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Visual inhibition and divided attention in college students. Does the amount of physical activity have any effect?

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Abstract

This study compares visual inhibition and divided attention in physically active and non-active young adults. Twenty male college students (age: 20.9 ± 1.8 y, height: 177.5 ± 6.9 cm, body mass: 80.4 ± 12.4 kg) were tested for cognitive performance in the Go/No-go task and the divided attention task. The level of physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ). Participants were classified as active (ACT) or non-active (NON-ACT) based on their self-reported frequency (days per week) and duration (minutes per day) of physical activity. Each group consisted of 10 male students. The results showed that the ACT group was physically twice as active as the NON-ACT (4.0 ± 0.8 and 2.0 ± 0.0 days a week). There were no significant differences between ACT and NON-ACT groups in visual inhibition tasks' median reaction time (290.0 ms and 301.0 ms, respectively; $p = 0.20$, ES = 0.19), while a tendency toward a higher error rate was observed in the ACT group (10% and 0%, respectively; $p = 0.05$, medium effect). The higher coefficient of variability in the ACT group may reflect greater impulsivity (16.6% and 13.9%, respectively; $p = 0.03$, large effect). There were no significant differences in divided attention between the groups ($p = 0.25–0.41$, ES = 0.06–0.23). The frequency of weekly physical exercise did not show any significant explanation for any of the cognitive performance variables ($p > 0.17$, $R^2 < .10$) though the largest value was found for threshold reaction time in divided attention task ($\beta = -10.42$, $p = .17$, $R^2 = .093$). Physically active students did not outperform their non-active peers in visual inhibition or divided attention. Activity frequency up to 4 days per week is not significantly associated with cognitive performance. These findings suggest that volume of physical activity has limited direct effects on cognitive performance outcomes in college students.

INTRODUCTION

The association of cognitive performance with sports expertise and physical activity (PA) is well documented in current literature[1,2]. Individuals with sport expertise exhibit superior stimulus-driven visual attention and motor inhibition compared to less active peers[3]. Evidence from the inhibitory control paradigms underscores these differences. For example, college students with higher PA levels tend to have higher accuracy and shorter reaction times in Go/No-Go tasks compared to their non-active peers[4,5].

Benefits of PA for enhanced cognitive performance are triggered by moderate-intensity aerobic training. For example, performing endurance training for six weeks significantly improves accuracy in a visual inhibition task[5]. There are also effects of the acute bouts of aerobic exercise on inhibitory control. The excitatory effect of exercise enhances response inhibition in college students, especially those with initially lower levels of self-control[6,7]. However, less is known about the attentional ability to divide attention among various stimuli. Athletes, particularly those trained in dynamic sports environments, demonstrate greater accuracy and maintain higher levels of attention in multitasking situations compared to their less active peers. This skill usually translates into better technical-tactical performance and fewer errors under demanding cognitive loads[6]. Such findings suggest that, in addition

to improving inhibitory control, physical activity may also enhance divided attention, cognitive flexibility, and multitasking ability. These domains are essential for achieving high athletic and academic performance. In previous research, inhibitory control explained a significant proportion of the variance in academic performance among Chinese high school students[8]. However, a recent study showed only a weak correlation between inhibitory control and academic grade point average[9].

Even though there are some discrepancies in the literature, it is acknowledged that both chronic and acute PA foster neuroplasticity and induce beneficial changes in neurotransmitter levels and brain structure. These changes are particularly prompt in the regions relevant to attention, multitasking, and executive functions[10]. Especially regions in the prefrontal cortex are highly responsible for executive functions. Inhibitory control is a key component of executive functions[11]. These regions of the brain are influenced by the fitness level of children and healthy young adults[12,13]. Studies made on college populations confirm that regular physical activity is associated with improvements in attention span, mental health, and academic achievement[14–16]. According to recent evidence[17] daily physical activity improves inhibitory function and attention of adults.

Apart from these studies, there is insufficient knowledge regarding the extent to which the amount physical activity influences the cognitive performance of university students. Therefore, it was compared visual inhibition and divided attention in physically active and non-active young adults. It is tested the hypothesis that physically active college students will achieve higher levels of performance in Go/No-Go and Divided attention tasks compared to their non-active peers. It is also assumed that weekly frequency of physical activity would be positively associated with inhibitory control, attentional capacity, and cognitive flexibility.

MATERIALS AND METHODS

Participants

This research employed G*power 3.1 software (G-Power v3.1.9.6, Dusseldorf, Germany) to determine the necessary experimental sample size in an experimental design. A total sample of at least 42 participants was projected to achieve an 80% statistical power level, with the significance level (α) set at 0.05 and the effect size at 0.8 for a two-tailed test. Due to a substantial dropout rate based on the study's inclusion and exclusion criteria - age between 18 and 24 years; absence of health-related issues; no visual problems (e.g., blurred vision, difficulty recognizing colors or shapes, or sensitivity to blue light); no prior experience with cognitive tests; and no physical or psychological fatigue due to stress, lack of sleep, or recent physical activity - the final sample consisted of twenty participants from Prince Sultan University. Subjects were divided into two groups based on their physical activity levels as reported in the previously completed Global Physical Activity Questionnaire (GPAQ), which assesses self-reported physical activity across the work, transport, and leisure domains. For each participant, the frequency (days/week) and duration (minutes/day) of moderate- and vigorous-intensity activities were used to calculate total

physical activity expressed as MET-minutes per week. Participants accumulating ≥ 600 MET-minutes/week were classified as physically active (ACT), whereas those accumulating < 600 MET-minutes/week were classified as not physically active (NON-ACT), in accordance with the WHO physical activity recommendations.[18]. Each group consisted of ten participants. The ACT group included males with a mean age of 20.0 ± 1.61 years, height 178.1 ± 3.75 cm, body mass 81.30 ± 11.96 kg, and BMI 25.68 ± 3.86. The NON-ACT group included males with a mean age of 21.7 ± 1.70 years, height 176.8 ± 9.51 cm, body mass 79.4 ± 13.41 kg, and BMI 25.52 ± 4.67. All participants provided written informed consent after receiving a full explanation of the study's purpose and procedures.

Study design

This study employed a cross-sectional design with between-subjects comparison. Two groups (ACT and NON-ACT) were measured using two tests (go/no-go task and divided attention task). After the subjects underwent an online questionnaire, they were scheduled for an evaluation of cognitive performance. This evaluation was conducted at approximately the same time for each participant, with a 24-hour interval between tests. Two tasks were conducted in a random order. These tasks measured the level of attention among college students. Firstly, the go/no-go test evaluates response inhibition ability, attention control, and executive functioning[19]. Secondly, a divided attention task evaluates the attentional control, information processing speed, and visuomotor coordination[20]. The tasks were administered via a Dell Precision 7000 computer equipped with a 17.3-inch monitor. The PsyToolkit web-based application (Psytoolkit v3.4.1, Stoet 2010; 2017) was used for the visual inhibition task, while the BrainHQ (Posit Science, San Francisco, CA, USA) software was employed for the divided attention task.

Cognitive performance evaluation

Go/No-go task

Testing consisted of one familiarization trial, followed by one analyzed trial. In total 50 randomly ordered stimuli were displayed in the middle of the computer screen. These stimuli either required an action (GO) or an omission (NO-GO), where 80% of the stimuli required an action. The fixation point was presented for 1000 ms, with stimuli occurring after this interval. In case of an error in omission, a pause of 2000 ms was included before the next fixation. The following parameters were evaluated; MED RT (ms): median reaction time in milliseconds; SD (ms): standard deviation of reaction times; CV (%): coefficient of variation (SD / average RT); and rate of errors (GNG errors, %): percentage of trials with omission errors.

Divided attention task

The Divided Attention Task was employed to evaluate participants' ability to process and respond to multiple streams of information simultaneously. During the task, participants were required to respond to

two concurrent visual stimuli presented on screen. In each trial, participants monitored two objects displayed within a gray rectangle located at the center of the green screen. While observing the central area of the screen, two symbols of different colors (red, blue, and yellow), shapes (square, circle, and triangle), and inner filling (inner shape or fully colored) were presented in the center. If symbols matched the same shape, the participant must have responded "yes" by clicking on the left arrow button on the keyboard. If the shapes did not match, they clicked on the right button. Participants were instructed to respond as quickly and accurately as possible when the target appeared, without losing focus on the task. The task adaptively adjusted its difficulty according to individual performance, consistent with BrainHQ's proprietary staircase algorithm. This adjustment modified the stimulus presentation time in which they occurred on the screen. Each testing session lasted approximately 2–3 minutes, comprising one familiarization block and one full block of 100 stimuli. Threshold (ms), z-score, and rate of errors (DA errors, %) were analyzed.

The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and was officially approved by the Ethics Committee of the Faculty of Physical Education and Sport, Comenius University in Bratislava (Approval No. 3/2026).

Statistical analysis

Data was collected from the computer software and exported to the Excel spreadsheet. Normality of the data distribution was assessed by Shapiro-Wilk test. The Breusch-Pagan test generally shown an acceptable homoscedasticity of dataset. To analyze differences between active and non-active groups of students we employed the Mann-Whitney U test. The effect size (ES) for non-parametric test was used ($ES = Z / \sqrt{n}$)[21]. The magnitude of effect was interpreted as small ($0.1 \leq ES < 0.3$), medium ($0.3 \leq ES < 0.5$), and large ($ES \leq 0.5$)[22]. Statistical significance was set at $p \leq 0.05$ for one-tailed hypotheses. Multiple linear regression was used to explain each performance variable among in relation to the level of physical activity of all participants. Data are presented as median values ± CI 95%.

RESULTS

Comparison of cognitive performance in active vs. non-active group

There were no significant group differences in MED RT in the visual inhibition task, with ACT (median = 290 ms [CI 95% = 260–306 ms]) performing similarly to the NON-ACT group (301 ms [260–360 ms]; p = 0.20, ES = 0.19, small). SD of RT did not differ between groups (46.6 ms [39.9–58.1 ms] and 45.1 ms [33.1–57.1 ms], respectively; p = 0.24, ES = 0.17, small). Coefficient of variation (CV) for reaction time was significantly higher in the ACT compared to NON-ACT group (16.6% [13.2–18.9] and 13.9% [11.3–16.1], respectively; p = 0.03, ES = 0.52, large). Analysis of error rate (%) revealed a trend toward higher errors in ACT group (10% [0–20%]) than in NON-ACT group (0% [0–20%]; p = 0.05, ES = 0.47, medium).

The speed threshold measure in the divided attention task showed no significant difference between ACT and NON-ACT group (304 ms [108–609 ms] and 370 ms [181–861 ms], respectively; p = 0.25, ES = 0.23, small). For the z-score outcome, there was no significant group effect (−0.04 [−0.71–0.84] and 0.18 [−0.47 − 0.42], respectively; p = 0.41, ES = 0.06, small). Error percentage in the divided attention task was similar between groups (29.5% [24–40%] and 31% [25–36%], respectively; p = 0.38, ES = 0.08, trivial). Data are summarized in Fig. 1.

Relationship between the weekly physical activity and cognitive performance

The ACT group was physically twice active as the NON-ACT (4.0 ± 0.8 and 2.0 ± 0.0 days a week). Multiple linear regressions indicated no significant associations between weekly PA and any of cognitive variables (all p > .17). The largest, though nonsignificant, relationship was found for threshold reaction time in divided attention task (β = −10.42, p = .17, R^2 = .093). Results for all variables are highlighted in Table 1.

Table 1
Multiple linear regression for the physical activity and cognitive performance variables.

Dependent Variables	β (Physical Activity)	t	p	R^2
MED RT	−3.97	−0.94	0.365	0.046
SD RT	0.33	0.28	0.781	0.004
CV RT	0.01	0.23	0.821	0.003
GNG errors	−0.03	−0.47	0.647	0.011
Threshold	−10.42	−1.43	0.172	0.093
Z score	−0.03	−0.36	0.722	0.007
DA errors	0.15	0.56	0.585	0.016

DISCUSSION

Our results indicate that physically active (ACT) and non-active (NON-ACT) college students did not differ significantly in reaction time to visual stimuli. However, the ACT group exhibited greater intra-individual variability and a tendency toward higher error rates in the visual inhibition task, suggesting reduced consistency in response execution rather than impaired performance. This distinction is important, as variability metrics are often more sensitive to subtle fluctuations in attentional control than central tendency measures. Performance in the divided attention task did not differ meaningfully between groups across any outcome, with effect sizes consistently small to trivial. This may indicate

that the cognitive processes underlying divided attention are less sensitive to differences in habitual physical activity, or that both groups operate at a comparable level in dual-task contexts.

Beyond overall activity volume, the type and intensity of physical activity appear to be critical. Research indicates that athletes engaged in open-skill sports—such as soccer or basketball—often outperform non-athletes in visual attention tasks, including multiple object tracking, reflecting enhanced selective attention and processing speed[23–25]. These sports may favor faster and more impulsive decision-making strategies, which may influence performance on tasks measuring response inhibition or attentional control[26]. Moderate-to-vigorous intensity exercise lasting ≥ 30 minutes has also been documented to improve working memory and reactive inhibitory control in college students[5,27]. Despite these established benefits, the present study found that ACT participants did not demonstrate higher cognitive performance on the selected tasks, regardless of the type or intensity of their physical activity. This discrepancy suggests that, in physically active college populations, even moderate-to-vigorous habitual exercise may not translate directly into measurable improvements in simple or moderately challenging cognitive tasks. Factors such as task sensitivity, individual variability, and potential ceiling effects may therefore obscure potential benefits.

Another factor that may explain the lack of observed cognitive benefits in the ACT group is the distinction between acute and habitual physical activity. Garrett et al.[28] reported that acute bouts of exercise can modestly enhance inhibitory control, while Kekäläinen et al.[29] found that higher intensity or greater active minutes in the ~ 20 minutes preceding testing were associated with faster reaction times, improved sustained attention, and, in some individuals, better performance on inhibition tasks. These findings suggest that acute physical activity immediately before testing may have a more pronounced effect on cognitive function than regular, habitual activity. Supporting this, a meta-analysis in children aged 6 to 12 years demonstrated that acute exercise positively influenced attention, and longitudinal exercise programs enhanced both attention and executive function[10]. These effects are likely driven by neuroplasticity and structural brain development, which are particularly prominent in preadolescents. In contrast, sensory processing systems are likely mature in college-aged individuals, although aspects of impulse control and executive regulation may continue to develop[30], potentially influencing responsiveness to physical activity interventions in this population.

Furthermore, regression analyses revealed no significant association between physical activity volume and cognitive performance across tasks. However, it is worth noting that the ACT group showed indications of lower sustained attention and reduced inhibitory control. In general, achieving ≥ 600 MET-minutes per week typically requires 21 to 30 minutes of daily physical activity, depending on the intensity, i.e. moderate intensity (e.g., brisk walking at ~ 4 METs) corresponds to ~ 21 minutes per day while vigorous intensity (e.g., jogging at ~ 8 METs) corresponds to ~ 11 minutes per day. According to official International Physical Activity Questionnaire (IPAQ) and World Health Organization guidelines, achieving ≥ 600 MET-minutes per week typically corresponds to 5 or more days of any combination of walking, moderate-intensity, or vigorous-intensity activities. Alternatively, it can be achieved in 3 or more days if

engaging strictly in vigorous-intensity physical activity. While the NON-ACT group was physically active only 2.0 ± 0.0 days a week, the ACT group was twice as active, 4.0 ± 0.8 days a week. Nevertheless, even this double the weekly volume of physical activity among physically active students was not enough to result in a higher level of cognitive performance compared to physically inactive students.

However, these findings should be interpreted cautiously given the limited sample size and statistical power. One possible explanation is that physically active individuals may not perform optimally on impulse-control tasks due to diminished self-regulation, but rather as a consequence of elevated arousal and greater sensation-seeking tendencies, as suggested by Mann et al.[26]. While many studies report a positive association between physical activity and cognitive function[17,27], some have found no or only weak relationships in college-aged populations. One potential explanation is that cognitive tasks used in such studies may be too simple for high-functioning students, producing a “ceiling effect” that obscures differences between active and inactive individuals[31]. Additionally, variability in physical activity levels across participants, along with prolonged sedentary behavior, may attenuate the potential cognitive benefits of sporadic or low-intensity exercise.

Physical activity shows no consistent direct effect on academic achievement in college students and contributes only modestly. However, it may indirectly support academic success by improving mental health, sleep, and stress management. Chung et al.[32] reported a significant association between physical activity levels and academic performance among medical and health sciences students, whereas Raja et al.[33] found no direct link between habitual exercise and grade point average in medical students. Overall, cognitive ability, conscientiousness, and physical activity together account for only approximately 15% of the variance in GPA[34]. In contrast to children and adolescents where physical activity is often positively correlated with academic performance[35,36], the relationship in college students appears more complex. This complexity likely reflects the influence of unique environmental factors (e.g., voluntary versus competitive sport participation) and personal factors such as academic stress and well-being. The high psychological burden experienced by college students may obscure modest cognitive benefits of physical activity that might be more detectable in less-stressed populations.

The present study is limited by a relatively small sample size, which reduces statistical power and may obscure subtle effects. Multiple regression analyses increase the risk of Type I error, and physical activity was assessed using non-objective measures. Cognitive performance measures were non-invasive and may lack sensitivity to detect subtle group differences, particularly in high-functioning populations.

Future research should employ larger samples, objective assessments of physical activity (and more sensitive or ecologically valid cognitive tasks. Focusing on intra-individual variability metrics may provide a more nuanced understanding of attentional control than traditional mean-based measures. Overall, the findings align with the literature suggesting that in young, high-functioning populations, habitual physical

activity has a limited association with mean cognitive performance, while more sensitive measures may reveal subtle differences in attentional control.

CONCLUSION

Physically active college students do not demonstrate significantly faster reaction time in the visual inhibition task or better performance in divided attention. In addition, they exhibit higher inconsistency and tend to make more errors in a visual inhibition task compared to their non-active peers. The frequency of physical activity up to 4 days per week is not significantly associated with cognitive performance, explaining only a small proportion of variance. Further studies should focus on factors that even modestly influence problems with sustained attention or cognitive control in physically active students and their relationship with their academic achievement.

Declarations

Consent for publication

Not applicable.

Funding

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Clinical trial number

Not applicable.

Data availability

The data supporting the findings of this study are available from the corresponding author upon a request. Due to ethical restrictions and privacy considerations involving participant data, the dataset is not publicly available.

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Author contributions

The authors have made substantial, direct, and intellectual contributions to the work and approved it for publication. **Martin Pacholek:** Conceptualization, Data curation, Funding acquisition, Investigation,

Methodology, Project administration, Resources, Validation, Writing – Original Draft, Writing – Review & Editing; **Filip Skalka:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Software, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing; **Erika Zemkova:** Conceptualization, Supervision, Validation, Writing – Original Draft, Writing – Review & Editing

Ethical approval statement

The study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and was officially approved by the Ethics Committee of the Faculty of Physical Education and Sport, Comenius University in Bratislava (Approval No. 3/2026). **All participants were informed about the study procedures and provided written informed consent prior to participation.**

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Table

TABLE 1: Multiple linear regression for the physical activity and cognitive performance variables.

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Note: MED RT = median of reaction time; SD RT = standard deviation of reaction time; CV = coefficient of variation; GNG errors [%] = percentage of errors in Go/No-go task; DA errors [%] = percentage of errors in DA task.

Figures

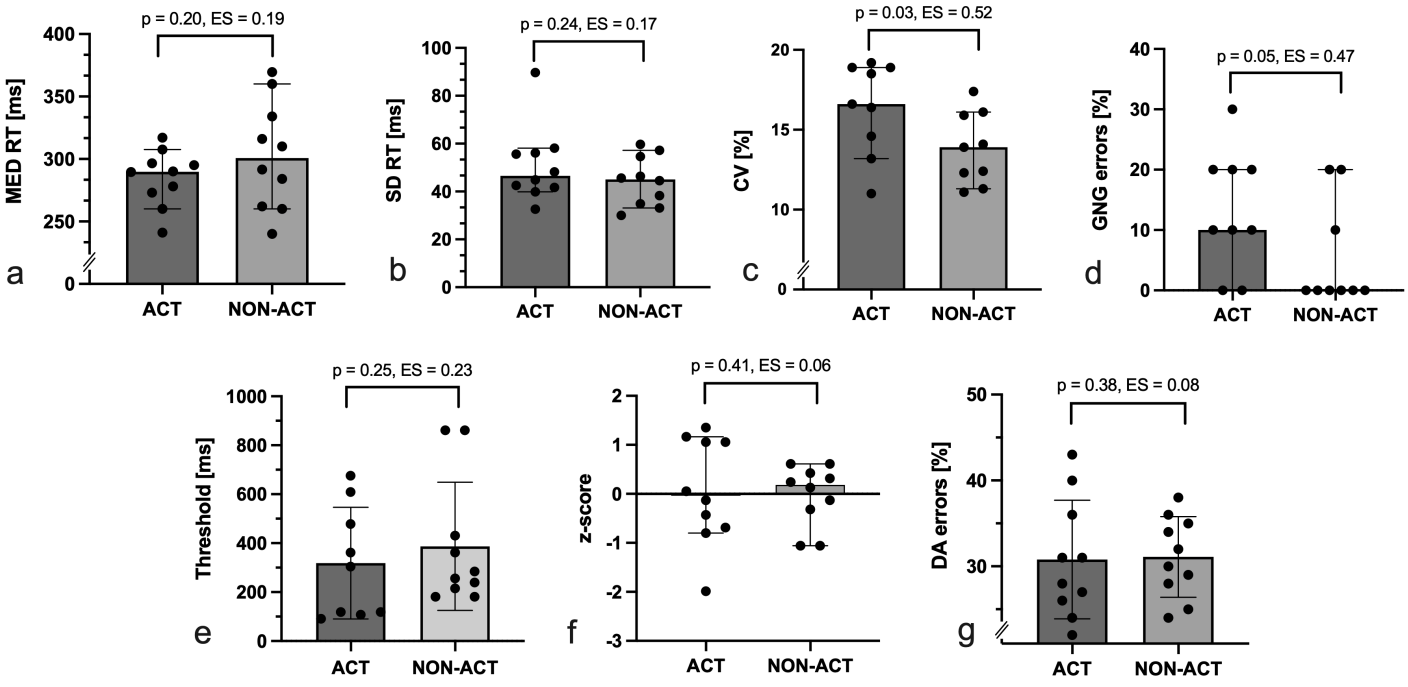


Figure 1

Comparison of active and non-active college students in Go/no-go task (a,b,c,d) and Divided attention task (e,f,g).

Note: MED RT = median of reaction time; SD RT = standard deviation of reaction time; CV = coefficient of variation; GNG errors [%] = percentage of errors in Go/no-go task; DA errors [%] = percentage of errors in Divided attention task.