network dynamics. Within the prefrontal cortex, optimal levels of dopamine and norepinephrine support key executive functions such as working memory, signal amplification, noise suppression, and goal-directed behavior (Arnsten, 2009; Robbins & Arnsten, 2009). These effects are regulated through an inverted-U relationship, whereby both insufficient and excessive neurotransmitter activity impair cognitive efficiency, while moderate levels optimize attentional performance.

Acute physical activity activates the locus coeruleus–norepinephrine (LC-NE) system, increasing cortical norepinephrine release and enhancing neural gain. This improves the signal-to-noise ratio in prefrontal circuits, thereby strengthening task-relevant neural representations and reducing distractibility. Concurrently, physical activity increases dopaminergic activity, particularly through the ventral tegmental area (VTA), which projects to the pré-frontal cortex and supports attentional stability, working memory maintenance, and cognitive flexibility. In addition, exercise elevates brain-derived neurotrophic factor (BDNF), which enhances synaptic plasticity and improves the efficiency of neural communication, further supporting attentional processing and executive functioning.

In addition to catecholaminergic regulation, serotonin plays a critical role in supporting attention control by modulating mood, stress reactivity, and cognitive stability. Exercise-induced increases in serotonergic activity reduce anxiety and emotional interference, thereby decreasing rumination and task-irrelevant thought processes that compete for limited attentional resources (Li et al., 2025). This stabilisation of affect enhances the efficiency of top-down attentional control by reducing internally driven disruptions to cognitive processing.

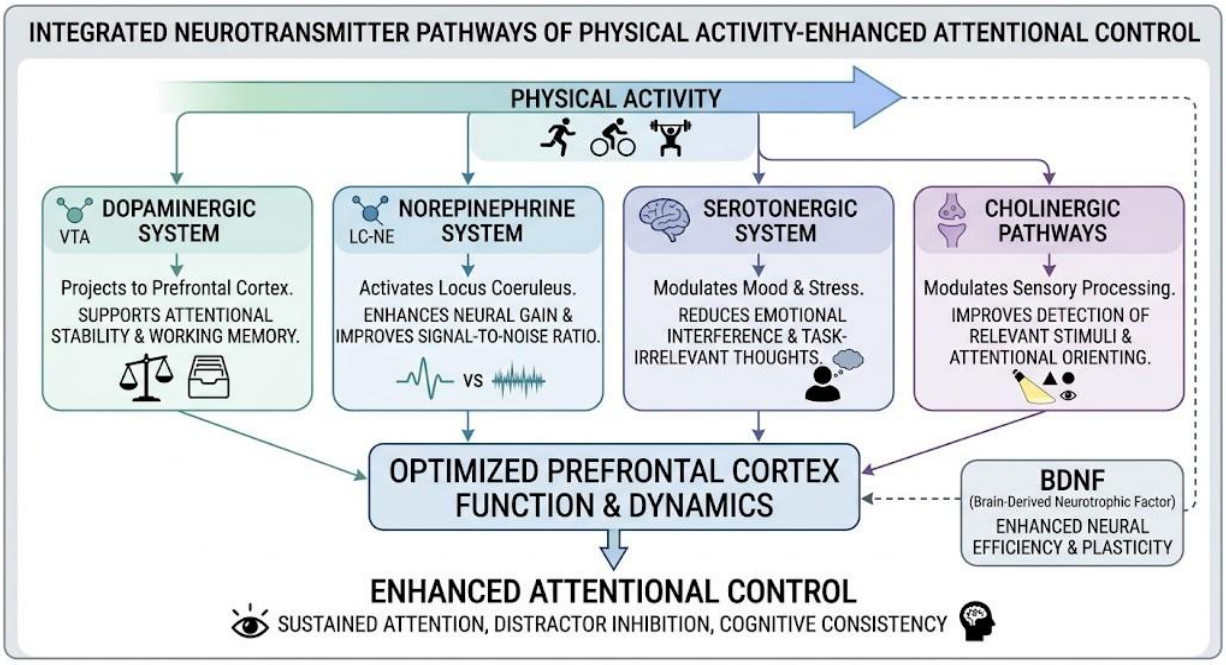
Alongside these systems, acetylcholine contributes to selective attention by modulating sensory processing within frontoparietal attention networks. Enhanced cholinergic transmission improves the detection of relevant stimuli while suppressing background neural noise, thereby facilitating attentional orienting and perceptual discrimination (Ljubojevic et al., 2018). This mechanism complements dopaminergic and noradrenergic functions by refining the quality of incoming sensory information that is subsequently prioritized by executive control systems.

At the network level, physical activity strengthens top-down regulation mediated by the prefrontal cortex while reducing neural variability and improving cognitive consistency. Dopamine and norepinephrine jointly support sustained attention, inhibition of distractors,

and adaptive attentional shifting, while serotonin and acetylcholine provide complementary support by regulating emotional stability and sensory selectivity. Exercise also modulates large-scale brain networks by decreasing default mode network activity and enhancing task-positive network engagement, promoting a shift away from internally focused processes such as mind-wandering toward externally directed attentional control.

Overall, physical activity enhances attention control by temporarily optimizing dopaminergic (VTA-mediated) and noradrenergic (LC-NE system) activity in the prefrontal cortex, while also increasing BDNF-driven neural efficiency. This integrated neurochemical state enhances executive functioning, strengthens top-down attentional regulation, and improves the allocation of cognitive resources toward task-relevant information.

Figure 1: Effects of Physical Activity on Neurotransmitter Modulation and Attentional Performance.



Source: researchers' files (2025)

4.1.4 Neuroinflammation

Physical activity also influences cognitive function through its effects on neuroinflammatory processes in the brain. Chronic low-grade inflammation has been increasingly identified as a contributing factor to cognitive decline, as it disrupts synaptic plasticity and impairs overall brain efficiency. In particular, elevated inflammatory activity is associated with reduced performance in attention and executive function processes (Phillips &

Fahimi, 2018).

Physical activity has been shown to exert strong anti-inflammatory effects. Regular exercise reduces levels of pro-inflammatory cytokines, including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), while simultaneously enhancing the production of anti-inflammatory mediators (Gleeson et al., 2011). Through these physiological changes, exercise helps to regulate the body's inflammatory response and prevent excessive immune activation. By reducing neuroinflammation, physical activity supports the preservation of neuronal integrity and promotes more efficient functioning of brain networks involved in attention control and higher-order cognition.

4.1.5 Stress regulation

Physical activity plays a critical role in stress regulation, which is closely linked to cognitive performance and attention control. Chronic stress is associated with prolonged elevations in cortisol and dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, which can impair prefrontal cortex functioning and disrupt attentional processes (Gądek-Michalska et al., 2013; McEwen, 2007). Regular physical activity has been shown to reduce baseline cortisol levels and improve HPA axis regulation, thereby enhancing stress resilience and mitigating the negative effects of stress on brain function (Merz et al., 2010). By protecting prefrontal cortex integrity and reducing stress-induced cognitive interference, exercise helps preserve and enhance attentional control. This is particularly relevant in young adults, where academic stress and rumination are common contributors to attentional deficits.

4.1.6 Acute and Chronic Exercise Effects on Attention Performance

A growing body of empirical research demonstrates that physical activity has significant positive effects on attention performance, particularly in young adults. These effects have been observed across both acute (short-term) and chronic (long-term) exercise interventions, with consistent improvements reported in attentional capacity, processing speed, and executive control (Tsuk et al., 2019, Alexander & Machado, 2024).

Acute physical activity, defined as a single bout of exercise, has been shown to produce immediate enhancements in attention performance. Studies indicate that even brief sessions of moderate-intensity aerobic exercise (e.g., 20–30 minutes) can improve reaction time, increase accuracy, and enhance selective attention (Ligeza et al., 2023). These effects are thought to be

mediated by transient increases in cerebral blood flow, arousal, and neurotransmitter activity, particularly dopamine and norepinephrine, which optimize prefrontal cortex functioning. For example, participants who engaged in moderate aerobic exercise demonstrated significantly improved performance on attention-based tasks such as the Stroop test, reflecting enhanced inhibitory control and reduced cognitive interference (Yanagisawa et al., 2010).

In contrast, chronic physical activity, involving regular and sustained engagement in exercise over weeks or months, leads to more stable and long-term improvements in attention control. Longitudinal studies have shown that individuals who maintain higher levels of physical activity exhibit superior performance in tasks requiring sustained attention and executive function compared to sedentary individuals (Loprinzi & Nooe, 2016). These long-term benefits are associated with structural and functional brain changes, including increased gray matter volume, enhanced neural connectivity, and improved neuroplasticity.

Importantly, the cognitive effects of physical activity are not uniform and are significantly influenced by key exercise variables, particularly type, intensity, and duration. Different forms of exercise produce distinct neurocognitive outcomes. Aerobic exercise, such as running, cycling, and swimming, has been most consistently associated with improvements in attention control due to its effects on cardiovascular fitness, cerebral blood flow, and neurochemical activation in brain regions involved in attentional regulation (Hillman, Erickson, & Kramer, 2008). Resistance training also contributes to cognitive enhancement, although through different mechanisms, including hormonal responses and growth factor release that support brain health and executive functioning (Castaño et al., 2022). Emerging evidence suggests that combined aerobic and resistance training may yield the most comprehensive cognitive benefits by engaging multiple physiological and neural pathways (Zhao & Omar Dev, 2025).

Exercise intensity further moderates these effects. Moderate-intensity exercise is widely considered optimal for improving attention control, consistent with the inverted-U hypothesis, which proposes that cognitive performance improves with physiological arousal up to an optimal level before declining (Ligeza et al., 2023). At this intensity, optimal levels of dopamine and norepinephrine are released within the prefrontal cortex, enhancing attentional regulation and executive control (Roig & Cristini, 2024). In contrast, low-intensity exercise may be insufficient to induce meaningful neurocognitive changes, whereas excessively high-intensity exercise may lead to fatigue, elevated cortisol levels, and temporary impairments in

cognitive performance, although it may still contribute to long-term adaptations when recovery is adequate.

Duration and frequency also play a critical role in determining cognitive outcomes. Acute exercise sessions lasting approximately 20–30 minutes have been shown to produce immediate improvements in attention and processing speed, particularly when performed at moderate intensity (Chang et al., 2025). For long-term benefits, regular physical activity is essential. Guidelines recommend at least 150 minutes of moderate-intensity aerobic exercise per week or 75 minutes of vigorous activity to support both physical and cognitive health (World Health Organization, 2021). Engaging in physical activity 3–5 times per week appears particularly beneficial for maintaining stable neurochemical and physiological conditions that support sustained attention and cognitive performance.

In addition to experimental findings, real-world studies in academic settings show that physically active students tend to demonstrate better concentration, improved academic performance, and reduced mental fatigue Du et al. (2023). Furthermore, physical activity enhances multiple components of attention, including selective attention, sustained attention, and attentional shifting. Improvements in selective attention allow for better filtering of irrelevant information, while enhanced sustained attention supports prolonged focus during cognitively demanding tasks.

Increased cognitive flexibility further facilitates efficient switching between tasks in dynamic environments (Yanagisawa et al., 2010).

5. IMPLICATIONS FOR UNIVERSITY STUDENTS

The effects of physical activity on attention control have important implications for university students, who are frequently exposed to high cognitive demands, academic pressure, and prolonged sedentary behavior. Given that attention control underpins learning, memory, and problem-solving, maintaining optimal cognitive functioning is essential for academic success (Deliens et al., 2015). The evidence suggests that regular physical activity enhances students' ability to sustain focus, process information efficiently, and manage cognitive load during demanding academic tasks (Latino et al., 2025).

In practical terms, even brief bouts of moderate-intensity exercise can improve concentration and attentional readiness, particularly before studying or examinations. Over time, consistent engagement in physical activity supports more stable cognitive functioning

and improved academic performance. Simple strategies such as incorporating short movement breaks during study sessions, engaging in active commuting, and participating in regular aerobic or resistance training can be effective in supporting both cognitive and mental well-being. According to global health guidelines, engaging in at least 150 minutes of moderate-intensity physical activity per week is recommended to maintain both physical and cognitive health (World Health Organization, 2021). Overall, physical activity represents a practical, accessible, and evidence-based strategy for enhancing attention control and supporting academic performance in university students.

6. CONCLUSION

Physical activity plays a critical role in enhancing attention control in young adults through multiple interconnected neurobiological and psychological mechanisms. By improving cerebral blood flow, promoting neuroplasticity, regulating neurotransmitter systems, and reducing stress and inflammation, exercise optimizes the functioning of brain regions responsible for attentional processes.

Evidence from both acute and chronic exercise studies demonstrates consistent improvements in attention performance, including increased focus, faster processing speed, and enhanced cognitive flexibility. In contrast, sedentary behavior and physical inactivity contribute to impairments in attention and executive function. Given the high cognitive demands and increasing prevalence of attentional challenges among university students, integrating regular physical activity into daily routines represents an effective and accessible strategy for improving cognitive performance and overall well-being.

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