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PHYSICAL ACTIVITY AS A PREDICTOR OF COGNITIVE FUNCTION: A STUDY OF UNIVERSITY STUDENTS

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Abstract

This research explored physical activity (PA) as a cognitive function predictor among university students at Gomal University, Pakistan. A quantitative cross-sectional study design was employed wherein 308 hostel-staying students were proportionally sampled from nine hostels using simple random sampling. Self-reported levels of PA (vigorous, moderate, sedentary) and sport participation were assessed using the International Physical Activity Questionnaire (IPAQ), whereas cognitive function was determined through the Cognitive Abilities Questionnaire (CAQ). Analyses found no meaningful connection between PA and cognitive results: Pearson correlation indicated negligible association ($r= .001$, $p= .987$), linear regression revealed PA intensities didn't forecast cognition ($F = 1.318$, $p = .268$; adj. $R^2 = .003$), and athletes didn't show any cognitive benefit compared to non-athletes ($t = 0.141$, $p = .888$). The results indicate that within high-pressure academic contexts such as Pakistan's collectivist university context, PA might not act as a cognitive predictor, stressing the significance of cultural and contextual moderators. The recommendations are culturally tailored PA interventions and comprehensive policies of well-being.

INTRODUCTION

Cognitive ability including processes such as memory, attention, executive control, and learning are central to academic and overall health success, especially for university students facing challenging intellectual environments. A large body of research has confirmed an intriguing relationship between physical activity (PA) and cognitive functioning throughout the lifespan. In elderly people, regular PA is a widely documented preventive factor for cognitive decline and dementia, increasing neuroplasticity and maintaining cognitive reserve (Rockwood & Middleton, 2007; Carvalho et al., 2014; Weuve et al., 2004; de Souto Barreto et al., 2016; Jehu et al., 2025). Likewise, in adolescents and youth, greater PA and fitness are strongly linked with enhanced cognitive functioning, academic performance, and basic movement skills (Bidzan-Bluma & Lipowska, 2018; Donnelly et al., 2016; Haapala et al., 2025; Grady et al., 2025). There is also evidence of benefits in middle-aged adults (Singh-Manoux et al., 2005; Dustman et al., 1994). The underlying mechanisms, commonly referred to as "exercise is brain food," include increased cerebral blood flow, neurogenesis, synaptic plasticity, and the release of neurotrophic factors (Ploughman, 2008). Nonetheless, the connection between PA and cognitive ability in young adulthood, particularly in university students, is a more complicated and less uniformly defined relationship than in other stages of life (Cox et al., 2016). Young adulthood is marked by extensive neurodevelopmental maturation, especially in prefrontal cortex executive functions, together with distinctive lifestyle demands. University students usually experience more intense academic stress, non-standard sleep schedules, psychosocial stressors, and possible reductions in habitual PA than in previous adolescence (Ahsan & Abualait, 2025). All these would independently and interactively affect cognitive functioning and mental well-being, and mental well-being itself is closely associated with both PA and cognition (Ahsan

LITERATURE REVIEW

Sustained research throughout the lifespan illustrates a strong, often favorable, association between physical activity (PA) and cognition. In older age, PA is a strongly proven safeguard against cognitive impairment and dementia, increasing neuroplasticity and cognitive reserve (Rockwood & Middleton, 2007; Carvalho et al., 2014; Weuve et al., 2004; de Souto Barreto et al., 2016; Jehu et al., 2025). In the same vein, strong evidence associates greater

PA and fitness levels in kids and adolescents with enhanced cognitive functioning, academic performance, motor development, and mental well-being (Bidzan-Bluma & Lipowska, 2018; Donnelly et al., 2016; Haapala et al., 2025; Grady et al., 2025; Ghanamah, 2025). Advantages are also seen in middle-aged groups (Singh-Manoux et al., 2005; Dustman et al., 1994), with mechanisms suggested as augmented cerebral blood flow, neurogenesis, synaptic plasticity, and release of neurotrophic factors (Ploughman, 2008). In young adulthood, especially among university students, the interaction is less straightforward and not as strong (Cox et al., 2016). This neurodevelopmental window is a time of critical development, overlapping with specific academic stresses, psychosocial challenges, possible reductions in regular PA levels, and strong connections between PA, mental well-being, and cognition (Ahsan & Abualait, 2025). Although PA has an array of benefits for mental health within this population, its unique function as a predictor of varied cognitive processes within the high-pressure university setting is less clearly established than among other age groups and necessitates further research (Cox et al., 2016).

RESEARCH GAP

Although a wide body of evidence does show a favorable relationship between physical activity (PA) and cognitive ability from birth to older age (e.g., children, older adults), the form, magnitude, and temporal consistency of this relationship in university students is not well described and contextually poorly explored. Prior reviews of young people (e.g., Cox et al., 2016) identify important heterogeneity in results, and propose that this key period of neurodevelopment—characterized by distinct academic pressures, psychosocial stressors, lifestyle instability, and well-documented associations between PA and mental health (Ahsan & Abualait, 2025)—may influence PA's cognitive effects differently from other age ranges. Key to this is a shortage of studies testing PA as a direct predictor of individual cognitive domains (e.g., executive function, working memory, processing speed) in the challenging university setting, controlling for influential confounding and mediating variables common in this group (e.g., stress, sleep quality, mental health status). This constrains the creation of individualized evidence-based PA interventions to maximize cognitive functioning and academic resilience in students.

RESEARCH HYPOTHESES

H_A 1 There will be a significant positive correlation between self-reported levels of moderate-to-vigorous physical activity cognitive function among university students.

H_A 2 Levels of objectively measured physical activity (e.g., via accelerometer) will be a significant positive predictor of overall cognitive functions in university students,

H_A 3 University students identified as athletes will report higher levels of perceived cognitive function compared to their non-athlete.

RESEARCH METHODOLOGY

This research utilized quantitative, cross-sectional design to explore the association between physical activity (PA) and cognitive function among hostel students of Gomal University, Dera Ismail Khan. The population of interest was 1,347 hostel students. Through the Slovin formula and proportional sampling according to hostel population size, a representative sample of 308 students was estimated and chosen through simple random sampling from 9 hostels. Concurrently, data were collected with the help of two standardised tools: International Physical Activity Questionnaire (IPAQ) to quantify PA levels (independent variable) and Cognitive Abilities Questionnaire (CAQ) for cognitive function assessment (dependent variable). Demographic variable (athletes and non-athletes) was also documented. Correlational as well as regression analyses were used to examine relationships between PA and cognitive function to answer the research hypotheses.

RESULTS

TABLE 1: PEARSON CORRELATION SHOWING THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVELS AND COGNITIVE FUNCTIONS

Descriptive Statistics

	Mean	Std. Deviation	N
Physical Activity Level Categories	2.3019	.66293	308
Cognitive Functions	2.0523	.28435	308

Correlations

		Physical Activity Level Categories	Cognitive Functions
Physical Activity Level Categories	Pearson Correlation	1	.001
	Sig. (2-tailed)		.987

	N	308	308
Cognitive Functions	Pearson Correlation	.001	1
	Sig. (2-tailed)	.987	
	N	308	308

The Pearson correlation analysis revealed a statistically non-significant, negligible relationship between Physical Activity Level Categories and Cognitive Functions among the sampled university students (r = .001, p = .987). The near-zero correlation coefficient indicates no meaningful linear association exists between these variables in this dataset. While the descriptive statistics show variation in both Physical Activity (M = 2.30, SD = 0.66) and Cognitive Function scores (M = 2.05, SD = 0.28), the lack of a significant correlation suggests that differences in self-reported physical activity levels, as measured, do not predict or correspond to differences in self-reported cognitive function scores within this specific sample.

TABLE 2: LINEAR REGRESSION SHOWING THE EFFECTS OF PHYSICAL ACTIVITY LEVELS ON COGNITIVE FUNCTIONS

***Model Summary*[b]**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.113[a]	.013	.003	.28391

a. Predictors: (Constant), Sedentary Physical Activity, Vigorous Physical Activity, Moderate Physical Activity

b. Dependent Variable: Cognitive Functions

***ANOVA*[a]**

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	.319	3	.106	1.318	.268[b]
Residual	24.503	304	.081		
Total	24.822	307			

a. Dependent Variable: Cognitive Functions

b. Predictors: (Constant), Sedentary Physical Activity, Vigorous Physical Activity, Moderate Physical Activity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.071	.029		70.780	.000
	Vigorous Physical Activity	-1.466E-5	.000	-.090	-1.519	.130
	Moderate Physical Activity	2.118E-5	.000	.081	1.354	.177
	Sedentary Physical Activity	-1.280E-5	.000	-.057	-.997	.320

a. Dependent Variable: Cognitive Functions

The linear regression model examining the predictive effect of physical activity levels (vigorous, moderate, sedentary) on cognitive functions was statistically non-significant ($F(3,304) = 1.318$, $p = .268$). The model accounted for only 1.3% of the variance in cognitive function scores (Adjusted $R^2 = .003$). None of the individual PA components significantly predicted cognitive function: vigorous PA ($\beta = -.090$, $p = .130$), moderate PA ($\beta = .081$, $p = .177$), or sedentary PA ($\beta = -.057$, $p = .320$). The extremely small standardized coefficients ($\beta \leq |.090|$) indicate no meaningful relationship between any PA intensity level and cognitive outcomes in this sample. The constant (intercept = 2.071, $p < .001$) confirms the baseline cognitive function level when PA is zero, but the overall model lacks predictive utility.

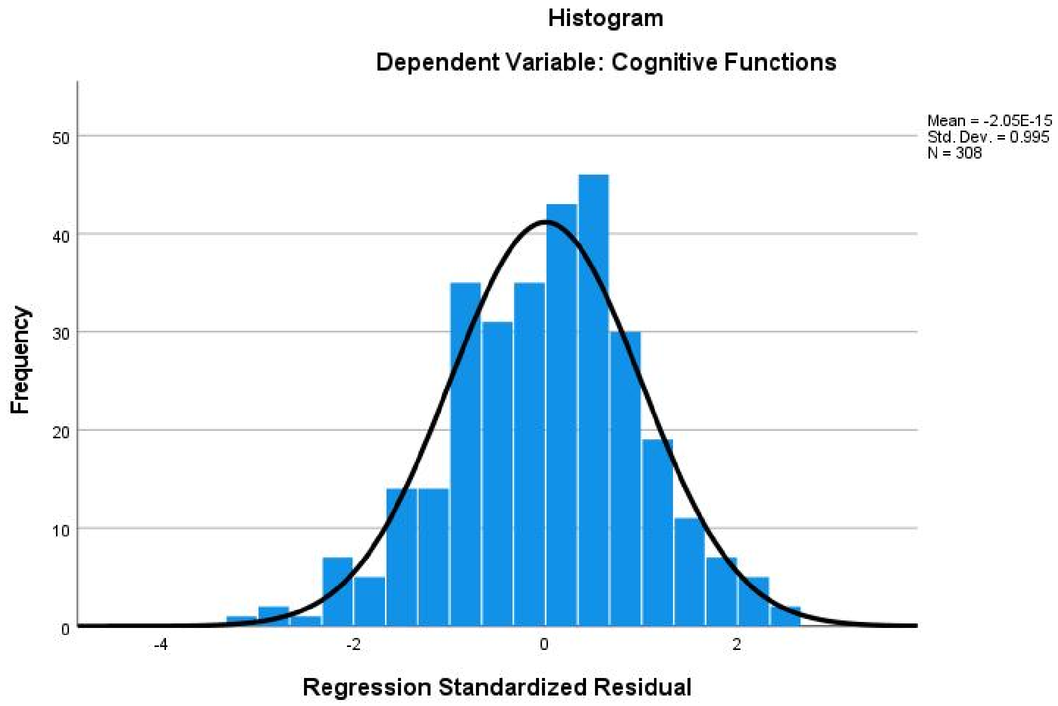

TABLE 3: INDEPENDENT SAMPLES T-TEST RESULTS: COGNITIVE FUNCTIONS BETWEEN ATHLETES AND NON-ATHLETES

Group Statistics

	Sports Participation	N	Mean	Std. Deviation	Std. Error Mean
Cognitive Functions	Athlete	115	2.0553	.24581	.02292
	Non-athlete	193	2.0506	.30561	.02200

Independent Samples Test

Levene's Test for Equality of Variances		t-test for Equality of Means						
							95% Confidence Interval of the Difference	
F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper

Cognitive Functions	Equal variances assumed	3.700	.055	.141	306	.888	.00473	.03355	-.06128	.07075
	Equal variances not assumed			.149	279.780	.882	.00473	.03177	-.05780	.06727

Independent Samples Effect Sizes

				95% Confidence Interval	
		Standardizer[a]	Point Estimate	Lower	Upper
Cognitive Functions	Cohen's d	.28480	.017	-.214	.247
	Hedges' correction	.28550	.017	-.214	.247
	Glass's delta	.30561	.015	-.215	.246

a. The denominator used in estimating the effect sizes.

Cohen's d uses the pooled standard deviation.

Hedges' correction uses the pooled standard deviation, plus a correction factor.

Glass's delta uses the sample standard deviation of the control group.

The independent samples t-test revealed no statistically significant difference in cognitive function scores between athletes (M=2.055, SD=0.246) and non-athletes (M=2.051, SD=0.306), t(306) = 0.141, p= .888. Effect sizes were negligible (Cohen's d= 0.017), confirming that athletic status did not meaningfully predict cognitive outcomes in this sample. The 95% confidence interval for the mean difference (-0.061 to 0.071) includes zero, reinforcing the absence of a meaningful group effect.

DISCUSSION

This research set out to explore whether physical activity would be predictive of cognitive function among university students. Contraryto expectations based on larger lifespan literatures, analysis showed no discernible relationship between the levels of physical activity and cognitive performance. Higher activity participants—with vigorous, moderate, or even athletic participation—did not show better cognitive function than their less active counterparts. This would indicate that in this particular academic and cultural setting, physical activity may not have the cognitive effects noted in other groups or environments. The lack of a PA-cognition relationship might indicate culturally particular Pakistani higher education dynamics. Within collectivist academic cultures in which high-stakes testing overwhelms agendas, physical activity might serve merely as stress reduction or social engagement and not cognitive improvement. Bronfenbrenner's ecological systems theory demonstrates: institutional stressors (e.g., overfilled hostels, tight curricula) can suppress PA's biological processes. Culturally immersed study strategies (e.g., extended sitting revision) may also disconnect activity from cognitive performance, supporting the need for contextual modification of Western-derived PA-cognition models. These results are consistent with literature citing inconsistent PA-cognition associations in young adults (Cox et al., 2016), compared to more robust evidence in children (Bidzan-Bluma & Lipowska, 2018) or elderly (Rockwood & Middleton, 2007).

The null athlete advantage fits with Ahsan & Abualait's (2025) focus on student-specific stressors being capable of cancelling out PA benefits. Methodologically, the use of self-reported indices (IPAQ/CAQ) mirrors strengths and weaknesses of other student research in which cultural meaning of "physical activity" and "cognitive difficulty" could be variable compared to clinical samples. Study limitations are that cross-sectional design avoids making causal inferences, self-report bias possibilities in cognition and physical activity measures, exclusion of important covariates such as sleep quality and academic pressure, and limited generalizability to hostel-residing students only. Future studies must utilize longitudinal designs with device-measured activity monitoring (e.g., accelerometers) and performance-based cognitive assessments. Culturally adapted interventions that incorporate PA with academic practice should be piloted, in addition to critical analysis of moderators such as resilience to stress and socioeconomic characteristics among South Asian university student groups. Sampling to various universities would improve transferability of evidence.

CONCLUSION

This work investigated whether physical activity is a predictor of cognitive function in students at the Gomal University of Pakistan. In contrast to established findings for other age groups and cultures, no evident association was found between physical activity levels—either self-reported overall activity, intensity by domain (vigorous, moderate, sedentary), or sports participation—and cognitive performance. The repeated failure to find association across regression, correlation, and group-comparison analyses indicates that, in this particular group of Pakistani hostel-resident students, physical activity does not serve as a significant predictor of intellectual outcome. These results emphasize the unique importance of cultural and academic context in shaping the PA-cognition link. The high-stakes, examination-driven culture of Pakistani higher education—combined with resource limitations and collectivistic study habits—can potentially derail neurobiological mechanisms connecting activity to cognitive benefit. Future studies need to make culture-adapted methods a top research priority, combining objective activity measurement (e.g., accelerometers), performance-based assessments of cognition, and important contextual covariates (e.g., academic stress, sleep quality). Interventions that address student cognition could necessitate means beyond universal PA promotion that incorporate hybrid strategies to synergize physical activity with the academic routine or stress-reduction protocols.

CONFLICT OF INTEREST

The authors declare no financial, personal, or professional conflicts of interest that could have influenced the design, execution, analysis, or reporting of this research.

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