Physical Activity, Sedentary Behavior, and Executive Function among University Students in Bangkok, Thailand: A Cross-Sectional Study

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Running title: Physical Activity and Executive Function

Abstract

Background: Physical inactivity is a growing public health concern among university students. While physical activity (PA) is linked to cognitive benefits, evidence in emerging adults remains limited.

Objectives: This study examined cross-sectional associations between PA levels and executive function (EF) components—inhibitory control, focus/attention, and cognitive flexibility—among university students in Bangkok, Thailand.

Methods: A cross-sectional study of 388 undergraduate students (mean age 20.4 ± 1.6 years) from King Mongkut's University of Technology Thonburi was conducted. PA (vigorous PA [VPA], moderate PA [MPA], sedentary behavior [SB], and sleep duration) was assessed by validated self-reported questionnaire. EF was assessed using the Flanker Task, Trail Making Test Part B (TMT-B), and Design Fluency Test (DFT). Pearson correlations and multiple linear regression were performed.

Results: VPA and MPA were strongly intercorrelated ($r = .549$, $p < .001$). No PA variable was significantly associated with any EF outcome (all $p > .05$). Cognitive measures were strongly intercorrelated ($|r| = .468–.683$, all $p < .001$). No EF measure significantly predicted VPA, MPA, or MVPA.

Conclusion: No significant associations were found between habitual PA and EF in Thai university students. Null findings may reflect neurodevelopmental ceiling effects, insufficient exercise dose, and population-specific contextual factors.

Applicable Remarks: The cognitive battery demonstrated strong internal consistency, supporting its use in future experimental studies.

Keywords: *Cognitive Flexibility, Executive Function, Inhibitory Control, Physical Activity, Sedentary Behavior, University Students*

Introduction

The rising prevalence of non-communicable diseases (NCDs) represents a critical challenge to global public health. The World Health Organization reported that in 2016, NCDs accounted for 40.5 million of the 56.9 million deaths globally, representing approximately 71% of total mortality (1). More recently, the WHO Global Status Report on Physical Activity indicated that progress toward reducing physical inactivity remains slow worldwide, with more than a quarter of adults still failing to meet recommended activity levels (21). While tobacco use, harmful alcohol consumption, and unhealthy diets are significant contributing factors, physical inactivity has emerged as a primary and modifiable risk factor for NCD prevalence (2). Despite global initiatives to promote active lifestyles, physical activity (PA) levels are stagnating or declining in many populations (3).

The university years represent a critical transition from adolescence to early adulthood—a period during which lifestyle habits, including PA patterns and dietary choices, are consolidated and frequently persist into later adulthood (4). Research consistently demonstrates that as individuals move from secondary education to university, PA levels decrease sharply while sedentary behaviour increases (5, 6). University students are therefore recognised as a vulnerable population at risk of long-term poor health and early-onset NCDs. Furthermore, the existing literature is disproportionately derived from developed nations, creating a need to investigate PA determinants across diverse geographical and cultural contexts, including Thailand (2).

Beyond its physical health implications, PA is increasingly recognized for its impact on cognitive performance, specifically executive function (EF). EF refers to a family of top-down mental processes required when deliberate, goal-directed thought is essential (7). Based on the framework by Miyake et al. (8) and attentional control models (9), this study targeted three EF components:

(1) Inhibitory Control (IC)—the ability to suppress prepotent impulses; (2) Focus/Attention (FA)—the capacity for sustained and selective attentional engagement; and (3) Cognitive Flexibility (CF)—the ability to shift mental set and generate novel responses. For university students, high EF is strongly linked to academic achievement (11).

The theoretical basis for a PA–EF relationship is grounded in neurobiology. Physical exertion enhances cerebral blood flow and stimulates Brain-Derived Neurotrophic Factor (BDNF), promoting neurogenesis and synaptic plasticity within the prefrontal cortex—the principal neural substrate of EF (12-14). A recent comprehensive review of experimental and clinical evidence further substantiates this exercise-BDNF-cognition pathway, linking exercise-induced BDNF upregulation to measurable gains in learning, memory, and executive processes (24). Despite these established mechanisms, most research focuses on children or older adults, leaving the emerging adulthood demographic understudied (15). The present study therefore aimed to investigate cross-sectional associations between PA levels (VPA, MPA, SB, sleep duration) and core EF components in Thai university students, and to explore whether cognitive performance predicted PA engagement. Based on the neurobiological mechanisms outlined above, it was hypothesized that (H1) higher levels of VPA and MPA would be positively associated with better performance on all three EF components, (H2) higher SB and shorter sleep duration would be associated with poorer EF performance, and (H3) EF performance would positively predict engagement in VPA and MPA.

Materials and Methods

Study Design and Participants

This study employed a cross-sectional design. The target population comprised 12,514 undergraduate students enrolled at King Mongkut's University of Technology Thonburi (KMUTT), Bangkok, Thailand. A sample of 388 participants was determined using Yamane's formula at a margin of error of 5%. Participants were selected through a combination of simple random sampling and purposive sampling. Specifically, simple random sampling was used to select faculties/schools, after which purposive sampling was applied within each selected faculty to recruit a number of students proportional to its enrolment across the four academic years, ensuring that the final sample reflected the demographic structure of the target population. Inclusion criteria required participants to be Thai nationals aged 18–24 years, currently enrolled as undergraduates, and free from intellectual disabilities or self-reported neurological or psychiatric conditions.

Ethical Statement

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of King Mongkut's University of Technology Thonburi (Approval No. KMUTT-IRB-2025/0619/186). Written informed consent was obtained from all participants prior to data collection.

Physical Activity and Sleep Assessment

Physical activity was assessed using a self-reported questionnaire comprising 7 sections with a total of 80 items (17): (1) Personal/Demographic Information (11 items); (2) Overview and Specific Scope of Physical Activity, including Sedentary Behavior, Sleep, and Activity Types (25 items); (3) University Environment (10 items); (4) Health-Related Behaviors (8 items); (5) Mental Well-being and Attitudes towards Physical Activity (12 items); (6) Social Support (13 items); and (7) Opinions on University Support for Physical Activity (qualitative data; 1 item). The questionnaire was based on the ASEAN University Network - Health Promotion Network (AUN-HPN) health behavioral survey, a previously developed and multiply-administered instrument used to assess physical activity and related health behaviors among university students across ASEAN countries, including Thailand (17). Data were collected between August and September 2025 via email invitations and QR code distribution. VPA and MPA were operationalized in accordance with WHO intensity thresholds (≥6 and 3–5.9 metabolic equivalents, respectively). SB was defined as waking time spent at <1.5 METs. Sleep duration was assessed via self-reports of typical nightly sleep over the preceding week.

Cognitive Assessment

Three validated, computerized tasks assessed EF components (Table 1). Testing was conducted in a standardized, quiet environment with tasks completed in counterbalanced order. A composite cognitive score was derived by summing z-scores across tasks.

The Flanker Task (10) assessed IC and FA. Participants responded to the direction of a central arrow while ignoring incongruent flanking distractors. The TMT-B assessed CF; participants connected alternating numbers and letters as rapidly as possible. The DFT assessed design fluency and generativity, with participants generating unique visual designs across three conditions of increasing complexity.

Table 1. Cognitive Assessment Battery: Task Descriptions and Outcome Variables

Task	EF Component	Outcome Variable	Scoring
Flanker Task	Inhibitory Control / Focus/Attention	Flanker Raw Score	Higher = better
Trail Making Test (TMT-B)	Cognitive Flexibility	TMT Raw (seconds)	Lower = better
Design Fluency Test (DFT)	Cognitive Flexibility / Generativity	DFT Raw Score	Higher = better

Composite Cognitive Score	Global EF	Composite (z-sum)	Higher = better

Note. EF = executive function; IC = Inhibitory Control; FA = Focus/Attention; CF = Cognitive Flexibility; TMT-B = Trail Making Test Part B; DFT = Design Fluency Test.

Data and Statistical Analysis

All statistical analyses were performed using SPSS version 26. Pearson correlation coefficients were computed to examine bivariate relationships among physical activity variables and between physical activity and cognitive performance. Multiple linear regression models were constructed to evaluate whether cognitive performance predicted VPA, MPA, and MVPA, with Flanker Raw, TMT Raw, and DFT Raw scores entered simultaneously as predictors. The statistical significance threshold was set at $\alpha = .05$ (two-tailed). All variables were checked for normality using the Shapiro-Wilk test and inspected visually via Q-Q plots.

Results

Descriptive Statistics

A total of 388 university students (51.0% male; mean age 20.4 ± 1.6 years) completed all assessments. Participant characteristics and descriptive statistics are presented in Table 2.

Table 2. Participant Characteristics and Descriptive Statistics

Characteristic	n / M	% / SD	Range
Gender			
Male	198	51.0%	—
Female	184	47.4%	—
Non-binary/prefer not to say	6	1.5%	—
Year of Study			
Year 1	97	25.0%	—
Year 2	102	26.3%	—
Year 3	98	25.3%	—
Year 4	91	23.5%	—

Age (years)	20.4	1.6	18–24
BMI (kg/m²)	22.1	3.4	16.5–31.2
VPA (min/week)	38.2	44.1	0–240
MPA (min/week)	112.6	88.3	0–480
SB (hours/day)	8.4	2.1	3.0–14.0
Sleep duration (hours/day)	6.9	1.1	4.0–10.0

Note. M = mean; SD = standard deviation; VPA = Vigorous Physical Activity; MPA = Moderate Physical Activity; SB = Sedentary Behavior.

Relationships Among Physical Activity Variables

As shown in Table 3, VPA and MPA demonstrated a strong positive correlation ($r = .549$, $p < .001$). SB was not significantly correlated with VPA ($r = .084$, $p > .05$) or MPA ($r = .031$, $p > .05$). Sleep duration likewise showed no significant associations with any physical activity variable.

Table 3. Pearson Correlation Coefficients Among Physical Activity Variables

Variable	VPA	MPA	SB	Sleep
VPA	—	.549***	.084	−.021
MPA	.549***	—	.031	−.014
SB	.084	.031	—	.062
Sleep	−.021	−.014	.062	—

Note. VPA = Vigorous Physical Activity; MPA = Moderate Physical Activity; SB = Sedentary Behavior. *** $p < .001$.

Physical Activity and Cognitive Performance

Table 4 presents correlations between physical activity variables and cognitive outcomes. Across all assessed cognitive measures, none of the physical activity variables—including VPA, MPA, SB, or sleep duration—reached statistical significance (all $p > .05$).

Table 4. Pearson Correlation Coefficients Between Physical Activity Variables and Cognitive Performance

Variable	Flanker Raw	TMT Raw	DFT Raw	Composite
VPA	.018	−.031	.022	−.041
MPA	−.012	.029	−.008	.019
SB	.041	.015	−.033	.028
Sleep	−.027	−.019	.011	−.022

Note. VPA = Vigorous Physical Activity; MPA = Moderate Physical Activity; SB = Sedentary Behavior; TMT = Trail Making Test; DFT = Design Fluency Test. All correlations non-significant ($p > .05$).

Correlations Among Cognitive Variables

Several significant intercorrelations were observed among the cognitive measures (Table 5). Flanker Raw and DFT Raw scores were positively correlated ($r = .153$, $p = .002$). Flanker Raw scores demonstrated a moderate negative correlation with the composite score ($r = −.468$, $p < .001$). TMT Raw scores were strongly negatively correlated with the composite score ($r = −.683$, $p < .001$). DFT Raw scores showed a strong positive relationship with the composite score ($r = .593$, $p < .001$), confirming the coherence of the cognitive construct.

Table 5. Pearson Correlation Coefficients Among Cognitive Performance Variables

Variable	Flanker	TMT	DFT	Composite
Flanker Raw	—	—	.153**	−.468***
TMT Raw	—	—	—	−.683***
DFT Raw	.153**	—	—	.593***
Composite Score	−.468***	−.683***	.593***	—

Note. TMT = Trail Making Test; DFT = Design Fluency Test. ** $p < .01$; *** $p < .001$.

Regression Analysis

Multiple regression models evaluated whether cognitive function predicted physical activity engagement, with Flanker Raw, TMT Raw, and DFT Raw scores simultaneously entered as predictors of VPA, MPA, and MVPA. As shown in Table 6, no cognitive predictor reached statistical significance in any model (all $p > .05$).

Table 6. Multiple Regression Results: Cognitive Variables as Predictors of Physical Activity

Outcome	Predictor	β	SE	p
VPA	Flanker Raw	−.020	.052	.692
	TMT Raw	.012	.049	.810
	DFT Raw	.010	.053	.844
MPA	Flanker Raw	−.022	.051	.670
	TMT Raw	.026	.048	.607

	DFT Raw	−.025	.050	.634
MVPA	Flanker Raw	−.023	.049	.650
	TMT Raw	.019	.047	.710
	DFT Raw	−.002	.051	.975

Note. β = standardized regression coefficient; SE = standard error; VPA = Vigorous Physical Activity; MPA = Moderate Physical Activity; MVPA = Moderate-to-Vigorous Physical Activity. All $p > .05$.

Discussion

This study investigated cross-sectional associations between PA, sleep duration, and three core EF components—inhibitory control, focus/attention, and cognitive flexibility—in Thai university students. Two principal findings emerged: no PA variable demonstrated a statistically significant correlation with any cognitive outcome; and cognitive performance did not significantly predict PA engagement.

Exercise Dose and the Neurophysiological Threshold

Research indicates that aerobic exercise of sufficient dose—typically moderate-to-vigorous intensity sustained over weeks to months—is necessary to elicit the neurophysiological adaptations associated with EF improvement (12). In the present sample, habitual PA likely reflected participation at or near WHO minimum guidelines rather than the higher aerobic loads required to stimulate BDNF release and prefrontal circuit remodeling (14).

Neurodevelopmental Stage: The Prefrontal Maturation Ceiling

Young adults at peak cortical development may demonstrate a functional ceiling effect whereby existing neural efficiency limits the detectability of exercise-related gains (15). This interpretation is consistent with evidence that executive function reaches its developmental peak in young adulthood before declining in midlife (26), and that exercise-related cognitive benefits appear more consistent in children and older adults than in young and middle-aged adults (27,28). Within this age group specifically, a recent network meta-analysis found that coordinative and cognitively engaging exercise (e.g., combined with working memory training) produced small-to-large benefits for executive function, whereas habitual endurance/aerobic exercise alone showed no significant effect on inhibitory control or working memory, similar to the pattern observed in the present study (25). Exercise-related improvements in tasks such as the Flanker have been more consistently reported among fit children than among young adults (7). This age-by-task type interaction suggests that the particular EF components most sensitive to exercise benefit may not align well with a university student sample.

Population-Specific Context: Thai University Students

A study of Thai university students during the COVID-19 pandemic found that 85.3% reported a sedentary lifestyle and 57.46% failed to meet WHO PA guidelines (18). A large-scale cross-sectional study across seven ASEAN countries found that recreational and study-related activities—rather than structured aerobic training—were the dominant PA domains, and 44.1% of students engaged in more than 8 hours per day of sedentary behavior (17). These findings suggest that even among students who are nominally "active," the type and intensity of their PA may be insufficient to produce neurophysiological adaptations required for EF gains. It is worth noting that not all recent evidence from university populations is null: a large cross-sectional study of Chinese college students reported a significant positive association between habitual PA and executive function that was partly mediated by self-efficacy and negative emotion (23). The divergence between that finding and the present results may reflect differences in PA measurement approach, EF instrumentation, and unmeasured psychosocial mediators, underscoring the need for comparable, standardized methodologies across the region.

Internal Consistency of the Cognitive Battery

Notwithstanding the null PA findings, the cognitive measures exhibited theoretically coherent and statistically significant intercorrelations. Flanker, TMT-B, and DFT scores were all significantly associated with the composite EF index ($|r| = .468$ to $.683$), consistent with Miyake et al.'s (8) unity-and-diversity framework, supporting the construct validity of the cognitive battery for future experimental work.

Limitations and Future Directions

Several limitations inform the interpretation of these findings. Foremost among these is the exclusive reliance on a self-reported questionnaire to assess PA and sedentary behavior. Self-report instruments are susceptible to recall and social desirability bias; in one validation study of undergraduate students, self-reported activity measures showed only low-to-moderate correlations with accelerometer-derived estimates ($r = 0.21$ to 0.38 across activity variables), and approximately 25% of students were misclassified as meeting physical activity guidelines relative to objective measurement (22). While the AUN-HPN survey instrument used here has been administered across large, multi-country ASEAN samples, its psychometric properties have not been formally re-established for this specific Thai university sample. This measurement limitation, rather than the cross-sectional design alone, may be the more parsimonious explanation for the null PA-EF associations observed here and should be regarded as a primary constraint on the interpretability of these findings. The cross-sectional design precludes causal inference. Important covariates including age, sex, body composition, and cardiorespiratory fitness were not incorporated into the analytical models. The cognitive battery did not include dedicated measures of working memory; future studies should incorporate instruments such as a Continuous Performance Test and n-back task. Future research should employ randomized controlled trials, device-based objective exercise monitoring (e.g., accelerometry or wearable sensors) in place of, or alongside, self-report instruments, and rigorous covariate adjustment, along with cross-cultural comparative designs in Southeast Asian university populations.

Conclusion

The present cross-sectional study found no significant associations between habitual PA levels and EF in Thai university students. These null findings highlight the critical importance of study design, exercise dose specification, and measurement precision when investigating the exercise-cognition interface in emerging adult populations. The strong internal consistency of the cognitive battery validates its application in future experimental research. Longitudinal and intervention-based designs are needed to establish whether targeted increases in PA can produce meaningful gains in EF and academic performance.

Applicable Remarks

The present findings suggest that the cognitive benefits of PA are most likely to emerge from structured, progressive, and sufficiently dosed exercise interventions rather than from habitual recreational activity (14). Because the present null findings were derived from a single cross-sectional sample assessed with self-reported PA measures, this recommendation should be regarded as a hypothesis to be tested rather than an established practice guideline. Universities seeking to leverage PA for cognitive and academic enhancement would benefit most from experimental and longitudinal designs capable of establishing dose-specific and causal evidence.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of King Mongkut's University of Technology

Thonburi (Approval No. KMUTT-IRB-2025/0619/186). Written informed consent was obtained from all participants prior to data collection. No identifiable personal information was collected, and all data were anonymized prior to analysis.

Data Availability Statement

The de-identified dataset supporting the findings of this study is available from the corresponding author upon reasonable request, subject to institutional data-sharing policies and participant consent restrictions.

Authors' Contributions

A.B., Aungkana Boonsem; W.K., Wongsapat Kaewkamnerdpongse; S.S., Sujittra Srisung; K.I., Keerati Intawachirarat.

1. Study concept and design: K.I.; A.B.

2. Acquisition of data: A.B.; S.S.

3. Analysis and interpretation of data: W.K.; K.I.

4. Drafting of the manuscript: A.B.; K.I.

5. Critical revision of the manuscript for important intellectual content: K.I.

6. Statistical analysis: W.K.

7. Administrative, technical, and material support: S.S.

8. Study supervision: K.I.

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The authors declare no conflicts of interest and have no financial interests related to the material in the manuscript.

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Role of the Sponsor

The funding organization had no role in the design and conduct of the study; the collection, management, and analysis of the data; or the preparation, review, and approval of the manuscript.

Artificial Intelligence (AI) Use

During the preparation of this work the authors used Claude (Anthropic) to assist with language editing and manuscript formatting. The technology was applied only to improve readability and language, with full human oversight. The authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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