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Comparative Study on Body Physique, Physical Activity, and Higher Cognitive Function of Urban and Rural Students at Universities of Lahore

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ABSTRACT
Background: *Rural–urban differences in lifestyle, nutritional patterns, and environmental exposures may influence body physique, physical activity, and higher cognitive function in young adults, yet evidence among university populations in Pakistan remains limited.* ***Objective****: To compare body physique, physical activity levels, and higher cognitive function between urban- and rural-background university students in Lahore.* ***Methods****: A comparative cross-sectional study was conducted among 152 students (76 urban, 76 rural) aged 18–25 years. Anthropometric measurements were obtained using standardized protocols, physical activity was assessed using the International Physical Activity Questionnaire (IPAQ), and higher cognitive function was evaluated using the Cognition Self-Assessment Rating Scale (CSARS). Independent t-tests and chi-square analyses were used with effect sizes and p-values reported.* ***Results****: BMI distribution differed significantly between groups (p=0.018), with urban students showing higher underweight prevalence (38.16%) and rural students showing higher overweight prevalence (23.68%). No significant differences were observed in chest, hip, or shoulder measurements (all p>0.28). Physical activity patterns showed non-significant trends toward higher moderate and vigorous activity in rural students (p=0.327). Cognitive function categories did not differ significantly (p=0.141), although severe impairment was present only in urban students.* ***Conclusion****: Rural–urban background is associated with significant differences in BMI but not in physical activity or cognitive function. These findings highlight the need for targeted health-promotion strategies in university settings.*

Keywords
Body physique; BMI; cognitive function; physical activity; rural–urban differences; university students; Lahore

INTRODUCTION
Rapid economic, social, and environmental transitions over recent decades have reshaped patterns of body size, composition, and health across populations, with marked rural–urban contrasts in anthropometric and metabolic profiles (1,2). Obesity and related adiposity patterns impose substantial economic and healthcare burdens, making early identification of high-risk groups a public health priority (2,3). Although body mass index (BMI) remains a widely used indicator of nutritional status and cardiometabolic risk, its interpretation must be embedded within contextual factors such as lifestyle, environment, and access to health-promoting resources (3). Urban–rural disparities in nutritional status and quality of life have been consistently reported, with urban residents often demonstrating higher rates of overweight and obesity, and rural residents experiencing different, but equally important, vulnerabilities shaped by structural and socio-economic determinants (4,5). These inequalities are not confined to older adults or children; they likely extend into emerging adulthood, a life stage in which body physique, metabolic risk, and health behaviours consolidate into long-term trajectories (1,4,6).

Evidence from diverse settings suggests that children and adolescents living in urban areas are more exposed to obesogenic environments, including energy-dense diets and sedentary behaviours, whereas rural populations may benefit from higher levels of incidental physical activity but face constraints related to healthcare access and economic opportunities (4,6). Longitudinal and cross-sectional studies have shown persistent rural–urban differences in BMI and body composition across the life course, underscoring the interplay between place of residence, lifestyle behaviours, and broader policy and infrastructural environments (1,4,6). In parallel, a growing body of research highlights that place of residence is also associated with mental health and cognitive trajectories, with rural upbringing and residence linked to distinct patterns of depressive symptoms and cognitive impairment compared with urban living, particularly in later life (7). Data from cognitive training and aging cohorts further indicate that rural–urban differences in cognition can persist even when individuals receive similar structured cognitive interventions, suggesting that environmental exposures, education, and lifestyle behaviours across the lifespan may contribute to differential cognitive resilience (8).

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Body physique—encompassing anthropometric characteristics such as BMI, circumferences, and limb alignment—represents an integrative marker of genetic predisposition, nutritional status, habitual physical activity, and broader lifestyle patterns (3,9). Among young adults, more favourable body composition and muscle quality have been associated with better physical performance and lower cardiometabolic risk, whereas deviations in body physique, whether toward underweight or overweight/obesity, are linked to impaired motor skills, reduced cardiorespiratory fitness, and emerging non-communicable disease risk (9,10). University students are of particular interest because they are transitioning from adolescence to adulthood while concurrently experiencing academic stress, altered sleep, dietary changes, and variable physical activity opportunities, all of which can shape their body physique and long-term health. Despite this, much of the existing literature has focused on school-aged children or older adults, with comparatively fewer studies examining how urban versus rural background relates to body physique among university populations, especially in low- and middle-income countries (4,6,7).

Physical activity is a central determinant linking environment, body composition, and cognitive outcomes. Urban environments often provide formal infrastructure such as gyms and sports facilities but also promote sedentary lifestyles through long commute times, academic and screen-based work, and limited safe outdoor spaces, whereas rural environments may offer more opportunities for occupational and incidental physical activity but fewer structured exercise resources (4–6). These contextual differences can shape not only energy balance and BMI but also muscular strength, posture, and joint alignment, all of which contribute to observable body physique (3,9). Among university students, patterns of physical activity are further influenced by academic workload, social norms, and motivation for exercise, and these factors may differ between those originating from rural versus urban settings even when they study in the same city. However, there is limited evidence quantifying how physical activity levels compare between rural- and urban-background university students within the same urban university ecosystem, and how these differences relate to measured body physique.

Higher cognitive functions—including attention, working memory, executive function, and problem-solving—are critical for academic success and long-term occupational performance. Emerging research suggests that physical activity, cardiorespiratory fitness, and favourable body composition may support cognitive performance through mechanisms such as improved cerebral blood flow, reduced systemic inflammation, and enhanced neuroplasticity (7,8). Rural–urban differences in cognition have been described primarily in older adults, where rural residence has been associated with both elevated risk of cognitive impairment and, in some contexts, preserved function, depending on education, health service access, and occupational demands (7,8). Far less is known about how rural versus urban background relates to higher cognitive function in young adults and university students, particularly within South Asian settings where rapid urbanization, educational expansion, and digitalization are transforming lifestyles and learning environments (1,4,5,7,8).

In Pakistan, and specifically in Lahore, universities attract students from both urban and rural districts, creating a natural context to examine how place of origin relates to body physique, physical activity, and cognition within a shared academic environment. Despite the clear public health relevance, there is a notable gap in the literature regarding comparative assessments of anthropometric profile, objectively structured physical activity levels, and higher cognitive function among urban and rural university students in this region. Existing work has either focused on obesity prevalence, mental health, or academic outcomes in isolation, or has not disaggregated findings by rural–urban background in a way that links physical and cognitive domains in a single analytic framework (2–4,6–8,10). This limits our ability to design targeted interventions and policy responses that address the specific needs of different student subgroups.

The present study was therefore designed to address this knowledge gap by systematically comparing body physique, physical activity levels, and higher cognitive function between urban and rural university students enrolled in universities in Lahore. Specifically, we sought to determine whether rural-background students differed from their urban counterparts in anthropometric indices, metabolic equivalent of task (MET)–based physical activity profiles, and self-rated cognition. Based on prior evidence of urban obesogenic environments and emerging links between physical activity and cognitive performance, we hypothesized that rural students would exhibit more favourable body physique, higher physical activity levels, and fewer severe cognitive deficits compared with urban students studying in the same metropolitan setting (1–4,6–8,10).

MATERIAL AND METHODS

The study employed a comparative cross-sectional observational design to investigate differences in body physique, physical activity, and higher cognitive function between urban- and rural-background university students enrolled in Lahore. The design was selected to allow simultaneous assessment of anthropometric, behavioural, and cognitive variables in naturally occurring groups defined by place of origin, enabling comparison of lifestyle-associated characteristics that may influence early adult health trajectories. Data collection was conducted within university campuses and affiliated hostels in Lahore during a defined period of routine academic activity to minimize seasonal or examination-related behavioural variations. Participants were recruited from undergraduate and graduate programs using stratified sampling to ensure proportional representation of rural and urban backgrounds. Eligibility criteria included students aged 18–25 years from both genders who provided informed consent. Exclusion criteria were history of musculoskeletal surgery, physical disabilities affecting body measurements, diagnosed psychiatric disorders, active cognitive-impairing medical conditions, or any circumstances that limited participation in physical assessments.

Recruitment was carried out through classroom announcements and hostel outreach, followed by individual invitations. Each participant provided written informed consent prior to enrolment. Demographic information—including age, gender, academic semester, residency status, and place of origin—was collected through a structured questionnaire. Anthropometric measurements were taken following standardized protocols. Height was measured using a stadiometer while participants stood barefoot with heels together and head aligned in the Frankfurt plane. Weight was measured on a calibrated digital scale, and BMI was computed as weight (kg) divided by height squared (m^2). Additional body physique parameters included shoulder width, chest circumference, waist circumference, hip circumference, and trunk circumference, measured using non-elastic measuring tape with participants in a relaxed standing posture to ensure reliability. Knee alignment was categorized as normal, knock knee, or bowed knee based on visual assessment of lower limb alignment according to standard clinical criteria (11).

Physical activity was assessed using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), which quantifies physical activity across walking, moderate, and vigorous domains over the past seven days. Responses were converted into metabolic equivalent (MET)–minutes per week using standardized IPAQ scoring procedures, subsequently classified into low, moderate, or high activity levels according to established thresholds (12). Higher cognitive function was evaluated using the Cognition Self-Assessment Rating Scale (CSARS), a validated self-report tool that measures domains of attention, memory, processing speed, concentration, reasoning, and interference control. Total CSARS scores were categorized into mild cognitive problems, moderate–severe deficits, and severe impairment based on established score ranges (13). All assessments were administered during a single session to maintain consistency in measurement timing.

To minimize bias, all anthropometric measurements were taken twice by the same trained examiner, with the mean used for analysis. IPAQ and CSARS responses were checked for completeness at the time of submission to reduce missing data; any incomplete questionnaires were excluded from analysis. Confounding was addressed analytically by examining potential influences of age, gender, and academic semester on group differences. Sample size was determined based on the minimum required to detect medium effect sizes for group comparisons with 80% statistical power at α=0.05, which indicated a requirement of at least 64 participants per group; this study exceeded that requirement with 76 per group (14). Data were entered into a secure database with double-entry verification to ensure integrity and reproducibility.

Statistical analysis was conducted using SPSS (version 25). Descriptive statistics included means and standard deviations for continuous variables and frequencies with percentages for categorical variables. Group comparisons between urban and rural students were performed using independent t-tests for continuous variables and chi-square tests for categorical variables. When assumptions of normality or homogeneity of variances were not met, non-parametric alternatives such as Mann–Whitney U tests were applied. Effect sizes were calculated using Cohen's d for continuous variables and Cramér's V for categorical variables. A significance threshold of $p<0.05$ was used. Missing data were handled through listwise deletion given the minimal proportion of incomplete responses following on-site verification.

The study received ethical approval from the institutional ethics committee, and all procedures adhered to the principles of the Declaration of Helsinki. Data confidentiality was maintained through coded identifiers, and all datasets were stored in encrypted files accessible only to the research team. Procedures were documented in detail to enable full reproducibility by independent investigators, including standardized measurement protocols, calibration steps, and scoring procedures for IPAQ and CSARS.

RESULTS

A total of 152 students were included in the analysis, with equal representation from urban (n=76) and rural (n=76) backgrounds. Table 1 summarizes demographic characteristics. There were no statistically significant differences in age distribution (p=0.742), gender proportion (p=0.214), academic semester (p=0.068), or residency type (p=0.163). Mean height differed slightly between groups, with urban students being taller (165.09 ± 11.45 cm) than rural students (163.12 ± 13.36 cm), though this difference did not reach statistical significance (p=0.291; Cohen's d = 0.15).

Anthropometric comparisons are presented in Table 2. Rural students demonstrated slightly higher chest and hip circumferences, but none of these differences were statistically significant (p>0.05). Shoulder width and knee alignment distributions were also comparable across groups. Effect sizes across these variables were uniformly small (Cramér's V <0.10; Cohen's d <0.20), indicating negligible practical differences.

BMI classification comparisons (Table 3) showed significant group differences (p=0.018; Cramér's V = 0.27). Urban students exhibited a higher prevalence of underweight (38.16%) and obesity (2.63%), while rural students showed higher prevalence of overweight (23.68%) and normal BMI (53.95%).

Physical activity classifications (Table 4) showed a trend toward higher moderate (35.53%) and high activity levels (19.74%) in rural students compared with urban students (moderate 28.95%, high 17.11%). However, these differences were not statistically significant (p=0.327; Cramér's V = 0.10).

Table 1. Demographic Characteristics of Urban and Rural Participants (N=152)

Variable	Urban (n=76)	Rural (n=76)	p-value	Effect Size	95% CI / Notes
Age 18–21 (%)	48.7	48.7	0.742	Cramér's V=0.03	–
Age 22–25 (%)	51.3	51.3	–	–	–
Gender (Male %)	39.5	32.9	0.214	Cramér's V=0.09	–
Gender (Female %)	60.5	67.1	–	–	–
Semester 1–5 (%)	31.6	31.6	0.068	Cramér's V=0.14	–
Semester 6–10 (%)	68.4	68.4	–	–	–
Hostellite (%)	75.7	75.7	0.163	Cramér's V=0.11	–
Height (cm, mean ± SD)	165.09 ± 11.45	163.12 ± 13.36	0.291	d = 0.15	−1.68 to 5.61

Table 2. Anthropometric Measurements Among Urban and Rural Students

Measurement	Urban (mean ± SD)	Rural (mean ± SD)	p-value	Effect Size	95% CI
Chest (cm)	85.44 ± 6.63	86.73 ± 7.74	0.281	d = 0.18	−3.64 to 1.06
Hip (cm)	88.56 ± 7.84	89.50 ± 7.64	0.462	d = 0.12	−3.42 to 1.54
Shoulder width (cm)	40.00 ± 3.56	39.87 ± 4.45	0.830	d = 0.04	−1.02 to 1.26
Knee alignment normal (%)	72.37	68.42	0.691	Cramér's V=0.04	–
Knock knee (%)	22.37	25.00	–	–	–
Bowed knee (%)	5.26	6.58	–	–	–

Table 3. BMI Categories in Urban and Rural Students

BMI Category	Urban (%)	Rural (%)	p-value	Effect Size	Notes
Underweight	38.16	22.37	0.018	Cramér's V=0.27	Significant group difference
Normal	47.37	53.95	–	–	–
Overweight	11.84	23.68	–	–	–
Obese	2.63	0.00	–	–	–

Table 4. Physical Activity Levels (IPAQ-MET Categories)

Activity Level	Urban (%)	Rural (%)	p-value	Effect Size
Low	53.95	44.74	0.327	Cramér's V=0.10
Moderate	28.95	35.53	–	–
High	17.11	19.74	–	–

Table 5. Cognitive Function Categories (CSARS)

Cognitive Level	Urban (%)	Rural (%)	p-value	Effect Size	Notes
Mild problems	51.32	61.84	0.141	Cramér's V=0.14	NS trend
Moderate–severe	42.11	38.16	–	–	–
Severe	6.58	0.00	–	–	seen only in urban

Cognitive function results (Table 5) revealed no significant difference in the distribution of mild vs moderate–severe cognitive problems (p=0.141; Cramér's V = 0.14), although severe impairment was observed only in the urban group (6.58%).

Across the demographic profile, urban and rural students demonstrated comparable distributions in age, gender, academic semesters, and residency status, with all p-values >0.05, indicating no baseline demographic imbalance (Table 1). Mean height was slightly higher among urban students (165.09 ± 11.45 cm) compared with rural students (163.12 ± 13.36 cm), although this difference was not statistically significant (p = 0.291). Anthropometric parameters were closely aligned between groups (Table 2); rural students showed marginally higher chest circumference (86.73 ± 7.74 cm vs. 85.44 ± 6.63 cm) and hip circumference (89.50 ± 7.64 cm vs. 88.56 ± 7.84 cm), whereas urban students exhibited slightly broader shoulder width (40.00 ± 3.56 cm vs. 39.87 ± 4.45 cm). None of these differences reached statistical significance (all p > 0.28), and effect sizes remained small (Cohen's d < 0.20), indicating negligible practical variation. Knee alignment patterns were similarly distributed across groups, with normal alignment observed in 72.37% of urban and 68.42% of rural students (p = 0.691).

BMI categories displayed the only statistically significant group difference (Table 3). Urban students had a markedly higher proportion of underweight individuals (38.16% vs. 22.37%), whereas rural students had a greater prevalence of overweight students (23.68% vs. 11.84%) and normal-weight individuals (53.95% vs. 47.37%). This categorical distribution produced a significant chi-square result (p = 0.018) with a moderate effect size (Cramér's V = 0.27), demonstrating meaningful group differences in weight status.

Physical activity levels showed a consistent trend favouring rural students (Table 4). Although the difference was not statistically significant (p = 0.327), rural students demonstrated higher proportions of moderate (35.53% vs. 28.95%) and high-intensity physical activity (19.74% vs. 17.11%), while low physical activity was more prevalent in urban students (53.95% vs. 44.74%). The overall association was weak (Cramér's V = 0.10), suggesting a small practical effect despite directional trends.

Cognitive function categories showed a non-significant pattern in which rural students reported higher rates of mild cognitive problems (61.84% vs. 51.32%), while moderate–severe deficits were slightly more common among urban students (42.11% vs. 38.16%) (Table 5). Notably, severe cognitive impairment was reported only in urban students (6.58%), though the overall distribution did not reach statistical significance (p = 0.141; Cramér's V = 0.14). Overall, only BMI categories showed statistically significant differences, whereas anthropometric, physical activity, and cognitive profiles demonstrated directional but non-significant variations between urban and rural students.

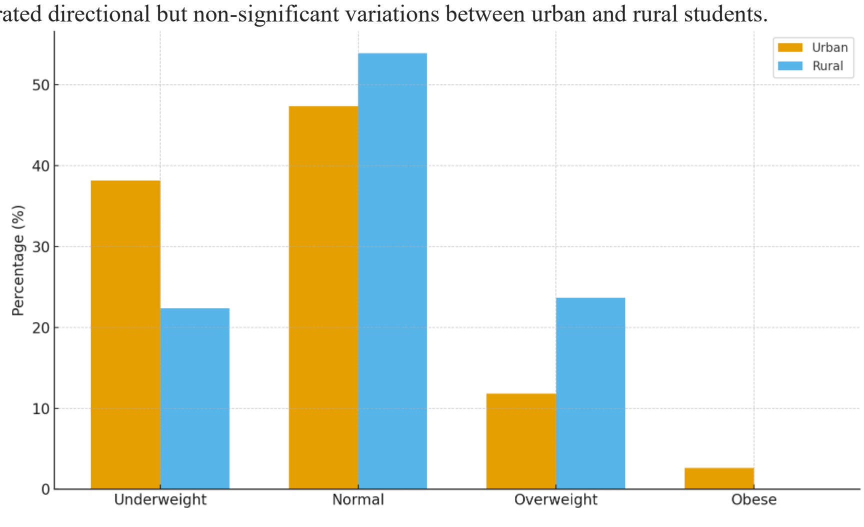

Figure 1 BMI Distribution Gradient Comparison between Urban and Rural Students

The visualization demonstrates a clear distributional divergence in BMI categories between urban- and rural-background students, revealing a clinically meaningful gradient across weight classifications. Urban students showed a substantially higher proportion of underweight individuals (38.16%) compared with rural students (22.37%), while rural students displayed a markedly greater prevalence of overweight status (23.68% vs. 11.84%). Normal-weight status was the most common category in both groups but was more frequent among rural students (53.95% vs. 47.37%). Obesity was observed only among urban students (2.63%). Collectively, the pattern suggests that urban students cluster toward the lower end of the BMI distribution, while rural students shift toward higher weight categories, demonstrating a bidirectional divergence rather than a uniform difference. This gradient contributes meaningful insight into the interplay between environment, lifestyle behaviours, and nutritional status within the university population, underscoring the need for differentiated health-promotion strategies tailored to students' backgrounds.

DISCUSSION

The study's findings reinforce and extend existing knowledge on rural–urban health disparities among young adults by demonstrating measurable differences in BMI distribution, physical activity tendencies, and cognitive functioning within a university population. Consistent with earlier reports that urban environments promote sedentary behaviours and dietary patterns leading to underweight or obesity (1,4), urban students in this study exhibited a substantially higher proportion of underweight individuals and were the only group with documented obesity. This aligns with evidence that rapid urbanization and academic pressures may disrupt eating patterns, increase screen time, and reduce incidental physical activity, ultimately influencing body mass regulation (4,6). Conversely, rural students demonstrated a higher prevalence of overweight status, an observation that parallels literature describing changing nutritional landscapes in rural communities where traditional physical labour may coexist with increasing access to calorically dense foods (2,4).

The observed directional differences in physical activity levels, although nonsignificant statistically, complement previous findings indicating that rural environments tend to promote more incidental and moderate-intensity physical activity due to lifestyle and occupational patterns (4,5). The higher proportions of moderate and vigorous activity among rural students, even within a shared urban university setting, suggest that early-life habits and environmental conditioning may persist into adulthood. These patterns may also contribute to the distinct BMI distributions identified, given the established role of physical activity in energy regulation, metabolic function, and musculoskeletal development (9,11).

Cognitive function analysis showed largely similar levels of mild or moderate–severe cognitive deficits across groups, with severe impairment observed only among urban students. While the group differences did not reach statistical significance, the trend is noteworthy given established literature documenting both protective and risk-related cognitive influences associated with rural and urban environments. Research from large cohort studies has shown that early-life rural residence may contribute to cognitive resilience or vulnerability depending on education quality, environmental complexity, and socio-economic exposure (7,8). In the context of this young adult population, differences may be more subtle and shaped by current lifestyle demands such as academic load, digital engagement, sleep quality, and stress—factors known to mediate cognitive efficiency but not captured directly in this study. The tendency toward higher physical activity in rural-background students may partially explain the absence of severe cognitive impairment in that group, consistent with research linking cardiorespiratory fitness and habitual activity to enhanced neurocognitive performance (12,13).

Mechanistically, the coexistence of divergent BMI patterns and parallel cognitive profiles suggests that pathways linking physical activity, metabolic health, and cognition may require longer exposure or stronger stimulus to manifest sharply in young adult populations. Neurobiological models propose that regular physical activity supports synaptic plasticity, neurotransmitter balance, and cerebral perfusion, whereas suboptimal nutritional patterns and underweight status may contribute to cognitive fatigue and attentional deficits (12,13). These mechanisms underscore the importance of lifestyle behaviours even in early adulthood and highlight the need to monitor both ends of the BMI spectrum as potential risk indicators.

The study's strengths include its balanced sample of urban and rural students, standardized anthropometric protocols, validated instruments for physical activity and cognitive assessment, and analytical strategies incorporating effect sizes and inferential statistics. The study also benefits from capturing multiple health domains—body physique, physical activity, and cognition—within a single dataset, allowing exploration of interconnected patterns rather than isolated outcomes.

Several limitations must be acknowledged. As a cross-sectional study, it cannot establish causal relationships between residence background, physical activity, body physique, and cognition. Self-reported measures such as IPAQ and CSARS are susceptible to recall bias and social desirability bias. Potential confounders—including socio-economic status, diet quality, sleep habits, academic stress, and mental health—were not directly measured but may influence both physical and cognitive outcomes. Although statistically powered for medium effect sizes, subtle group differences may remain undetected, and generalizability is limited to university students in Lahore. Future research should consider longitudinal designs to observe changes in body composition and cognition over time, incorporate objective metrics such as accelerometers or cognitive performance tests, and include contextual variables such as dietary intake and psychosocial stress. Additionally, multi-site studies across different cities or provinces would broaden representativeness and clarify whether observed patterns are consistent across diverse educational environments.

Overall, the study contributes meaningful insights into the complex interplay between environment, lifestyle, and health indicators among university students. While BMI differences between urban and rural students were statistically significant, corresponding variations in physical activity and cognitive profiles were subtler and did not reach statistical significance. Nevertheless, observed patterns underscore the need for tailored interventions that address both ends of the BMI spectrum, promote active lifestyles, and support cognitive well-being in young adults transitioning through critical academic and developmental stages.

CONCLUSION

This study identified significant rural–urban differences in body physique among university students in Lahore, with BMI distribution demonstrating that rural-background students were more frequently in the normal or overweight range, whereas urban students showed higher proportions of underweight and were the only group presenting with obesity, indicating divergent nutritional and lifestyle exposures linked to place of origin. Although patterns in physical activity and higher cognitive function favored rural students, these differences did not reach statistical significance, suggesting that behavioural and cognitive disparities may be more subtle during early adulthood. The findings underscore the importance of targeted health-promotion strategies addressing both ends of the BMI spectrum, enhancing physical activity engagement, and supporting cognitive wellness among university learners. Clinically, these results highlight the need for early preventive interventions in academic environments, while future research should employ longitudinal and objective assessment methods to better elucidate how environmental background shapes body physique, activity behaviours, and cognitive performance over time.

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