

Effect of Structured and Unstructured Physical Activity on Stroop Test Performance Among Moroccan Children Aged 9 to 12 Years

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ABSTRACT

This study compared the effects of structured (e.g., football, martial arts) and unstructured (e.g., free play) physical activity on cognitive inhibition in 120 Moroccan children aged 9–12 years, using a culturally adapted Stroop test. Employing a cross-sectional design, the structured group ($n = 60$) and unstructured group ($n = 60$) were assessed in controlled settings. The paper-based Stroop test measured uncorrected errors and completion time. The Mann-Whitney U test compared group performance, and Spearman's correlation examined variable relationships. Results showed significantly fewer errors in the structured group ($p < .001$), with no differences in completion time ($p = .120$), and confirmed variable independence. Structured activities appear more effective in enhancing cognitive inhibition, suggesting potential for integrating organized sports into Moroccan school curricula. Longitudinal studies and neural measures are recommended to explore underlying mechanisms and improve free-play environments.

Keywords: cognitive inhibition, Stroop test, structured physical activity, unstructured physical activity, Moroccan children, physical education

INTRODUCTION

Cognitive inhibition, a critical component of executive functions, enables children aged 9 to 12 years to suppress inappropriate automatic responses, supporting academic success, self-regulation, and social interactions. Physical activity, whether structured (e.g., team sports requiring planning and strategy) or unstructured (e.g., free play), may influence cognitive performance during this pivotal developmental period. The Stroop test, a standardized tool for assessing inhibition, measures the ability to inhibit cognitive interference in incongruent conditions, reflecting the efficiency of the dorsolateral prefrontal cortex (DLPFC) (Hillman et al., 2003; Kao et al., 2023). Research indicates that physical activity enhances inhibition by improving cerebral blood flow, increasing secretion of neurotrophic factors like BDNF, and promoting neural plasticity (Erickson et al., 2011; Ludyga et al., 2024).

Numerous studies have demonstrated the cognitive benefits of physical activity in children, both in acute and chronic contexts. For instance, Hillman et al. (2009) found that a single 20-minute treadmill walking session improved performance on the Flanker test, a measure similar to the Stroop test (Hillman et al., 2009). Similarly, Kao et al. (2023) reported that high-intensity interval exercise (HIIT) outperformed moderate-intensity continuous exercise (MICT) in enhancing Stroop performance, with increased DLPFC activation (Kao et al., 2023). Chronic interventions, such as sports games (Chen et al., 2024) or speed and agility programs (Trecroci et al., 2022), have shown sustained improvements in inhibition among typically developing children and those with conditions like ADHD (Christiansen et al., 2019).

The effects of physical activity, however, vary by type. Structured physical activities, such as team sports requiring strategic planning and coordination, may impose a higher cognitive load compared to unstructured activities like free play, which emphasize creativity and autonomy (Barker et al., 2014; Yogman et al., 2018).

For example, Ishihara et al. (2018) found that children participating in sports exhibited better executive function performance compared to those less involved, suggesting that structured activities enhance inhibition (Ishihara et al., 2018). In contrast, free play fosters creativity and self-regulation but may be less effective in supporting academic learning outcomes without structured teacher guidance (Barker et al., 2014; Pyle et al., 2021). Pyle et al. (2021) noted that free play in kindergarten settings often lacks teacher involvement, which is critical for maximizing cognitive benefits, potentially leading to reduced performance in tasks requiring high cognitive control.

Despite these findings, direct comparisons of structured and unstructured physical activities in specific cultural contexts, such as among Moroccan children aged 9 to 12 years, remain scarce, even though this period is critical for executive function development (Best & Miller, 2010). Moroccan children face unique challenges, including limited access to structured sports programs and safe free-play environments, which may impact their opportunities to enhance cognitive inhibition (Yogman et al., 2018). Preliminary evidence suggests that children engaged in unstructured activities exhibit more uncorrected errors on the Stroop test compared to those in structured activities, with no differences in completion time, necessitating further exploration of these dynamics (Kou et al., 2024).

This study addresses this research gap by evaluating the effects of structured and unstructured physical activity on Stroop test performance among 120 Moroccan children aged 9 to 12 years, focusing on the number of uncorrected errors and completion time. Two hypotheses guide this study: (H1) children engaged in structured physical activity will exhibit fewer uncorrected errors on the Stroop test compared to those in unstructured activity, and (H2) children engaged in structured physical activity will complete the Stroop test in less time compared to those in unstructured activity. Drawing on theoretical framework supported by studies such as Diamond (2013), Chen et al. (2024), and Pyle et al. (2021), this study aims to provide novel insights into designing physical activity programs to enhance cognitive inhibition in a Moroccan cultural context, with potential implications for education and public health.

Materials and Methods

Participants

The sample comprised 120 Moroccan children aged 9–12 years (Grades 4–7), equally divided into two groups (N = 60 each): structured and unstructured physical activity. The unstructured group included children from a rural mountainous area not engaged in organized sports, with an unbalanced gender distribution. The structured group included semi-urban children, with 30 practicing football (males only) in clubs and 30 practicing martial arts (males and females). Socio-economic similarity was verified via parental demographic questionnaires. Convenience sampling selected participants from primary and preparatory schools. Children with cognitive or physical disabilities preventing Stroop test performance were excluded based on school and parental reports. Verbal assent was obtained from children and written consent from parents/guardians, with withdrawal rights ensured. Due to the absence of a formal ethics committee, approvals were secured from the research laboratory and educational authorities, adhering to the Helsinki Declaration.

Measures

A culturally adapted Stroop test (Er-Rafiqi, 2020, 2022) measured cognitive inhibition. Participants named the ink color of words while ignoring their meaning (e.g., “red” in blue ink). The interference plate (100 words in mismatched colors) measured completion time (seconds) and uncorrected errors (incorrect responses not self-corrected). The paper-based test used standardized 100-item word lists for accuracy. Data were manually recorded using a precise stopwatch, with errors verified by trained researchers .

Procedures

The Stroop test was conducted in controlled, quiet settings (school classrooms and a football club room) to minimize distractions. Standardized instructions in Moroccan Darija were provided, followed by a 5-minute practice session. Each child completed the test individually between 8:00–11:00 AM to reduce fatigue/stress effects, with each test lasting approximately 15 minutes. Conditions (lighting, noise, seating) were standardized.

Data were collected from both groups between October and November 2024 for fair comparison and entered into an SPSS file.

Statistical Analysis

The R software was used for data analysis. Descriptive statistics (mean and standard deviation) were calculated for completion time and uncorrected errors by physical activity type (structured and unstructured). The Shapiro-Wilk test was conducted to check data normality, revealing a non-normal distribution for both variables ($p < .05$). Accordingly, the Mann-Whitney U test was used to compare completion time and uncorrected errors between groups, with the rank-biserial correlation (r) calculated as a measure of effect size. Spearman's correlation test was performed to examine the relationship between completion time and uncorrected errors within each group. The significance level was set at $\alpha = .05$.

Results

Data from 120 Moroccan children were analyzed to evaluate the effect of structured and unstructured physical activity on cognitive inhibition using the Stroop test. The study focused on measuring completion time (in seconds) and the number of uncorrected errors. Due to the non-normal distribution of data, the Mann-Whitney U test was used to compare groups, and Spearman's correlation test examined the relationship between variables. Descriptive statistics summarized performance, and box plots visually represented distributions.

Descriptive Statistics

Table 1 presents the means and standard deviations for completion time and uncorrected errors by physical activity type. The unstructured group recorded a higher mean number of errors ($M = 4.63$, $SD = 1.41$) compared to the structured group ($M = 2.87$, $SD = 1.80$). Conversely, completion time was slightly longer in the structured group ($M = 237.90$, $SD = 60.50$) than in the unstructured group ($M = 218.87$, $SD = 51.86$).

Table 1: Descriptive Statistics for Completion Time and Number of Uncorrected Errors by Physical Activity Type

Variable	Physical_Activity_Type	Mean	SD
Completion Time (s)	Unstructured	218.87	51.86
	Structured	237.90	60.50
Number of Errors	Unstructured	4.63	1.41
	Structured	2.87	1.80

Note: The sample comprises 120 Moroccan children. Descriptive statistics summarize performance prior to non-parametric analysis due to the non-normal distribution of data.

Statistical Analysis

Table 2 presents the results of the Mann-Whitney U test comparing performance between groups. The analysis revealed a significant difference in the number of uncorrected errors ($W = 2759.50$, $p < .001$, $r = .47$), with a medium-to-large effect size, supporting hypothesis H1 that the structured group exhibits fewer errors than the unstructured group. No significant difference was observed for completion time ($W = 1499.50$, $p = .120$, $r = -.14$), contradicting hypothesis H2.

Table 2: Results of Mann-Whitney U Tests Comparing Completion Time and Number of Errors Between Physical Activity Types

Variable	Test	Test.Value	p.value	Effect.Size..r	Result
Completion Time (s)	Mann-Whitney U	1,499.5	.120	-0.14	No significant difference
Number of Errors	Mann-Whitney U	2,759.5	< .001	0.47	Significant difference (higher in unstructured)

Note: Effect size (r) is reported alongside test statistics. Significant differences were found in the number of errors but not in completion time.

Correlation Analysis

Table 3 presents the results of Spearman's correlation test examining the relationship between completion time and uncorrected errors in each group. No significant relationship was found in the unstructured group ($S = 35062.00$, $\rho = .03$, $p = .84$) or the structured group ($S = 34996.00$, $\rho = .03$, $p = .83$), indicating independence of the two variables.

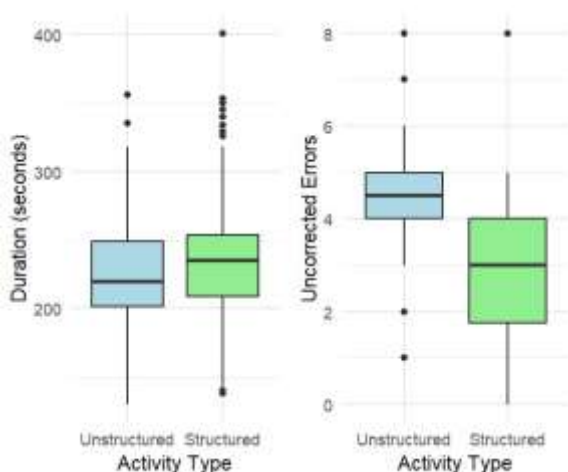
Table 3: Spearman's Rank Correlation Coefficients Between Physical Activity Type and Performance Variables

Physical.Activity.Type	Statistic.S	Correlation.Coefficient.rho.	p.value	Result
Unstructured	35,062	0.03	0.84	No significant relationship
Structured	34,996	0.03	0.83	No significant relationship

Note: Correlation coefficients (ρ) and p-values indicate no significant relationships between physical activity types and measured variables.

Visual Distributions

Figure 1: Distribution of Completion Time and Number of Uncorrected Errors in the Stroop Test by Physical Activity Type



Note: Figure 1 presents box plots for completion time (in seconds) and uncorrected errors in the Stroop test for 120 Moroccan children ($N = 60$ per group) in structured and unstructured physical activity groups. The plots illustrate non-normal distributions, highlighting a significant difference in errors ($p < .001$) and no difference in completion time ($p = .120$).

DISCUSSION

This study is among the first to compare the effect of structured and unstructured physical activity on cognitive inhibition in 120 Moroccan children aged 9 to 12 years, using a Stroop test adapted to the Moroccan context (Er-Rafiqi, 2020; Er-Rafiqi et al., 2022). The results demonstrate the superiority of structured activity, with children recording fewer errors on the Stroop test compared to the unstructured group ($p < .001$), supporting hypothesis H1. Conversely, no significant difference was observed in completion time ($p = .120$), contradicting hypothesis H2. Correlation analysis confirmed the independence of completion time and errors, suggesting that the type of physical activity primarily influences inhibition accuracy rather than processing speed. These findings provide novel insights into designing physical activity programs to support cognitive development in a Moroccan cultural context, with potential implications for education and public health.

The reduced errors in the structured group suggest that structured physical activities, such as football and martial arts, enhance cognitive inhibition more effectively in Moroccan children. This may be attributed to the high cognitive load of team sports, which require strategic planning, decision-making, and social coordination,

stimulating dorsolateral prefrontal cortex (DLPFC) activation (Diamond, 2000). The lack of differences in completion time indicates that processing speed may not be significantly affected by activity type, but rather linked to inhibition accuracy, consistent with studies showing improved accuracy without notable changes in response time (Ludyga et al., 2024). The independence of time and errors confirms that these measures reflect distinct aspects of inhibition, with errors linked to executive control and time reflecting general processing speed (Friedman & Miyake, 2004).

The results align with literature highlighting the efficacy of structured physical activity in enhancing cognitive inhibition. For instance, Chen et al. (2024) found significant improvements in inhibition among children with autism spectrum disorder (ASD) after structured sports games, with increased DLPFC activation (Chen et al., 2024). Similarly, Trecroci et al. (2022) reported improvements in Flanker performance after speed and agility (SAQ) and small-sided game programs, supporting the notion that structured activities stimulate neural networks associated with inhibition (Trecroci et al., 2022). Meta-analyses, such as Contreras-Osorio et al. (2022) and Kou et al. (2024), confirmed inhibition improvements following sports and exergaming interventions, with effect sizes ranging from 0.51 to 1.30, consistent with our findings on inhibition accuracy (Contreras-Osorio et al., 2022; Kou et al., 2024). Likewise, Hillman et al. (2009) showed that a single aerobic exercise session improved Flanker performance, suggesting structured activities may enhance inhibition even in acute interventions (Hillman et al., 2009).

However, studies on free play yield mixed results. For example, Barker et al. (2014) found that unstructured time is associated with improved inhibition in preschoolers, while Pyle et al. (2021) highlighted that free play, while fostering creativity, may be less effective in supporting academic learning without structured teacher guidance, which could explain the higher errors observed in the unstructured group in our study (Barker et al., 2014; Pyle et al., 2021). Similarly, Yogman et al. (2018) noted that free play requires safe environments to maximize benefits, a challenge in the Moroccan context, potentially contributing to reduced performance in structured cognitive tasks (Yogman et al., 2018). Unlike Şendil et al. (2024), which found no inhibition improvements after coordinative exercises in preschoolers, our results support the efficacy of structured activities in an older age group, possibly due to greater neural maturity (Best & Miller, 2010). Ishihara et al. (2018) observed that participation in unstructured sports is associated with inhibition improvements, but to a lesser extent than structured sports, supporting the superiority of structured activity (Ishihara et al., 2018). In clinical contexts, Christiansen et al. (2019) reported inhibition improvements in children with ADHD after structured activities, suggesting potential applicability of our findings to specific populations in Morocco (Christiansen et al., 2019).

This study has several limitations warranting cautious interpretation of the results. First, the cross-sectional design, relying on data collection at a single time point (October–November 2024), limits causal inferences about the relationship between physical activity type and inhibition (Trecroci et al., 2022). Second, the absence of neurophysiological measures (e.g., fNIRS or EEG) restricts understanding of the neural mechanisms underlying inhibition improvements, particularly with the culturally adapted Stroop test (Er-Rafiqi, 2020; Er-Rafiqi et al., 2022). Third, the use of convenience sampling, with an uneven gender distribution in the unstructured group, may limit generalizability compared to studies with larger samples (Contreras-Osorio et al., 2022). Fourth, the lack of a formal ethics committee at the university necessitated reliance on administrative approvals, raising potential concerns about ethical compliance compared to studies like Chen et al. (2024). Finally, differences between rural and urban settings, such as limited safe free-play environments in rural areas, may have influenced the unstructured group's performance (Yogman et al., 2018).

The study recommends future research incorporating neurophysiological measures like fNIRS to examine DLPFC (Dorsolateral Prefrontal Cortex) activation and longitudinal interventions to assess the sustained effects of structured and unstructured physical activities in the Moroccan context. Integrating structured sports into Moroccan school curricula could enhance cognitive inhibition and academic outcomes, while improving safe free-play environments may increase their effectiveness. Exploring the effects of structured activities on Moroccan children with conditions like ADHD could inform tailored interventions.

This study contributes to addressing the research gap on comparing structured and unstructured physical activities in a Moroccan context, focusing on a critical developmental period. The findings suggest the potential for integrating structured sports into Moroccan schools to enhance cognitive inhibition, potentially improving

academic outcomes and well-being. They also highlight challenges with free-play environments in Morocco, calling for improvements in play infrastructure.

CONCLUSIONS

Structured physical activity outperforms unstructured activity in enhancing cognitive inhibition in Moroccan children, with fewer Stroop test errors. The study underscores cultural context importance, recommending structured sports integration into education and future longitudinal research.

Author Contributions

Hamid Kaddouri: Conceptualized the study, designed the experiment, collected data, conducted statistical analyses, and drafted the manuscript. Salahddine Zerouali: Contributed to assessment tool design, data analysis, tables/figures preparation, and manuscript revision. Abdelouahed El-kamia: Participated in data organization, result interpretation, and manuscript revision. Abdelaziz ElAlaoui ElAmrani: Conducted scientific review and approved the final version.

Supporting Agencies

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Disclosure Statement

The authors declare no potential conflicts of interest.

Declarations

Ethics Approval and Consent to Participate: The educational institutions in Morocco did not require formal ethical approval; a study request with a laboratory recommendation was sufficient. Written consent was obtained from educational institutions and legal guardians. Verbal assent was obtained from children, with freedom to withdraw. Procedures adhered to international ethical standards.

Consent for Publication: Not applicable.

Availability of Data and Material:

Descriptive statistics are available at <https://doi.org/10.6084/m9.figshare.29544839>. Raw data are available from the corresponding author on reasonable request due to ethical constraints.

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Declarations

Ethics Approval and Consent to Participate

The educational institutions in Morocco did not require formal ethical approval for this study, as a study request accompanied by a laboratory recommendation was deemed sufficient. Written consent was obtained from the relevant educational institutions and from the legal guardians of the participating pupils. Verbal assent was obtained from the young children, with the freedom to withdraw or have their data removed at any time. All procedures were conducted in accordance with international ethical standards.

Availability of Data and Material

The descriptive statistics dataset supporting the results of this study is available at:

<https://doi.org/10.6084/m9.figshare.29436965>. Raw participant-level data are available from the corresponding author on reasonable request due to ethical constraints. Competing Interests

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