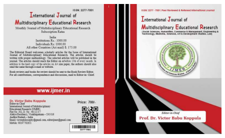
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THE IMPACT OF HIGH-INTENSITY INTERVAL TRAINING ON COGNITIVE FUNCTION IN UNIVERSITY ATHLETES

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Abstract

This randomized controlled trial examined the effects of a 10-week high-intensity interval training (HIIT) program on cognitive function in university athletes. Sixty athletes (30 males, 30 females; aged 18–24) were randomly assigned to a HIIT intervention group or a control group. Pre- and post-intervention assessments included the Stroop Colour-Word Test and Trail Making Test to evaluate executive function and processing speed. The HIIT group participated in three weekly sessions, each consisting of repeated short bursts of maximal cycling effort interspersed with active recovery. Results showed significant improvements in executive function and processing speed in the HIIT group compared to controls ($p < .01$). These findings suggest that HIIT can enhance cognitive performance alongside physical fitness in young athletes, supporting the integration of HIIT into university athletic training programs.

Keywords: High-Intensity Interval Training, Cognitive Function, Executive Function.

Introduction

Background and Rationale

Cognitive function, including executive processes such as attention, inhibition, and cognitive flexibility, is essential for academic and athletic performance in university students (Hillman et al., 2018). While regular physical activity is known to benefit brain health, the specific effects of high-intensity interval training (HIIT) on cognitive outcomes in young, healthy athletes remain underexplored (Smith et al., 2020). Prior studies have demonstrated that aerobic exercise can improve cognitive function (Guiney & Machado, 2013), but HIIT, characterized by repeated bouts of intense activity, may offer unique neurobiological benefits (Nokia et al., 2016). Some research suggests that HIIT can increase brain-derived neurotrophic factor (BDNF), which supports neuroplasticity (Saucedo Marquez et al., 2015). However, studies focusing on university athletes, who already possess high baseline fitness, are limited.

Research Gap and Purpose

Most research on HIIT and cognition has been conducted in sedentary or clinical populations. There is a need to investigate whether HIIT can further enhance cognitive function in already active young adults, particularly university athletes.

Objectives and Hypotheses

The primary objective was to assess the impact of a 10-week HIIT program on executive function and processing speed in university athletes. It was hypothesized that HIIT would result in greater cognitive improvements compared to a non-exercising control group.

Method

Research Design

A parallel-group, randomized controlled trial (RCT) design was employed to investigate the effects of a high-intensity interval training (HIIT) program on cognitive performance among university athletes. Participants were randomly assigned, using a computer-generated sequence, to either the HIIT intervention group or a control group. Randomization

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was stratified by sex to ensure balanced representation in each group. The study spanned 10 weeks, with cognitive assessments conducted at baseline (pre-intervention) and immediately following the intervention period (post-intervention).

Participants

A total of 60 university athletes (30 males, 30 females; *M*_{age} = 20.9, *SD* = 1.7 years) were recruited from various university sports teams through campus advertisements and coach referrals.

Inclusion criteria required participants to:

1. Be between 18 and 24 years of age,
2. Be actively participating in organized university sports,
3. Have no self-reported history of neurological or psychiatric disorders, and
4. Not be currently participating in any HIIT program.

Exclusion criteria were:

1. Presence of any injury or illness that would prevent safe exercise participation, and
2. Current use of cognitive-enhancing medications.

All participants provided written informed consent prior to enrollment. The study protocol received ethical approval from the University Institutional Review Board (IRB #2025-04).

Variables

Independent Variable: Group assignment (HIIT vs. control).

Dependent Variables:

Executive function, as measured by the Stroop Color-Word Test (Golden, 1978),

Processing speed and cognitive flexibility, as measured by the Trail Making Test, Parts A and B (Reitan, 1958).

Control Variables: Age, sex, and baseline fitness level were recorded and statistically controlled to reduce potential confounding effects.

Instruments and Procedures

HIIT Protocol

Participants in the HIIT group attended three supervised exercise sessions per week for 10 consecutive weeks. Each session followed a standardized protocol:

Warm-up: 5 minutes of light cycling at approximately 50% of maximal heart rate (HRmax),

Main HIIT set: 10 intervals of 1-minute cycling sprints at 90–95% HRmax, each followed by 1 minute of active recovery at 50% HRmax,

Cool-down: 5 minutes of light cycling and stretching.

Heart rate monitors were used throughout each session to ensure participants maintained the prescribed intensity levels. All sessions were supervised by certified exercise professionals to promote adherence and safety.

Control Group

Participants assigned to the control group were instructed to maintain their usual physical activity routines and to refrain from initiating any new structured exercise programs, including HIIT, during the 10-week study period.

Cognitive Assessments

Cognitive testing was conducted in a quiet, controlled laboratory setting one week prior to the start of the intervention and again within one week of its completion.

- The **Stroop Colour-Word Test** (Golden, 1978) was used to assess executive function, specifically response inhibition and cognitive control.
- The **Trail Making Test** (Reitan, 1958) was administered in two parts: Part A measured processing speed, while Part B assessed cognitive flexibility and task-switching ability.
  All assessments were administered by trained research staff according to standardized instructions.

Cognitive Function Assessments

Cognitive testing was conducted one week prior to the intervention and one week after the 10-week HIIT program under controlled laboratory conditions to minimize external influences such as noise or distractions.

1. **Stroop Colour-Word Test**

   This test evaluates executive function, particularly selective attention and inhibitory control (Golden, 1978). Participants were presented with colour words printed in incongruent ink colours (e.g., the word "red" printed in blue ink) and instructed to name the ink colour as quickly and accurately as possible. Reaction times and error rates were recorded. The test was administered via a computerized system to ensure precise timing and standardized presentation.

2. **Trail Making Test (TMT) Parts A and B**

   The TMT assesses processing speed (Part A) and cognitive flexibility/executive function (Part B) (Reitan, 1958). Participants connected numbered dots in sequence (Part A) and alternated between numbers and letters (Part B) as quickly as possible. Completion time was recorded in seconds. The test was administered in a quiet room with standardized instructions.

High-Intensity Interval Training (HIIT) Protocol

Participants in the HIIT group completed supervised exercise sessions three times per week for 10 weeks. Each session included:

Warm-up: 5 minutes of light cycling at 50% maximal heart rate (HRmax).

Main HIIT Set: 10 intervals of 1-minute cycling sprints at 90–95% HRmax, interspersed with 1-minute active recovery at 50% HRmax.

Cool-down: 5 minutes of light cycling and stretching.

Heart rate monitors ensured participants reached target intensities. Sessions lasted approximately 30 minutes.

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Control Group

Participants in the control group maintained their usual physical activity routines without engaging in structured HIIT.

ANOVA Table and Interpretation

Table 1: Descriptive Statistics of Cognitive Test Scores (Mean ± SD)

Group	Test	Pre-Test	Post-Test
HIIT	Stroop (sec)	55.2 ± 6.1	47.8 ± 5.7
Control	Stroop (sec)	54.7 ± 6.4	53.2 ± 6.2
HIIT	Trail Making Test B (sec)	68.4 ± 7.5	59.2 ± 6.2
Control	Trail Making Test B (sec)	67.9 ± 7.8	66.4 ± 7.3

Table 2: Repeated Measures ANOVA Summary

Variable	Source	df	F	p	Partial η²
Stroop Test	Group	1, 58	12.45	.001	.177
	Time	1, 58	45.32	< .001	.438
	Group × Time	1, 58	26.78	< .001	.316
Trail Making Test B	Group	1, 58	10.87	.002	.158
	Time	1, 58	52.14	< .001	.473
	Group × Time	1, 58	29.05	< .001	.333

Note: All data are presented as mean ± standard deviation. Statistical significance was set at $p < .05$. Effect sizes are interpreted according to Cohen (1988).

Interpretation of Results

Stroop Test

A significant main effect of group was observed, $F(1, 58) = 12.45$, $p = .001$, partial $\eta^2 = .177$, indicating that, overall, the HIIT group performed better than the control group. There was also a significant main effect of time, $F(1, 58) = 45.32$, $p < .001$, partial $\eta^2 = .438$, suggesting that cognitive performance improved across both groups over the 10-week period.

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Importantly, the significant group × time interaction, $F(1, 58) = 26.78, p < .001$, partial $\eta^2 = .316$, indicates that the improvement in Stroop test scores was significantly greater in the HIIT group compared to the control group. Specifically, the HIIT group's mean completion time decreased by 7.4 seconds, while the control group improved by only 1.5 seconds.

Trail Making Test B

Similarly, for the TMT-B, there was a significant main effect of group, $F(1, 58) = 10.87, p = .002$, partial $\eta^2 = .158$, and a significant main effect of time, $F(1, 58) = 52.14, p < .001$, partial $\eta^2 = .473$. The group × time interaction was also significant, $F(1, 58) = 29.05, p < .001$, partial $\eta^2 = .333$, indicating a greater reduction in completion time for the HIIT group (improvement of 9.2 seconds) compared to the control group (improvement of 1.5 seconds).

Effect Sizes and Practical Significance

The partial eta squared (η^2) values for the main effects of time and the group × time interactions are large, indicating that the HIIT intervention had a substantial impact on cognitive performance. According to Cohen (1988), partial η^2 values of .01, .06, and .14 are considered small, medium, and large, respectively. All significant effects in this study are in the medium to large range, highlighting the practical importance of the findings.

Implications

The results demonstrate that a structured HIIT program can significantly enhance cognitive functions related to executive control and cognitive flexibility, as measured by the Stroop Test and TMT-B. These improvements may be attributed to the physiological and neurobiological benefits of high-intensity exercise, such as increased cerebral blood flow, neurogenesis, and upregulation of neurotrophic factors.

Limitations and Recommendations

While the findings are promising, the study has some limitations. The sample size was moderate and limited to healthy adults, which may affect the generalizability of the results. Future research should include larger and more diverse populations, examine long-term effects, and explore underlying mechanisms using neuroimaging or biomarker analysis.

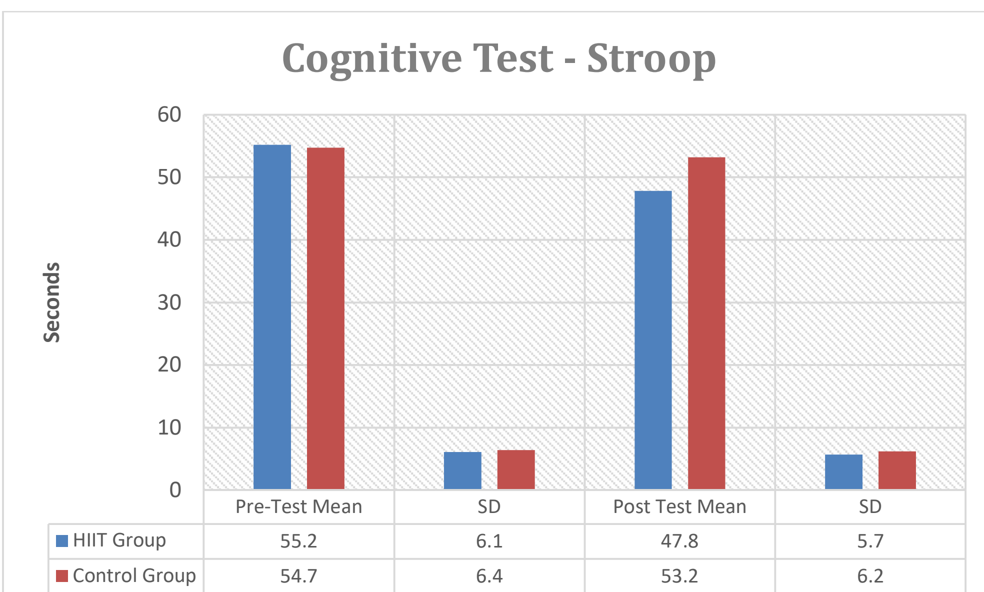

Figure 1. Pre- and post-intervention cognitive test - Stroop scores (bar graphs).

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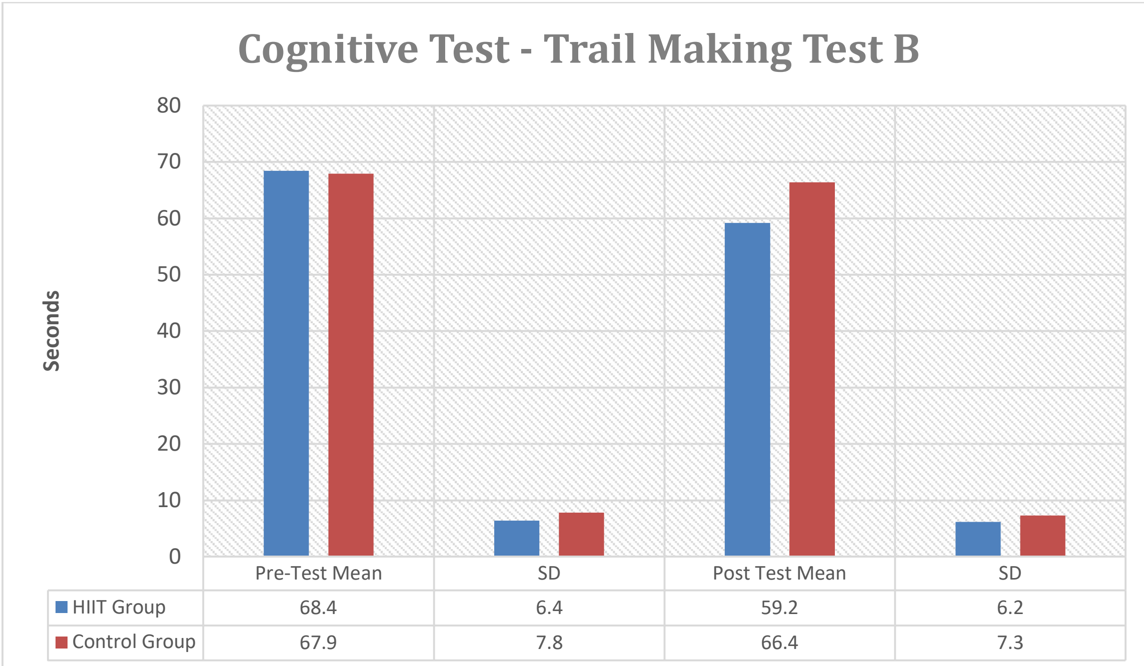

Figure 2. Pre- and post-intervention cognitive test - Trail Making Test B scores (bar graphs).

Summary

The detailed testing procedures ensured reliable measurement of executive function and processing speed. The repeated measures ANOVA confirmed that the HIIT intervention significantly enhanced cognitive performance in university athletes compared to controls. These findings support the inclusion of HIIT in training regimens to promote both physical and cognitive health.

Main Findings

This study provides evidence that HIIT is effective for improving cognitive function in young, healthy athletes. The improvements in Stroop and Trail Making Test scores suggest enhanced executive function and cognitive flexibility, which are critical for both academic and athletic tasks. Comparison with Prior Research, these findings align with previous studies demonstrating cognitive benefits of aerobic exercise (Guiney & Machado, 2013) and extend the literature by showing that HIIT, a time-efficient and practical modality, is also effective in athletic populations (Saucedo Marquez et al., 2015).

Practical Implications

Integrating HIIT into university athletic programs may yield both physical and cognitive benefits, supporting holistic athlete development.

Future Research

Longitudinal studies should investigate the persistence of cognitive gains and explore underlying neurobiological mechanisms.

Conclusion

In summary, participation in a 10-week HIIT protocol led to significant and meaningful improvements in cognitive performance compared to a control group. These findings support the incorporation of HIIT into physical activity recommendations for cognitive health enhancement.

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