International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effect of Simple Desk Exercises on Concentration and Fatigue among University Students during Long Lectures: A Quasi-Experimental Pre-Post Interventional Study

Kush Sharma[1], Dr. Akshita Gaur[2]
Dr Shivani Gupta[3]

[1]Student, Physiotherapy, Career Point University, Kota
[2,3] Assistant Professor, Physiotherapy, Career Point University, Kota

ABSTRACT

Background: Prolonged lecture-based academic sessions lasting 120 minutes or more are a defining feature of higher education worldwide. Extended sedentary exposure during lectures is associated with progressive cognitive fatigue, attentional decline, and reduced academic engagement. Simple desk exercises, performable within classroom constraints without disrupting instruction, offer a promising non-pharmacological strategy to counteract these effects; however, empirical evidence in the Indian university context is limited.

Objective: To evaluate the effect of a one-week structured desk exercise programme on academic fatigue and sustained concentration among undergraduate university students during long lectures.

Methods: A quasi-experimental pre–post interventional design was employed. Eighty-nine undergraduate students from Career Point University, Kota, were initially screened; 64 who met the inclusion criteria (age 18–25 years, enrolled in ≥120-minute lecture courses, no major attentional or mobility disorders) were enrolled using stratified random sampling (37 females, 27 males). Participants underwent a one-week desk exercise programme comprising neck stretches, shoulder rolls (forward and backward), seated spinal twists, wrist circles, ankle pumps and leg extensions, and deep breathing exercises, performed during long lecture sessions. Primary outcome measures were the Fatigue Severity Scale (FSS; 9-item validated scale, score range 9–63) and the Wechsler Digit Span Test (WDST; forward and backward components assessing short-term verbal memory and working memory). Pre- and post-intervention data were compared using paired t-tests; statistical significance was set at $\alpha = 0.05$.

Results: Sixty-four participants completed both assessments. FSS scores decreased significantly from 45.86 ± 7.10 (pre) to 33.81 ± 12.90 (post), representing a mean reduction of 12.05 points ($t = 7.76$; $p < 0.001$). WDST scores improved significantly from 3.86 ± 1.33 (pre) to 6.59 ± 1.27 (post), a mean gain of 2.73 points ($t = -14.44$; $p < 0.001$). Both outcomes showed large and statistically highly significant within-group improvements.

Conclusion: A one-week structured desk exercise programme significantly reduced academic fatigue and improved short-term memory and attentional concentration in university students. These findings support the integration of brief, classroom-compatible movement breaks into higher education pedagogy as a low-cost, feasible, and evidence-based strategy for enhancing student well-being and cognitive engagement during prolonged academic sessions.

Keywords: desk exercises; academic fatigue; concentration; Fatigue Severity Scale; Wechsler Digit Span Test; university students; sedentary behaviour; classroom physical activity; working memory; cognitive performance

1. INTRODUCTION

Long lecture-based teaching remains the dominant instructional modality in higher education globally, valued for its efficiency in conveying large volumes of structured information to cohorts of students simultaneously [1]. In many universities across India, lecture sessions routinely last 90–120 minutes, often with minimal structured breaks. While pedagogically entrenched, this format places substantial and sustained demands on students' cognitive resources and produces prolonged, largely uninterrupted sedentary exposure [1,2]. The intersection of cognitive load and sedentary behaviour in this context has increasingly been identified as a significant but underaddressed public health and educational concern.

Sedentary behaviour during academic lectures is defined as prolonged sitting with minimal muscular activity and low energy expenditure. Neurophysiologically, extended sitting reduces cerebral blood flow and cortical arousal, diminishes catecholamine release, suppresses the reticular activating system, and increases subjective fatigue each independently compromising attentional capacity and information processing efficiency [2,5]. Students exposed to these conditions exhibit measurable attentional fluctuations within as little as 15–20 minutes of passive lecture time, with progressive decline in concentration, comprehension, and information retention as session duration increases [4,9].

Academic fatigue, encompassing both the physical and mental dimensions of exhaustion arising from sustained cognitive effort, is among the most frequently reported complaints in university populations. Li et al. (2022) reported that high academic demands combined with inadequate physical activity were the primary predictors of elevated fatigue in university students, with fatigue demonstrating significant negative associations with sleep quality and subjective well-being [14]. The Fatigue Severity Scale (FSS), validated by Krupp et al. (1989) and subsequently confirmed psychometrically across populations by Learmonth et al. (2013), provides a reliable, nine-item measure of fatigue severity and its functional impact, making it well suited for assessing intervention effects in an academic cohort [21,27].

Physical activity has been established as a potent modulator of cognitive function. Even brief bouts of low-to-moderate intensity movement increase cerebral perfusion, upregulate catecholamine and BDNF (brain-derived neurotrophic factor) levels, heighten arousal, and temporarily restore executive resource pools depleted by sustained cognitive effort [10,11]. In educational settings, classroom-embedded movement breaks, structured exercise intervals, and active learning strategies have each demonstrated measurable effects on attentional capacity and task performance. Fenesi et al. (2018) demonstrated that short exercise breaks during a university lecture significantly increased on-task attention and improved learning outcomes [7]. Peiris et al. (2021) confirmed via mixed-methods feasibility data that brief movement breaks during university classes were well-accepted, reduced sedentary behaviour, and

improved concentration and alertness [16]. Lynch et al. (2022) synthesised evidence from multiple trials showing that classroom movement breaks and physically active learning strategies reduced fatigue and supported student well-being [13].

Despite this growing evidence base, a significant gap remains in the literature regarding desk exercises defined as structured, low-intensity physical movements specifically designed to be performed while seated at a desk, without requiring equipment, specialist supervision, or interruption to the lecture flow. Most prior studies have examined standing breaks, formal exercise intervals outside the classroom, or active learning pedagogies, rather than simple, in-situ desk movements executable within standard classroom constraints. This distinction is particularly relevant in the Indian university context, where classroom design, lecture culture, and resource availability make external exercise breaks logistically challenging.

Concentration and working memory, assessed in the present study via the Wechsler Digit Span Test (WDST), are foundational cognitive capacities underpinning academic learning. The WDST evaluates both forward (short-term verbal memory) and backward (working memory) digit recall and is a well-validated, widely used neurocognitive instrument [26,28]. Improvement in WDST scores following an intervention provides direct evidence of enhanced attentional control and information processing capacity.

The present study was therefore designed to evaluate the effect of a one-week structured desk exercise programme, performed during long lectures, on academic fatigue (FSS) and cognitive concentration (WDST) in undergraduate university students. The alternate hypothesis posited that the intervention would produce significant reductions in FSS scores and significant improvements in WDST scores.

2. MATERIALS AND METHODS

Study Design and Setting

A quasi-experimental pre–post interventional design was employed, in which each participant served as their own control. The study was conducted at the Department of Physiotherapy, Career Point University, Kota, Rajasthan, India, from November 2025 to April 2026. Institutional approval and written informed consent from all participants were obtained prior to commencement.

Sample Size and Recruitment

Eighty-nine undergraduate students from Career Point University initially responded to the pre-screening Fatigue Severity Scale administered via a Google Form. Of these, 64 students met all inclusion criteria, provided written consent, and were enrolled in the study by stratified random sampling to ensure balanced gender representation. No participants withdrew after enrolment.

Inclusion and Exclusion Criteria

Inclusion criteria: (i) undergraduate students aged 18–25 years; (ii) enrolled in courses with scheduled ≥120-minute lecture sessions; (iii) regular attendance status; (iv) no requirement for mobility assistance; (v) willingness to attend all study sessions and adhere to the protocol; (vi) provision of written informed consent.

Exclusion criteria: (i) current diagnosis of a major attentional disorder (e.g., untreated ADHD); (ii) musculoskeletal, cardiovascular, vestibular, or neurological condition contraindicating mild seated movement; (iii) use of sedative or stimulant medication markedly affecting attention; (iv) acute illness on the day of assessment; (v) irregular student status; (vi) failure to attend all study sessions.

Intervention Protocol

All 64 participants underwent an identical structured desk exercise programme for one week, performed during long lecture sessions under the guidance of the investigator. Each exercise session lasted approximately 10–15 minutes and was embedded within the lecture without requiring participants to leave their seats or use any equipment. The protocol comprised six exercise types:

Table 1. Desk Exercise Intervention Protocol

Exercise	Technique / Instruction	Primary Benefit
Neck Stretches	Gentle lateral flexion and rotation of the neck to each side; held 5–10 seconds per side	Cervical muscle tension relief; reduces headache
Shoulder Rolls	Forward and backward circular rolling of shoulders; 10 repetitions each direction	Shoulder girdle circulation; reduces trapezius fatigue
Seated Spinal Twist	Rotate trunk to each side while seated; hands on opposite knee; hold 5 seconds	Spinal mobility; reduces lower back stiffness
Wrist Circles	Full rotational wrist circles in both directions; 10 repetitions each	Forearm and wrist muscle activation
Ankle Pumps & Leg Extensions	Dorsiflexion-plantarflexion pumps and straight knee extensions; 10 repetitions each	Lower limb circulation; reduces venous stasis
Deep Breathing Exercises	Diaphragmatic breathing: 4-count inhale, 4-count hold, 4-count exhale; 5 cycles	Autonomic modulation; reduces cortical arousal fatigue

Protocol administered in-situ within lecture settings for 1 week. No equipment required.

Outcome Measures

Fatigue Severity Scale (FSS): The FSS is a nine-item self-report scale assessing the severity of fatigue and its functional impact during daily activities over the preceding week. Each item is rated on a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree); total scores range from 9 to 63, with higher scores indicating greater fatigue. The FSS demonstrates high internal consistency (α = 0.88–0.95), strong test-retest reliability (r = 0.84), and robust construct validity, with published cut-off scores ($\geq$36 indicating clinically significant fatigue in non-clinical populations) [21,27]. It was administered via Google Form at baseline and immediately post-intervention.

Wechsler Digit Span Test (WDST): The WDST, derived from the Wechsler Adult Intelligence Scale (WAIS-IV), evaluates short-term verbal memory (forward span) and working memory / attentional control (backward span) [26,28]. The longest digit string correctly recalled in both forward and backward conditions was recorded; combined scores were used as the primary cognitive outcome measure. The WDST is a widely validated, clinician- and researcher-accepted measure of cognitive concentration and information processing capacity, with established normative data across the 18–25-year age range [26,28]. It was administered using printed standardised forms at pre- and post-intervention.

Statistical Analysis

All data were entered and analysed using Microsoft Excel. Descriptive statistics (mean ± standard deviation, median, range) were computed for all continuous variables at both time points. Within-group pre–post differences for FSS and WDST scores were evaluated using paired samples t-tests. Effect sizes were calculated using Cohen's d (d = mean difference / SD of differences). Statistical significance was defined as $p < 0.05$ (two-tailed). Gender-based descriptive comparison was also performed.

3. RESULTS

Participant Characteristics

Sixty-four participants completed the study (37 females, 27 males; mean age 19.86 ± 1.14 years; age range 17–22 years). All participants were undergraduate students at Career Point University, Kota, enrolled in courses with ≥120-minute scheduled lecture sessions. No participants withdrew after enrolment (0% attrition).

Table 2. Participant Demographic Profile (n = 64)

Variable	Category / Value	n (%)
Gender	Female	37 (57.8%)
	Male	27 (42.2%)
Age (years)	Mean ± SD	19.86 ± 1.14
	Range	17–22 years
Lecture Duration	Enrolled in ≥120-min courses	64 (100%)
Attrition	Completed both assessments	64 (100%)

SD = standard deviation.

Fatigue Severity Scale (FSS) Results

Pre-intervention, the mean FSS score was 45.86 ± 7.10, consistent with moderate-to-high academic fatigue in the study population, with all 64 participants scoring above the clinical threshold of 36, confirming clinically significant baseline fatigue. Post-intervention, the mean FSS score decreased to 33.81 ± 12.90, representing a mean absolute reduction of 12.05 points. Paired t-test analysis confirmed this change was statistically highly significant ($t = 7.76$; $df = 63$; $p < 0.001$). Post-intervention score variability increased (SD 12.90 vs 7.10), reflecting heterogeneity in individual response a finding discussed in relation to adherence and baseline fatigue severity below. The effect size was large (Cohen's $d \approx 0.97$).

Table 3. Fatigue Severity Scale (FSS) — Pre- and Post-Intervention Results (n = 64)

Variable	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Change (Δ)	t-value	p-value	Cohen's d	Significance
FSS Score	45.86 ± 7.10	33.81 ± 12.90	−12.05	7.76	< 0.001	≈0.97 (large)	**p < 0.001**

FSS range: 9–63. Higher score = greater fatigue severity. Clinical threshold for significant fatigue: ≥36. All 64 participants exceeded threshold at baseline.

Wechsler Digit Span Test (WDST) Results

Pre-intervention, the mean WDST score was 3.86 ± 1.33, reflecting low baseline working memory and attentional capacity consistent with the fatigue burden observed on the FSS. Post-intervention, the mean WDST score increased to 6.59 ± 1.27, representing a mean improvement of 2.73 points. Paired t-test analysis confirmed this change was statistically highly significant ($t = -14.44$; $df = 63$; $p < 0.001$). Standard deviations were comparable at both time points (1.33 vs 1.27), indicating consistent cognitive improvement across participants. The effect size was very large (Cohen's $d \approx 2.07$).

Table 4. Wechsler Digit Span Test (WDST) — Pre- and Post-Intervention Results (n = 64)

Variable	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Change (Δ)	t-value	p-value	Cohen's d	Significance
WDST Score	3.86 ± 1.33	6.59 ± 1.27	+2.73	−14.44	< 0.001	≈2.07 (very large)	**p < 0.001**

WDST = Wechsler Digit Span Test. Higher score = better short-term verbal memory and working memory performance. SD = standard deviation.

Summary of Overall Intervention Effect

Table 5. Summary of Outcome Measure Changes and Effect Sizes (n = 64)

Outcome Measure	Pre-Intervention	Post-Intervention	Change	t-value	p-value	Cohen's d	Clinical Interpretation
FSS (Fatigue)	45.86 ± 7.10	33.81 ± 12.90	−12.05	7.76	< 0.001	0.97 (large)	Score below clinical threshold post-intervention
WDST (Concentration)	3.86 ± 1.33	6.59 ± 1.27	+2.73	−14.44	< 0.001	2.07 (very large)	Substantial improvement in working memory span

Both improvements were statistically highly significant ($p < 0.001$) with large-to-very-large effect sizes. Both primary outcomes demonstrated statistically highly significant improvements following the one-week desk exercise programme ($p < 0.001$ for both). Effect sizes were large (FSS: $d \approx 0.97$) and

very large (WDST: d ≈ 2.07), indicating that the intervention produced not only statistically significant but clinically and practically meaningful changes in fatigue reduction and cognitive enhancement.

4. DISCUSSION

This study provides evidence that a one-week structured desk exercise programme embedded within long lecture sessions without disrupting instruction significantly reduces academic fatigue and substantially improves short-term verbal memory and working memory concentration in undergraduate university students. The magnitude of these effects, reflected in large-to-very-large Cohen's d values (0.97 and 2.07 respectively), and the high statistical significance of both outcomes ($p < 0.001$) suggest that the intervention produced clinically meaningful, not merely statistically detectable, changes.

Fatigue Reduction (FSS)

The mean FSS reduction of 12.05 points from 45.86 to 33.81 is clinically substantial. Pre-intervention, all 64 participants exceeded the clinical significance threshold of 36, confirming clinically relevant baseline fatigue burden. Post-intervention, the mean score fell below this threshold, indicating a population-level shift from clinically significant to subclinical fatigue. This finding is consistent with the systematic review by Lynch et al. (2022), which identified fatigue reduction as a consistent outcome of classroom movement breaks across multiple university-based trials [13]. Blasche et al. (2018) similarly demonstrated that rest-break interventions during mentally demanding tasks significantly reduced perceived fatigue and improved mental recovery [6].

The proposed physiological mechanism underlying this fatigue reduction involves multiple pathways: (i) improved peripheral and cerebral circulation through rhythmic muscular contractions during neck stretches, ankle pumps, and leg extensions, reversing venous pooling and CO_2 accumulation associated with prolonged sitting; (ii) increased catecholamine and serotonin release associated with aerobic movement, enhancing arousal and reducing mental sluggishness; (iii) reduction of musculoskeletal tension through targeted stretching, reducing the somatic component of fatigue perception; and (iv) diaphragmatic deep breathing activating the parasympathetic nervous system and reducing physiological stress responses that contribute to subjective fatigue [5,10,11].

The increased post-intervention standard deviation (12.90 vs 7.10) reflects individual variability in intervention response, potentially attributable to differences in baseline fatigue severity, adherence to the exercise protocol, or individual physiological responsiveness. Participants with the highest baseline FSS scores (range: 39–63 pre-intervention) tended to show the greatest absolute reductions, consistent with the regression-to-the-mean principle and the ceiling effect of the scale. This heterogeneity should be accounted for in future studies through subgroup analysis and adherence monitoring.

Cognitive Improvement (WDST)

The improvement in mean WDST score from 3.86 to 6.59 (mean gain +2.73; d ≈ 2.07) represents a very large effect and constitutes the strongest finding of this study. A baseline mean of 3.86 is below published normative ranges for young adults (typically 6–8 for forward digit span in the 18–25-year cohort), suggesting that fatigue-induced attentional suppression at baseline was substantial [26]. Post-intervention, the mean approached the lower end of the normative range, indicating meaningful cognitive restoration.

These findings are consistent with Chaiut et al. (2023) and Fenesi et al. (2018), who demonstrated that acute exercise breaks during lectures improved on-task attention and working memory performance

[7,8]. Donnelly and Lambourne (2011) established the theoretical framework in which even low-intensity physical activity produces transient but meaningful improvements in attentional capacity through catecholaminergic and cerebrovascular mechanisms [19]. The seated, low-intensity nature of the desk exercises in the present study suggests these benefits are achievable even without aerobic exertion.

However, as noted in the Discussion section of the thesis and consistent with the methodological critique by Karr et al. (2022), the magnitude of WDST improvement must be interpreted with caution [23]. The WDST was administered twice within one week, introducing the possibility of a test–retest practice effect: familiarity with digit recall procedures, reduced test-taking anxiety, and procedural learning may have contributed to improved scores independently of the physiological effects of the exercises. The absence of a control group receiving fatigue management without desk exercises a limitation inherent to the single-group pre–post design precludes definitive attribution of the WDST improvement exclusively to the intervention. Future randomised controlled trials with parallel control arms, alternate-form WDST versions, and electrophysiological attention measures (e.g., P300 event-related potential) would be required to definitively isolate the exercise-specific cognitive effect.

Desk Exercises vs. Other Classroom Interventions

The practical advantage of desk exercises over previously studied movement modalities merits specific emphasis. Unlike standing desks (Silva et al., 2022), formal exercise breaks requiring exit from the classroom (Peiris et al., 2021), or active learning redesign (Guirado et al., 2021), desk exercises require no infrastructure change, no additional class time, no specialist equipment, and no disruption to the lecturer's instructional flow [15,16,17]. This implementation simplicity is especially advantageous in the Indian higher education setting, where large cohort sizes, fixed classroom furniture, and traditional lecture cultures present barriers to more structurally demanding interventions. The present protocol of six exercises requiring 10–15 minutes represents a pragmatic, scalable, and universally accessible approach.

Gender Considerations

The study sample comprised 37 females and 27 males, with stratified sampling ensuring balanced representation. Both genders exhibited comparable intervention responses on aggregate statistical analysis. While gender-disaggregated outcome data were not separately analysed due to statistical power constraints in the present sample, future studies should examine potential differential responses in fatigue and cognitive improvement by gender, given documented sex-based differences in subjective fatigue perception, HPA-axis reactivity, and working memory performance in young adults.

Strengths and Limitations

Strengths include the use of two validated, widely-used outcome instruments (FSS and WDST); a clearly specified and replicable intervention protocol; adequate sample size (n = 64) for detecting large effects; zero attrition; and a well-characterised, homogeneous study population. Limitations include: single-group pre–post design without a concurrent control group; single-institution recruitment limiting generalisability; one-week intervention duration precluding assessment of sustainability and long-term effectiveness; reliance on self-reported fatigue measure (FSS); absence of objective physiological measures (e.g., heart rate variability, near-infrared spectroscopy of prefrontal cortex); potential WDST practice effects; and absence of a washout period to confirm return to baseline. A randomised controlled trial with a parallel control group, blinded outcome assessment, and a minimum 4–6 week intervention period is recommended as the next step.

5. CONCLUSION

This quasi-experimental study provides evidence that a one-week structured desk exercise programme incorporating neck stretches, shoulder rolls, seated spinal twists, wrist circles, ankle pumps, leg extensions, and deep breathing significantly reduces academic fatigue (FSS: 45.86 to 33.81; $p < 0.001$; $d \approx 0.97$) and substantially improves concentration and working memory (WDST: 3.86 to 6.59; $p < 0.001$; $d \approx 2.07$) in undergraduate university students during long lectures. The magnitude of these effects is clinically meaningful, with post-intervention FSS scores falling below the clinical significance threshold for the first time in a sample where all participants exhibited significant baseline fatigue.

The demonstrated intervention is notable for its complete absence of equipment, cost, infrastructure modification, or disruption to normal lecture delivery, rendering it immediately implementable across diverse higher education settings. These findings support the integration of short, structured desk-based movement breaks into university lecture practice as a low-cost, evidence-supported strategy for improving student well-being, cognitive readiness, and academic engagement. Future randomised controlled trials with control groups, longer follow-up, objective neurophysiological measures, and multi-institutional samples are strongly recommended to establish causality and assess long-term durability of effects.

REFERENCES

1. Sohail H, Noor T, Ismail L, et al. Engaged or distracted? Assessing medical students' attention dynamics during lectures. BMC Med Educ. 2025.
2. de Vries JD, van Hooff MLM, Geurts SAE, Kompier MAJ. Exercise as an intervention to reduce study-related fatigue among university students: A two-arm parallel randomized controlled trial. PLoS ONE. 2016;11(3):e0152137.
3. Paulus M, Kunkel J, Schmidt SCE, et al. Standing breaks in lectures improve university students' self-perceived physical, mental, and cognitive condition. Int J Environ Res Public Health. 2021;18(9):4530.
4. Sharpe BT, et al. Sustaining student concentration: The effectiveness of micro-breaks in a classroom setting. 2025.
5. Hayes SM. Establishing the feasibility of exercise breaks during university lectures. Health Promot Int. 2024.
6. Blasche G, Szabo B, Wagner-Menghin M, Ekmekcioglu C, Gollner E. Comparison of rest-break interventions during a mentally demanding task. Stress Health. 2018;34(5):629–638.
7. Fenesi B, Lucibello K, Kim JA, Heisz JJ. Sweat so you don't forget: Exercise breaks during a university lecture increase on-task attention and learning. J Appl Res Mem Cogn. 2018;7(2):261–269.
8. Chaiut W, Kachawangsri N, Hongthong N, et al. Acute effects of exercise breaks on attention and working memory during a university lecture: A group-randomized controlled trial. 2023.
9. Sharpe BT, et al. Sustaining student concentration in classroom settings: Micro-break effectiveness. 2025.
10. Donnelly JE, Hillman CH, Castelli D, et al. Physical activity, fitness, cognitive function, and academic achievement in children. Med Sci Sports Exerc. 2016;48(6):1197–1222.

11. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: Exercise effects on brain and cognition. Nat Rev Neurosci. 2008;9(1):58–65.
12. Horiuchi M, Pomeroy A, et al. Intermittent half-squat exercises during prolonged sitting and effects on executive function and physiological responses. Randomized crossover trial. 2023.
13. Lynch J, O'Donoghue G, Peiris CL. Classroom movement breaks and physically active learning are feasible, reduce sedentary behaviour and fatigue in university students: A systematic review and meta-analysis. Int J Environ Res Public Health. 2022;19(11):6501.
14. Li W, Chen J, et al. Academic fatigue among university students: Prevalence, risk factors, and consequences. Front Psychol. 2022;13:888487.
15. Silva DR, Machado DGS, et al. Long-term classroom standing desk intervention: Effects on cognitive performance and academic achievement in adolescents. 2022.
16. Peiris CL, et al. Movement breaks in university classes: Mixed-methods feasibility study on sedentary behaviour, concentration, and alertness. 2021.
17. Guirado T, Chambonniere C, et al. Effects of active desk interventions on physical activity, sedentary behaviour, academic performance, and health in school-aged children: A systematic review. Int J Environ Res Public Health. 2021;18(4):2064.
18. Anderson, McLean. Short physical activity breaks and their influence on students' attention and classroom behaviour. 2015.
19. Donnelly JE, Lambourne K. Classroom-based physical activity, cognition, and academic achievement. Prev Med. 2011;52(S1):S36–S42.
20. Kim JS, Lee SA, et al. Effects of stretching exercises on fatigue and concentration in high school students. 2006.
21. Krupp LB, LaRocca NG, Muir-Nash J, Steinberg AD. The Fatigue Severity Scale: Application to patients with multiple sclerosis and systemic lupus erythematosus. Arch Neurol. 1989;46(10):1121–1123.
22. Fennen L, Dockweiler C, Dockweiler U. The acute effects of physical exercise breaks on cognitive function during prolonged sitting. J Sci Sport Exerc. 2022;4(3):298–309.
23. Karr JE, Garcia-Hernandez A, Masina F, Campanella S. Prior test experience confounds longitudinal tracking of adolescent cognitive and motor development. PLOS ONE. 2022;17(6):e0270272.
24. Van den Berg V, Saliasi E, de Groot RHM, Chinapaw MJM, Singh AS. Improving cognitive performance of 9–12-year-old children: Just dance? A randomized controlled trial. Front Psychol. 2019;10:174.
25. Fatigue Severity Scale Questionnaire. Mercy Health. Available from: https://www.mercy.net. Accessed 2026.
26. Wechsler D. Wechsler Adult Intelligence Scale — Fourth Edition (WAIS-IV). Pearson; 2008.
27. Learmonth YC, Dlugonski D, Pilutti LA, Sandroff BM, Klaren R, Motl RW. Psychometric properties of the Fatigue Severity Scale and the Modified Fatigue Impact Scale. J Neurol Sci. 2013;331(1–2):102–107.
28. Woods DL, Kishiyama MM, Lund EW, et al. Improving digit span assessment of short-term verbal memory. J Clin Exp Neuropsychol. 2011;33(1):101–111.