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ARTICLE

The Impact of a 9-Week Exercise Program on College Students' Executive Function

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Abstract

Background: Executive functions (EF), which encompass inhibitory control, working memory, and cognitive flexibility, are essential for managing daily activities. These functions are particularly crucial for the academic success of post-secondary students. Accordingly, this study implemented a 9-week exercise intervention specifically designed to enhance EF in post-secondary students. **Purpose**: The primary objectives were to assess the effectiveness of the exercise intervention on EF and to provide insights for future program development. **Methods**: Thirty-one students participated in the study, which utilized a waitlist comparison group design. Participants engaged in a 9-week exercise program with three structured sessions per week aimed at enhancing EF. Preliminary ANOVAs were conducted to analyze participant characteristics and physical activity measures. ANCOVAs, with age, gender, and body mass index as covariates, were used to test the exercise intervention's effect on inhibitory control, working memory, and cognitive flexibility. **Results**: The results indicated small, albeit statistically non-significant effects of the exercise intervention on inhibitory control ($\eta_p^2 = 0.052$, $p = 0.262$) and working memory ($\eta_p^2 = 0.013$, $p = 0.579$). **Conclusion:** The study provides guidance for future research and practical advice for post-secondary institutions looking to support students' academic success through similar initiatives. Recommendations include extending the exercise intervention length to 17 to 22 weeks, promoting adherence by incorporating elements of the transtheoretical model for behaviour change and self-determination theory, maximizing time spent on cognitively demanding tasks during exercise sessions, and targeting students who would benefit the most, such as those who are sedentary, from disadvantaged backgrounds, or with learning impairments.

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Introduction

Executive functions (EF) encompass several cognitive skills important for organizing and managing activities in daily life. They are crucial for tasks such as dialing a phone number, following a recipe, or engaging in conversation. EF comprises various core functions, with inhibitory control, working memory, and cognitive flexibility being the most commonly referenced (Diamond, 2013). Inhibitory control reflects the capacity to focus on a task while suppressing irrelevant stimuli. For instance, maintaining attention during a lecture despite the temptation to check social media notifications. Working memory refers to the short-term retention and manipulation of information, such as processing and writing down essential points from a lecture. Cognitive flexibility is the ability to switch perspectives and adapt to evolving circumstances, exemplified by the willingness to critically appraise conflicting lecture content based on its individual merit rather than simply dismissing it (Diamond, 2013). From childhood through adolescence and into early adulthood, EF undergo protracted development (Ferguson et al., 2021). The prefrontal cortex, a brain region associated with EF, continues to mature well into the third decade of life (Haverkamp et al., 2020; Lebel et al., 2008).

The foundational capacities facilitated by EF, including focused attention, ignoring distractions, recalling and manipulating information, and assimilating conflicting information, serve as crucial prerequisites for academic success (Diamond, 2013; O'Shaughnessy et al., 2003). Indeed, the correlation between EF and academic success in college students is well-established (Knouse et al., 2014; Ramos-Galarza et al., 2020). Given the high cognitive demands academic pressures place on post-secondary students (Pascoe et al., 2020), institutions may benefit from implementing targeted EF interventions to support student success.

The benefit of interventions designed to bolster EF have been well documented in the research literature (e.g., Diamond, 2013; Haverkamp et al., 2020). The effects of exercise on EF in particular is substantiated by a large body of research (e.g., Ludyga et al., 2020; Ludyga et al., 2023). Acute enhancements in EF are observed following singular bouts of exercise, while long-term exercise interventions elicit more sustained improvements (Haverkamp et al., 2020). Particularly beneficial is exercise comprised of complex movement patterns (Shi et al., 2022) performed at moderate to vigorous intensity (Hsieh et al., 2021; Wang et al., 2023). Exercise combining complex movement patterns with cognitively challenging tasks has been demonstrated as especially effective (e.g., Kolovelonis et al., 2022; Kolovelonis & Goudas, 2023).

Despite the extensively researched exercise-cognition benefits, there is a need for more translational research to determine how these findings can be effectively applied to develop exercise interventions that bring about significant improvements in EF among college students. Accordingly, the purpose of this study was to implement a 9-week exercise intervention with the specific goal of improving EF in college students. The aim was to determine the intervention's effectiveness, identifying strengths and potential areas for improvement for future iterations. The findings from this study are intended to offer practical insights for academic institutions seeking to implement similar exercise interventions as a way of supporting academic success in their students.

Methods

Participants

Students from an academic institution in western Canada, primarily offering 2-year diplomas and select 4-year degrees, were invited to join a 9-week exercise intervention via campus posters and in-class presentations. Inclusion criteria required participants to be enrolled in full-time studies. The exercise intervention started in September of 2022 and ended in December of 2022, coinciding with the fall term in the Canadian academic calendar. Students who expressed interest after the fall iteration was at capacity or wished to be part of a future iteration could add their name to a waitlist for a winter iteration of the exercise intervention. Those who volunteered for the 9-week exercise intervention were assigned to the intervention group (EG) while those who were waitlisted were assigned to the comparison group (CG). Forty-four participants initially signed up for the study. However, 10 participants withdrew citing personal reasons, time constraints, and deregistration from their studies. Additionally, data from three participants who did not attend post-testing was excluded from the analysis. Of the 13 participants that either withdrew or were excluded, nine started in the EG and four in the CG. Data from 31 participants was ultimately included in the analysis with 15 participants in the EG and 16 in the CG. The participants were 23.7 ± 8.7 years of age and self-reported 155 ± 167.1 minutes of weekly physical activity prior to the start of the study. Of the 31 participants included in the analysis, 18 identified as male, 12 identified as female, and one identified as non-binary. All participants provided written informed consent and ethical approval was obtained from Institutional Research Ethics Board (Lethbridge Polytechnic Research Ethics Board protocol number: 25). The study adhered to the guidelines established by the Declaration of Helsinki.

Exercise Intervention

This study implemented a 9-week exercise intervention designed to align with current exercise-cognition research. The intervention was 9 weeks in length to align with the typical length of the Canadian academic term, ensuring adequate time for recruiting, pre-testing, and post-testing. The primary objective of the intervention was to improve students' EF, and by extension, support academic success (Ramos-Galarza et al., 2020). The exercise intervention was structured as 50-minute exercise sessions held every Tuesday, Wednesday, and Thursday. The exercise sessions consisted of four phases: Activation, brain preparation, brain stimulation, and relaxation. The activation phase (approximately 7 minutes) included a cardiorespiratory warm-up (e.g., jogging, stationary cycling), followed by dynamic stretching and mobility exercises (e.g., leg swings, arm circles). The brain preparation phase (approximately 18 minutes) included simple, repetitive movement patterns performed at moderate to high intensity. Exercises included Tabata intervals, stair climbing, and basic calisthenics, aimed at enhancing blood flow to both muscles and the brain. During the brain stimulation phase (approximately 18 minutes), participants engaged in sequences of cognitively challenging exercises in line with the parameters outlined by Kolovelonis et al. (2022). The sequences consisted of combined motor and cognitive tasks. The goal of this phase was to create conditions where the participants would engage in complex, non-repetitive movements while simultaneously completing tasks that required EF. The objective of this phase was to stimulate neural networks connecting the prefrontal, premotor, and primary motor cortices, which are critical for EF. The goal of the final phase, the relaxation phase (approximately 7 minutes), was to promote recovery through static stretching. Throughout the exercise intervention, supervision was provided by a qualified exercise professional to ensure safety and adherence.

Measures

Get Active Questionnaire and Anthropometrics

The Get Active Questionnaire or GAQ (Canadian Society for Exercise Physiology, 2022) was used to evaluate participants' physical activity readiness. Participants completed the GAQ to disclose whether they had pre-existing cardiorespiratory and/or musculoskeletal conditions that would limit their participation in physical activity. Prior weekly physical activity minutes (pPA) were also collected through the GAQ. Body weight (kg) and height were collected using a HealthOmeter Professional 402KL Physician Balance Beam Scale (Pelstar LLC, Countryside, IL, USA). Body weight and height were converted to body mass index (BMI) by dividing body weight (kilograms) by the square of body height (meters).

Stroop Test

The Stroop Colour and Word test (Golden, 1978) was used to assess inhibitory control. The test consisted of three subtasks: the Word subtask, the Colour subtask, and the Colour-Word subtask. In the Word subtask, colour words (i.e., red, blue, green) were presented in random order and printed in black ink. Participants were instructed to read the colour words as quickly as possible. The Colour subtask involved a random order of four letters (XXXX) printed in either red, blue, or green ink, and participants were instructed to identify the colour of the ink as quickly as possible. The Colour-Word subtask presented participants with colour words printed in different coloured ink (e.g., the word "red" printed in blue ink), and participants were instructed to identify the ink colour as quickly as possible. As per Golden (1978), prior to each subtask, the assessors read standardized instructions, including sample tasks, to the participants to ensure task comprehension. Participants were given 45 seconds per subtask to verbally list as many colours as possible. The assessor pointed out incorrect responses, and participants were instructed to correct the error before continuing. Errors affected the participants' score only in that the correction of errors reduced the time availability. Inhibitory control was quantified as the number of correct responses for the Stroop Colour-Word subtask (SCW).

Digit Span Test

The Digit Span test of the Wechsler Adult Intelligence Scale (Egeland, 2015; Wechsler, 2008) was used to assess working memory. The test assessed participants' ability to temporarily hold and manipulate numerical sequences of increasing length, which is a key component of working memory (Diamond, 2013). Like the Stroop test, it consisted of three subtasks: Digit Span Forward, Digit Span Backward, and Digit Span Sequencing. In the Digit Span Forward subtask, participants were presented with a series of digits and were required to repeat them in the same order they were presented (e.g., 9-2-4 → 9-2-4). In the Digit Span Backward subtask, participants were presented with a series of digits and were required to repeat them in the opposite order they were presented (e.g., 8-2-7 → 7-2-8). In the Digit Span Sequencing subtask, participants were again presented with a series of digits and were required to repeat them in ascending order (e.g., 5-1-3 → 1-3-5). Each of the subtasks started with a practice trial to ensure task comprehension and then progressed through a series of progressively longer trials. Each trial consisted of two items.

Trial 1 contained two, two-digit items, Trial 2 contained two, three-digit items, Trial 3 contained two, four-digit items, and so on. Each subtask continued as long as participants correctly repeated one of the two items within one trial. If participants incorrectly repeated both sequences within one trial, the subtask was terminated, and participants moved to the next subtask. Working memory was quantified as the total number of correct sequences from the Digit Span Backward subtask (DSB).

Trail-Making Test

The Trail-Making test (Reitan, 1958) was used to evaluate cognitive flexibility. The test consists of Part A and Part B. In Part A, participants were presented with a pen or pencil and a sheet of paper containing randomly distributed numbers (1 to 25). They were instructed to connect the numbers sequentially by drawing lines as quickly and accurately as possible, without lifting the pen or pencil from the paper. Part B built on Part A by introducing participants to both numbers (1 to 12) and letters (A to L) scattered randomly on the paper. Participants were instructed to connect the numbers and letters alternately in ascending order (1-A-2-B, and so on). Prior to both Part A and Part B, the assessor demonstrated both tasks using a short form of Part A and Part B. The time to complete each part was noted, starting when participants' pen or pencil touched the first number (1) and ending when it touched the final number or letter (25 or L). If the participants made an error, the assessor pointed it out immediately and allowed the participants to correct it. Errors affected the participants' score only in that the correction of errors was included in the completion time for the task. Cognitive flexibility was quantified as the time to complete Part B of the Trail-Making test (TMB).

Weekly Physical Activity Journal

Participants were each provided with a Fitbit Inspire 2.0 fitness tracker equipped with a wrist-based heart rate sensor (Fitbit Ltd., San Francisco, CA, USA) and asked to wear it during three separate seven-day periods throughout the study (Weeks 1, 5, and 9). They were instructed to record their physical activity duration (minutes) and average heart rate (bpm) in the provided physical activity journal. Participants could either retrieve data directly from the fitness tracker or extract it from the paired smartphone application. Participants submitted their physical activity journals following each of the three, seven-day periods. Physical activity minutes were summed for each seven-day period and averaged over the three periods to represent participants' weekly physical activity minutes during the 9-week exercise intervention period (iPA). Similarly, for each seven-day period, weighted average heart rate was calculated using the formula $wHR = \Sigma(PA \cdot HR)/ \Sigma(PA)$; where wHR = weighted average heart rate (bpm), PA = total physical activity accumulated (min), and HR = average heart rate during physical activity (bpm). wHR was expressed as a percentage of maximum heart rate, which was predicted using the Tanaka equation (Tanaka et al., 2001): Age predicted heart rate maximum = 208 – [0.7 x age].

Procedure

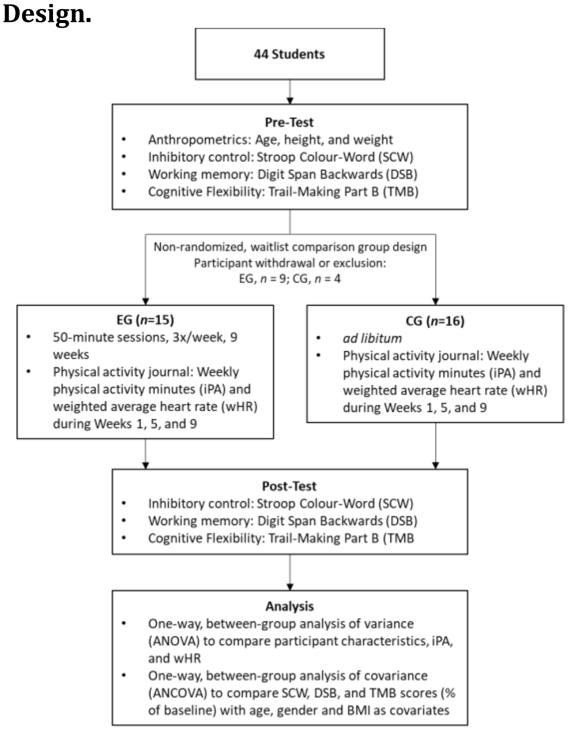
Upon receiving written consent and GAQ forms, participants were scheduled for pre-testing. Pre-testing started with the collection of anthropometric information (i.e., body height and weight) followed by completion of the Stroop, Digit

Span, and Trail-Making tests in that specific order. Each pre-test took approximately 20 minutes. The tests were administered in a private space by one of six qualified assessors. Each assessor had completed an undergraduate program in Kinesiology or a related field and possessed prior experience with psychometric testing. Additionally, the assessors participated in a pre-assessment orientation session led by the primary investigator, during which they conducted a series of hypothetical Stroop, Digit Span, and Trail-Making assessments. Intraclass correlation coefficients calculated from the hypothetical assessments demonstrated very good agreement among the assessors for the Stroop Colour-Word subtask (ICC = 0.86), the Digit Span Forward subtask (ICC = 1.00), and Part B of the Trail-Making test (ICC = 0.98).

Following pre-testing, both EG and CG participants were asked to monitor their physical activity using the study-provided fitness tracker and log their physical activity in the physical activity journals during Weeks 1, 5, and 9 of the study. E-mail reminders to complete the physical activity journals were sent during each journaling week.

Participants in the EG were encouraged to attend all three weekly exercise sessions. The average attendance rate across each of the three weekly exercise sessions was 58.5 ± 21.4%. Quantified differently, EG participants accumulated an average of 87.8 ± 26.2 minutes in the exercise sessions per week. Participants in the CG were asked not to deviate from their normal behaviours during the 9-week exercise intervention period. Following the 9-week exercise intervention period, participants were scheduled for post-testing. Whenever possible, participants were scheduled at the same time of day, with the same assessor, and in the same space as pre-testing. A summary of the procedure is provided in Figure 1.

Figure 1: Summary of Quasi-Experimental Design.



Statistical Analysis

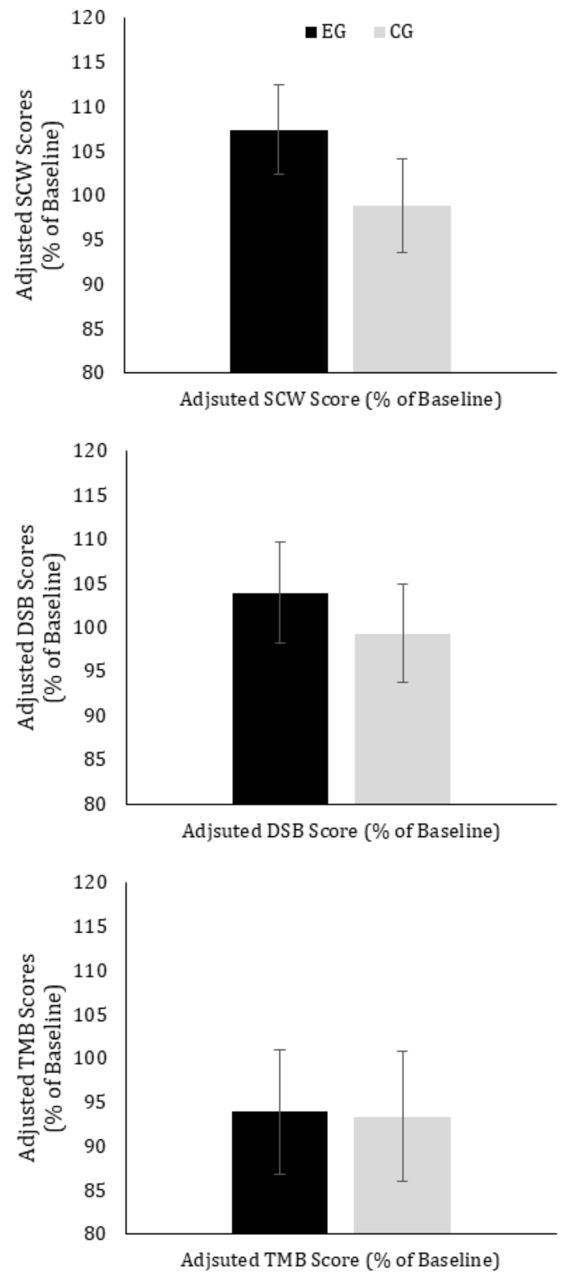
All statistical analyses were performed using SPSS 26.0 (SPSS Inc., Chicago, IL, USA). Preliminary analyses involved ANOVAs for between-group comparisons of participant characteristics, including age, pPA, and BMI. Two one-way ANOVAs were conducted to determine between-group differences in iPA and wHR. To assess the impact of the exercise intervention on EF, three separate ANCOVAs were performed, with pre- and post-test differences in SCW, DSB, and TMB scores as dependent variables. Age, gender, and BMI were used as covariates. The scores of two participants were excluded from the ANCOVAs due to missing weight and age data. The significance level was set at $p < 0.05$ for all analyses. Eta squared (η^2) and partial eta squared (η_p^2) were reported as an estimate of effect size for the ANOVAs and ANCOVAs, respectively. Preliminary checks were conducted prior to each ANCOVA to ensure that there was no violation of the assumption of normality, linearity, homogeneity of variances, homogeneity of regression slopes, or reliable measurement of the covariates.

Results

Preliminary ANOVAs revealed that participants in the EG and CG did not significantly differ in age (EG = 25.00 ± 10.95 years, CG = 22.38 ± 6.01 years, F = 0.70, p = 0.411 and η^2 = 0.023), pPA (EG = 142.33 ± 148.23 minutes, CG = 166.88 ± 187.21 minutes, F = 0.16, p = 0.690, η^2 = 0.006), and BMI (EG = 24.79 ± 6.92 kg/m^2, CG = 26.92 ± 5.67 kg/m^2, F = 0.82, p = 0.375, η^2 = 0.029). While statistical significance was not achieved, small and medium exercise intervention effects were detected for iPA (EG = 203.78 ± 147.48 minutes, CG = 157.8 ± 207.79 minutes, F = 0.50, p = 0.486, η^2 = 0.017) and wHR (EG = 62.27 ± 8.13 % of maximum, CG = 58.30 ± 5.60 % of maximum, F = 2.14, p = 0.156, η^2 = 0.079), respectively.

ANCOVA results controlling for age, gender, and BMI revealed small, albeit statistically non-significant exercise intervention effects for SCW (EG = 106.62 ± 23.35 % of baseline, CG = 99.68 ± 26.81 % of baseline, F = 1.32, p = 0.262, η_p^2 = 0.052) and DSB (EG = 102.20 ± 24.29 % of baseline, CG = 101.21 ± 15.27 % of baseline, F = 0.32, p = 0.579, η_p^2 = 0.013). No exercise intervention effect was detected for TMB (EG = 92.18 ± 21.03 % of baseline, CG = 95.30 ± 31.29 % of baseline, F = 0.00, p = 0.960, η_p^2 = 0.000). Figure 2 shows the exercise intervention effect on the dependent variables adjusted for the covariates.

Figure 2: Stroop Colour-Word (SCW), Digit Span Backward (DSB), and Trail-Making Part B (TMB) scores (means, standard errors, n = 29) expressed as % of baseline and adjusted for covariates.



Discussion

Program Effectiveness

The primary objective of this study was to evaluate the effectiveness of a 9-week exercise intervention designed to improve EF in college students. However, no statistically significant effects were detected for SCW (inhibitory control), DSB (working memory), or TMB (cognitive flexibility).

The findings of this study differ from the existing literature. Contreras-Osorio et al. (2021), Wang et al. (2023), and Haverkamp et al. (2020) all found exercise to have a statistically significant effect on working memory, inhibitory control, and cognitive flexibility in their respective systematic reviews and meta-analyses. These reviews primarily examined children and adolescents, highlighting the novelty of this study and the importance of future research on the benefits of exercise on EF in college students.

Several factors may account for the statistically non-significant effects observed in this study, with the duration of the exercise intervention being a primary consideration. While interventions lasting between 17 and 22 weeks have demonstrated robust cognitive improvements (Ludyga et al., 2020; Shi et al., 2022), shorter interventions, such as those lasting 6 weeks, often yield modest or small effects (Xue et al., 2019). This study's 9-week intervention may therefore have been insufficient to bring about significant improvements in EF, despite some evidence that shorter interventions can produce limited benefits. The length of this study was constrained by the length of the academic term, as it was not feasible to extend the program beyond the term's start and end dates. Future studies should extend the length of exercise interventions to 17 to 22 weeks to adhere to timeframes that have been shown to produce larger interventions effects.

The second possible reason for the statistically non-significant effects found in this study was the frequency of weekly exercise sessions attended by the participants. The exercise intervention was intended to have participants engage in exercise sessions three times per week; however, the average attendance rate across each of the weekly sessions was 58.5 ± 21.4%. This resulted in participants attending fewer than two weekly sessions on average. The discrepancy between the programmed exercise frequency and the actual attendance likely attenuated the benefits of the exercise intervention on EF. According to the available literature, a frequency of three to four exercise sessions per week appears to be critical in eliciting substantial improvements in EF (Shi et al., 2022; Wang et al., 2023).

A third explanation for the statistically non-significant effects could be the overall time participants spent exposed to cognitively demanding forms of exercise during each session. The programmed brain stimulation phase of the sessions lasted only approximately 18 minutes. The remaining time was devoted to the activation, preparation, and relaxation phases. The lower specificity during these phases combined with the relatively brief duration of the cognitively demanding phase may have limited the effect of the exercise intervention. Research indicates that sessions between 30 and 90 minutes are most beneficial (Wang et al., 2023; Xue et al., 2019). To increase the likelihood of more robust improvements in EF, future exercise interventions should make efforts to prolong the duration of the brain stimulation phase. Given that college students have busy schedules, and barriers to adherence appear to be a limiting factor in producing favourable effects, it would perhaps be prudent to increase the brain stimulation phase and decrease the activation, preparation, and relaxation phases rather than increase the overall length of the sessions. This would increase students' exposure to the stimulative component of the session without increasing the burden of overall time demand.

Finally, self-selection bias is another likely contributor to the statistically non-significant effects observed. Based on the information gathered in the GAQ, many of the participants had accumulated a significant amount of pre-intervention physical activity (155 ± 167.1 minutes). Participants who began the exercise intervention already meeting the 150-minute weekly physical activity recommendations for the general population (Canadian Society for Exercise Physiology, 2018) may have experienced diminished cognitive benefits from additional exercise.

Guidance for Future Programs

The second objective of this study was to comment on possible areas of improvement. The goal was to provide practical insights for other academic institutions looking to adopt similar initiatives to support their students' academic success. As discussed previously, a significant challenge encountered in this study was exercise intervention adherence. Despite efforts to encourage regular participation, maintaining consistent attendance among students proved challenging. The primary reasons cited for missing exercise sessions were time constraints and conflicts with academic obligations such as exams and assignments. Addressing challenges related to attendance should be a priority for future exercise interventions delivered to college students.

There are several ways future exercise interventions can encourage attendance. One way is to increase the number of exercise sessions. By offering exercise sessions on more days, including weekends, students would have greater flexibility to incorporate them into their schedules. Another approach is to integrate a shortened version of the exercise intervention into academic courses. While this approach may only be feasible for select courses, it presents an opportunity to introduce elements of cognitively challenging exercise directly within academic curricula. Either of these options, however, present financial and/or logistical challenges. Therefore, modifying the content of the exercise intervention itself may be a more viable solution.

One possible modification could be to incorporate aspects of the transtheoretical model for behaviour change to support students in their journey to make exercise part of their daily routine. The transtheoretical model provides a framework for understanding behaviour change. It acknowledges that students may be at varying stages of readiness to adopt new habits (Prochaska & DiClemente, 1983; Prochaska & Velicer, 1997). Central to the transtheoretical model are five stages of change: Precontemplation, contemplation, preparation, action, and maintenance. Individuals progress from unawareness to active engagement to sustained behaviour across these stages.

In implementing the transtheoretical model, it is imperative to first identify the current stage of each student. Once achieved, the next step is to tailor the exercise intervention in a way that meets each student in their current stage (Liu et al., 2018). Those in the precontemplation phase may benefit from educational initiatives, while those in the contemplation phase may need slightly more one-on-one time to help them get started.

A transtheoretical approach requires consideration of barriers and motivators (Liu et al., 2018). For students, time availability due to academic commitments may pose a significant obstacle. Creating personalized plans to carve out time for exercise during busy periods is therefore essential. For students in the action and maintenance phases, emphasis may shift from addressing barriers to sustaining motivation. Incorporating elements of self-determination theory, which emphasizes autonomy, competence, and relatedness, may help foster intrinsic motivation (Deci & Ryan, 1985; Teixeira et al., 2012). For instance, allowing individuals to choose their exercises can promote autonomy; ensuring a progressive increase in exercise difficulty can foster competence; and integrating social interactions and relationship-building activities can help fulfill the need for relatedness.

One additional modification that could be made to future exercise interventions pertains to recruitment. Based on the data collected as part of the GAQ, many participants in this study already had established physical activity routines. Consequently, the impact of the exercise intervention was likely attenuated among this cohort. To maximize effectiveness, future exercise interventions may wish to target students who have the most to gain. Sedentary individuals stand to gain significantly in terms of general health improvements. In addition, a recent study of over 400,000 adults suggests that women may experience increased health benefits from exercise when compared to men (Ji et al., 2024). Moreover, individuals with lower EF, including those from disadvantaged backgrounds and those with learning impairments, are likely to derive the most benefits from exercise interventions designed to improve EF (Diamond, 2013; Flook et al., 2010; Montalva-Valenzuela et al., 2022).

Conclusion

This study highlights the potential of implementing effective exercise interventions to enhance EF in college students. The results emphasize the importance of intervention duration, session frequency, and time spent in cognitively demanding forms of exercise in each session. Future programs should extend intervention periods and focus on optimizing adherence through flexible scheduling and individualized approaches. Additionally, targeting students with the greatest potential for cognitive gains, such as sedentary individuals or those with lower baseline EF, could help enhance the effectiveness of the program.

Limitations

It is important to acknowledge the limitations. The capacity limits of the program, due to the available space and the limited number of qualified exercise professionals, led to a small sample size. This, in turn, reduced the statistical power of the analyses. Low statistical power increases the likelihood of type II errors (Algina & Olejnik, 2003). Therefore, the results of this study should be interpreted with caution, as they are not generalizable without larger sample follow-up studies that are sufficiently powered. Second, participants were not randomly assigned to the exercise and comparison groups, but rather determined partially on a first-come, first-serve basis and by their preference (fall versus winter iteration of the exercise intervention). This introduced a level of baseline variability that the ANCOVA (i.e., addition of covariates) perhaps did not adequately account for, which potentially undermined the internal validity. Third, the reliance on voluntary participation may have introduced self-selection bias, wherein individuals already engaged in physical activity were more inclined to participate. This bias may have skewed the observed effects of the exercise intervention, rendering the results less representative of the target population.

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Authors' Qualifications

The authors' qualifications are as follows: Simon Schaerz MSc, PhD, CSEP-CPT; Ricardo Quesada B.Sc., CSEP-CPT.

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