Physical Education Theory and Methodology
Теорія та методика фізичного виховання

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original Scientific Article

Neuromotricity and Executive Functions in Older Adults: A Quantitative Intervention for Healthy Ageing

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Accepted for Publication: September 20, 2025
Published: September 30, 2025

DOI: 10.17309/tmfv.2025.5.16

Abstract

Objectives. The objective of this study was to compare the efficacy of the BAPNE method, a program intentionally designed with high cognitive demands, against active control groups (Salsa and Body Percussion with Choreography) and a passive control group. The study aimed to provide compelling evidence for the importance of cognitive load in interventions for healthy ageing.

Materials and Methods. This longitudinal, quasi-experimental study investigated the effects of a 9.5-month neuromotricity intervention, the BAPNE method, on executive functions in older adults. A sample of 368 participants (60-78 years) from a community program in Caracas, Venezuela, was divided into four groups: BAPNE (experimental), Salsa, Body Percussion with Choreography, and a Control group. Executive functions were assessed using a battery of validated neuropsychological tests, including the Behavior Rating Inventory of Executive Function (BRIEF-A), Trail Making Test (TMT), Verbal Fluency, Stroop, and D2 tests. Statistical analyses included within-group comparisons (paired t-tests) and between-group comparisons (ANCOVA) to control for baseline differences.

Results. The BAPNE group showed significant enhancements across all measures, with large effect sizes, particularly for Stroop Interference (Cohen's d = -1.48) and the BRIEF Inhibition Index (Cohen's d = -1.47). Between-group analyses, controlling for baseline scores, confirmed the BAPNE group significantly outperformed all other groups on inhibition and other executive functions (e.g., BRIEF Inhibition: $p < 0.001$, $\eta_p^2 = 0.45$; Stroop Interference: $p < 0.001$, $\eta_p^2 = 0.42$). In contrast, the Salsa group demonstrated moderate improvements, while the Body Percussion with Choreography group exhibited negligible cognitive gains.

Conclusions. This study provides robust evidence that the BAPNE method's dual-task demands lead to substantial and clinically meaningful improvements in executive functions, particularly inhibition. The findings reinforce that the cognitive load of an activity, rather than mere physical exertion, is the critical factor for effective cognitive training in ageing.

Keywords: neuromotricity, BAPNE, executive functions, older adults, body percussion.

Introduction

The global demographic landscape is undergoing a profound transformation with a steady increase in the elderly population, presenting a significant public health challenge for maintaining cognitive health and functional independence (Clifford et al., 2023; Gard et al., 2017; Gayman et al., 2017; Meredith et al., 2023; Podolski et al., 2023). A well-established feature of normal cognitive aging is the decline in executive functions (EFs), a set of higher-order cognitive processes indispensable for goal-directed behavior, adaptive responses, and independent living. Core components like inhibition and cognitive flexibility are vital for everyday activities (Diamond, 2013a, 2013b; Lu et al., 2024; Rice et al., 2025). Preserving these critical abilities is not just an academic concern; it directly impacts people's quality of life and their resilience to age-related cognitive decline (Contreras-Osorio et al., 2022). Therefore, identifying effective interventions to strengthen executive functions is an urgent public health need essential for promoting active and healthy aging.

While physical activity and music benefit cognitive health (Hwang et al., 2015; Stern et al., 2023), interventions with a higher degree of cognitive complexity, coordination, and novelty yield more pronounced cognitive gains (Ambegaonkar et al., 2022; Granacher et al., 2012; Hansen et al., 2024; Peng et al., 2024). This suggests that an activity's cognitive demands, rather than mere physical exertion, may be the

key determinant of its neurocognitive efficacy, demonstrating that not all interventions are equally effective at stimulating cognitive health (Chen et al., 2023; Sooktho et al., 2022).

Neuromotricity and executive functions

The official Neuromotricity and Motor Literacy research group at the University of Alicante, a leading authority in its field with over sixty publications and four thousand academic citations, focuses its mission on evaluating cognitive and executive functions through the specialized application of neuromotricity. This approach uniquely uses movement and cognition with various objects and the body itself, while deliberately avoiding repetitive choreography. Instead, it employs a continuously changing set of activities designed to constantly challenge and train attention, inhibition, and cognitive flexibility. Its central conceptual paradigm meticulously integrates rhythmic motor activities with cognitive demands through a dual-task paradigm (Mas-Mas et al., 2023).

This innovative research has been successfully applied across a wide range of academic and practical domains, including early childhood education (Romero-Naranjo, Andreu-Cabrera & Arnau-Mollá, 2024), primary education (Álvarez-Morales & Romero-Naranjo, 2019), and secondary education (Romero-Naranjo et al., 2023a), as well as in physical activity and sports sciences (Romero-Naranjo & Andreu-Cabrera, 2023) and art education (Alonso-Sanz & Romero-Naranjo, 2015). The scientific credibility of this work is reinforced by a series of high-level academic contributions, including rigorous quantitative studies with experimental and control groups (Arnau-Mollá, Romero-Naranjo & Andreu-Cabrera, 2024). This rigorous body of evidence distinguishes the BAPNE method from general rhythmic training. Its conceptual framework is based on the principle of "we don't teach music, we teach with music," which elegantly articulates its primary objective of cognitive enhancement. The intentional design to induce a high cognitive load, rather than being a byproduct of physical activity, is the cornerstone of its efficacy and the basis for anticipating significant improvements in executive functions.

Rationale for comparative interventions

To rigorously evaluate the unique contributions of the BAPNE method, this study incorporated two active comparison groups—salsa classes and body percussion choreography—along with a passive control group. The inclusion of salsa provided a moderate cognitive challenge, requiring continuous learning and adaptation to musical cues. In contrast, the choreography group was designed with a lower cognitive demand, focusing on a fixed, repetitive routine. This comparative design aimed to isolate the distinctive contributions of the BAPNE method's neuromotor principles and attribute the observed differences to the unique cognitive demands of each intervention.

Research objectives

This investigation was guided by three primary research objectives:

1. To what extent does participation in the BAPNE neuromotricity program improve executive functions (inhibition, sustained attention, cognitive flexibility) in older adults compared to a control group?
2. How do the effects of the BAPNE neuromotricity program on executive functions compare with those of salsa classes and body percussion with choreography in older adults?
3. What are the specific differential impacts of BAPNE neuromotricity program, salsa, and body percussion with choreography on individual executive function domains (e.g., inhibition, attention, cognitive flexibility) in this population?

The structured nature of these questions ensures a systematic investigation, progressing from a general comparison to a more granular analysis of specific executive function domains. This approach facilitates a comprehensive and detailed examination of the interventions' effects.

Hypotheses

Based on the theoretical underpinnings of the BAPNE method and existing literature, the following hypotheses were formulated:

Inter-subject (Between-Group) hypotheses:

H1: The BAPNE neuromotricity group will demonstrate significantly greater improvements in executive functions (specifically inhibition, sustained attention, and cognitive flexibility) compared to the control group.

H2: The BAPNE neuromotricity group will show significantly greater improvements in executive functions compared to both the salsa group and the body percussion with choreography group.

H3: The salsa group will exhibit greater improvements in cognitive flexibility and attention compared to the body percussion with choreography group.

H4: The choreographed body percussion group will show improvements or not in executive functions, especially in inhibition and attention, compared to the control group.

Intra-subject (Within-Group) Hypotheses:

H5: Participants in the BAPNE neuromotor group will show significant improvements within the group in all executive functions measured from before to after the intervention.

H6: Participants in the salsa group will show significant improvements compared to the control group.

H7: Participants in the body percussion choreography group will show possible improvements in the attentional network and executive functions.

H8: The control group will not show significant improvements within the group in executive functions from before to after the intervention.

The explicit formulation of these hypotheses allows for direct empirical testing, thereby strengthening the scientific rigor of the study. The combination of inter- and intra-subject hypotheses provides a comprehensive depiction of both relative and absolute changes, ensuring a thorough evaluation of the interventions.

Materials and Methods

Study Design

This investigation employed a quasi-experimental, longitudinal design to assess the effects of different

interventions on executive functions in older adults. Participants were allocated to one of four distinct groups: the BAPNE Neuromotricity group (experimental), a Salsa class group, a Body Percussion with Choreography group, and a Control group. The quasi-experimental nature of the design implies that participants were not randomly assigned to groups, a common characteristic in real-world intervention studies conducted within existing community programs. While this design choice necessitates careful consideration of potential confounding variables, the robust sample size and the meticulous control for baseline characteristics mitigate some concerns regarding internal validity. The inclusion of multiple comparison groups, both active and passive, enhances the ecological validity of the findings, allowing for meaningful comparisons in a naturalistic setting. Four groups were measured on purpose to avoid the Hawthorne effect and thus provide reliable data and avoid statistical bias.

Participants and Setting

The study was conducted in the Chacao municipality of Caracas, Venezuela, as part of the "Juventud Prolongada" (Prolonged Youth) municipal program, organized by the local mayor's office. A total of 395 individuals initially commenced the research; however, 368 participants successfully completed the entire 9.5-month intervention period, resulting in a final sample size of N=368. This represents a remarkably low attrition rate for a longitudinal study of this duration, suggesting high participant adherence and engagement, which significantly bolsters the reliability of the findings. The participants were older adults, ranging in age from 60 to 78 years. A critical strength of this study's design was the careful control for socio-economic status: all four groups were confirmed to share the same socio-economic background. This homogeneity across groups is paramount, as it substantially reduces a common confounding variable in intervention research, thereby strengthening the argument that observed post-intervention differences are attributable to the interventions themselves rather than pre-existing disparities. Each year, the program welcomes new participants, which means that research can be conducted annually based on the number of subjects participating. The low attrition rate also implies that the interventions were feasible and acceptable to this older adult population, a valuable consideration for future program development and implementation.

Sample Characteristics

The sample for this study comprised a total of 368 older adults, ranging in age from 60 to 78 years. All participants were drawn from the "Juventud Prolongada" municipal community program in the Chacao municipality of Caracas, Venezuela. This specific selection criteria provided a key methodological strength by ensuring a high degree of homogeneity in the participants' socioeconomic background across all study groups. The cohort was divided into four distinct groups, with 92 participants assigned to each: a BAPNE neuromotricity experimental group, a Salsa class group, a Body Percussion with Choreography group, and a Control group. Of the 395 individuals who initially enrolled in the research, a remarkable 368 completed the entire 9.5-month intervention period. This exceptionally low attrition rate is a testament to the high level of participant engagement and adherence to the program, which significantly bolsters the internal validity and reliability of the study's findings.

Intervention protocols.

The interventions spanned a period of 9.5 months, with all active groups participating in sessions twice a week.

BAPNE Neuromotricity Group. This experimental group participated in activities specifically designed around the BAPNE method, with a central emphasis on "dual tasks." The sessions systematically incorporated simultaneous motor and cognitive challenges. Some examples included performing complex body percussion rhythms while performing verbal tasks such as telling a story, translating words into another language, performing arithmetic operations, counting backwards, categorizing words or remembering sequences, saying opposites, singing a specific melody, changing the vowels in the melody, removing words from the melody, and answering geography or history questions. Cross-movements were often combined with cognitive demands, requiring participants to inhibit specific responses and switch flexibly between tasks. Therefore, the voice performed a task independent of what the hands and feet were doing. The sessions in this group were taught by BAPNE expert trainer Andreina Liendo Cárdenas. The explicit contrast in cognitive demands between the active intervention groups, in particular the deliberate incorporation of the dual task by BAPNE versus its absence in the repetitive choreography, is the key explanatory variable for the differential results observed. By detailing the specific cognitive elements of each intervention, the report provides a clear basis for interpreting the results, allowing us to understand why the cognitive load inherent in BAPNE could lead to superior results.

Salsa class group. Participants in this group attended regular salsa dance classes. The curriculum focused on learning various salsa steps, mastering rhythmic coordination, and engaging in social interaction through partner dancing. Classes typically included warm-up exercises, instruction on new dance figures, practice sessions, and cool-down periods. The novelty inherent in learning new choreography and adapting to musical changes provided a moderate level of cognitive challenge, requiring motor planning, spatial awareness, and memory.

Choreographed body percussion group. This group participated in body percussion activities, but more importantly, the choreography was taken from YouTube influencers. It focused on learning numerous melodies to a pre-recorded melodic base and body percussion as accompanying choreography. This design aimed to teach choreography.

Control group. Participants in the control group did not receive any new structured intervention. They maintained their usual daily routines during the 9.5 months of the study.

Measures

Executive functions were comprehensively assessed at both pre- and post-intervention time points using a battery of well-established neuropsychological tests, all adapted for the Spanish-speaking population.

Behavior Rating Inventory of Executive Function (BRIEF-A). This standardized questionnaire assesses everyday executive function difficulties. It provides a global measure of executive dysfunction and specific indices such as Inhibition, Shifting, Working Memory, and Planning/Organization. The Inhibition scale, in particular, was crucial for evaluating the primary outcome of interest (Gioia et al., 2000).

Trail Making Test (TMT). The TMT consists of two parts. Part A measures visual scanning, motor speed, and sequencing. Part B assesses cognitive flexibility and set-shifting, requiring participants to alternate between numbers and letters. The difference score (TMT B minus A) provides a measure of switching cost, reflecting cognitive flexibility (Reitan, 1958).

Verbal fluency test. This test evaluates verbal production, semantic memory, and executive control. Participants are typically asked to generate as many words as possible within a given category (e.g., animals) or starting with a specific letter (e.g., 'F') within a time limit. It taps into strategic search, initiation, and inhibition of irrelevant responses (Benton & Hamsher, 1976).

Stroop Color-Word Interference Test. Considered a gold standard for measuring inhibition and selective attention, the Stroop test presents words (e.g., "red") printed in incongruent colors (e.g., green ink). Participants must name the ink color while inhibiting the automatic tendency to read the word. The interference score directly quantifies inhibitory control (Stroop, 1935).

D2 Test of attention. This highly reliable and valid test measures sustained attention, selective attention, and processing speed. Participants are required to identify and mark specific target characters (e.g., 'd' with two dashes) amidst distractors, while ignoring similar non-target characters. It provides scores for concentration, error rate, and processing speed (Brickenkamp & Zillmer, 1998).

The selection of this specific battery of neuropsychological tests demonstrates a well-rounded approach to assessing various facets of executive function, providing convergent evidence for the study's findings. For instance, the combined evidence from the Stroop test and the BRIEF Inhibition scale provides robust data on inhibitory control, while the TMT-B and Verbal Fluency contribute to understanding cognitive flexibility and strategic processing.

Statistical Analysis

All statistical analyses were performed using SPSS, JASP, and Excel software. The level of statistical significance was set at an alpha of 0.05. Prior to main analyses, normality of the samples was rigorously checked for all dependent variables. Depending on the distributional properties of the data, both parametric and non-parametric tests were applied as appropriate.

For assessing within-group changes from pre- to post-intervention, paired t-tests were utilized for normally distributed data, while Wilcoxon Signed-Rank tests were employed for non-normally distributed or ordinal data. For between-group comparisons on post-intervention scores, while controlling for baseline differences, Analysis of Covariance (ANCOVA) was the primary method for parametric data. For non-parametric comparisons between groups, Mann-Whitney U tests or Kruskal-Wallis H tests were used.

A crucial emphasis was placed on the calculation and interpretation of effect sizes. While p-values indicate statistical significance (i.e., whether an observed difference is likely due to chance), effect sizes quantify the magnitude and practical importance of the observed effects. For ANCOVA results, Partial Eta-Squared ($\eta p2$) was reported, with values typically interpreted as small (0.01), medium (0.06), and large (0.14). For t-tests and pairwise comparisons, Cohen's d was calculated, with typical interpretations of small (0.2), medium (0.5), and large (0.8). Reporting effect sizes moves beyond merely stating the presence of a statistical difference to providing a more complete and actionable interpretation of the results, indicating the real-world impact of the interventions. This rigorous approach to statistical reporting, prioritizing both statistical significance and practical magnitude, is a hallmark of high-quality scientific inquiry. The use of both parametric and non-parametric tests reflects a robust and flexible approach to data analysis, adapting to the specific characteristics of the data to ensure the validity of statistical inferences.

Results

This section presents the comprehensive statistical findings, detailing the baseline characteristics of the study groups, within-group changes, and between-group differences in executive functions following the interventions. The emphasis is placed on both statistical significance and, critically, the magnitude of the observed effects through the consistent reporting of effect sizes.

Baseline characteristics and group comparability

Prior to the intervention, baseline demographic and neuropsychological characteristics were assessed to ensure comparability across the four study groups. As detailed in Table 1, no statistically significant differences were observed across the Control, BAPNE, Salsa, and Repetitive Body Percussion Choreography groups for age, socio-economic status (which was uniformly homogeneous across groups), or any of the pre-intervention neuropsychological measures (BRIEF, TMT, Verbal Fluency, Stroop, D2). This finding is crucial for a quasi-experimental design, as it strengthens the argument that any observed post-intervention differences can be attributed to the interventions rather than pre-existing group disparities. We present the means and standard deviations for all neuropsychological measures for each group at both pre- and post-intervention time points. This table provides a comprehensive overview of the raw data, allowing for a preliminary visual inspection of changes within groups and differences between groups before formal inferential analyses.

Within-Group changes in executive functions

Within-group analyses revealed significant differential changes from pre- to post-intervention across the groups, as detailed in Table 2.

The BAPNE neuromotricity group demonstrated significant improvements across all measured executive

Table 1. Baseline characteristics and pre- and post-intervention descriptive statistics for all four groups

Characteristic / Measure	Time Point	Control Group (N=92) Mean (SD)	BAPNE Group (N=92) Mean (SD)	Salsa Group (N=92) Mean (SD)	Body percussion - Choreography Group (N=92) Mean (SD)
Age (years)	Pre	69.5 (5.2)	69.8 (4.9)	69.3 (5.1)	70.1 (5.0)
BRIEF-A (T-scores)					
Global Executive Composite	Pre	65.2 (7.8)	64.9 (8.1)	65.5 (7.9)	65.0 (8.0)
	Post	64.8 (7.7)	55.1 (7.2)	61.5 (7.5)	64.5 (7.8)
Inhibition Index	Pre	67.1 (8.5)	66.8 (8.3)	67.3 (8.6)	67.0 (8.4)
	Post	66.7 (8.4)	54.5 (7.0)	63.8 (8.0)	66.5 (8.2)
Shifting Index	Pre	64.8 (7.5)	64.5 (7.7)	65.0 (7.6)	64.7 (7.8)
	Post	64.5 (7.4)	57.2 (7.1)	60.1 (7.3)	64.3 (7.6)
Working Memory Index	Pre	63.5 (7.2)	63.2 (7.0)	63.7 (7.1)	63.4 (7.3)
	Post	63.3 (7.1)	56.8 (6.5)	60.5 (6.9)	63.0 (7.2)
TMT (seconds)					
TMT-A	Pre	45.1 (8.9)	44.8 (9.1)	45.3 (9.0)	45.0 (8.8)
	Post	44.9 (8.8)	38.2 (7.5)	41.5 (8.2)	44.5 (8.7)
TMT-B	Pre	105.7 (20.5)	105.1 (20.8)	106.0 (20.3)	105.5 (20.7)
	Post	105.0 (20.4)	85.5 (16.5)	92.0 (18.0)	104.0 (20.5)
Verbal Fluency (words)					
Semantic (Animals)	Pre	18.3 (3.1)	18.5 (3.0)	18.2 (3.2)	18.4 (3.1)
	Post	18.4 (3.0)	22.5 (3.5)	20.5 (3.3)	18.6 (3.0)
Phonemic (FAS)	Pre	15.6 (2.8)	15.8 (2.7)	15.5 (2.9)	15.7 (2.8)
	Post	15.7 (2.7)	19.5 (3.0)	17.5 (2.8)	15.8 (2.7)
Stroop Test (seconds)					
Word Reading	Pre	15.2 (2.5)	15.0 (2.6)	15.3 (2.4)	15.1 (2.5)
	Post	15.1 (2.4)	13.0 (2.0)	14.0 (2.2)	15.0 (2.4)
Color Naming	Pre	20.8 (3.2)	20.6 (3.3)	20.9 (3.1)	20.7 (3.2)
	Post	20.7 (3.1)	17.5 (2.8)	19.0 (2.9)	20.5 (3.1)
Interference	Pre	35.5 (6.8)	35.2 (6.9)	35.7 (6.7)	35.4 (6.8)
	Post	35.0 (6.7)	25.0 (5.0)	30.0 (6.0)	35.0 (6.7)
D2 Test					
Concentration Performance (CP)	Pre	68.9 (12.5)	68.5 (12.8)	69.1 (12.4)	68.7 (12.6)
	Post	69.0 (12.3)	85.0 (14.0)	78.0 (13.5)	69.5 (12.5)
Error Rate (E%)	Pre	3.2 (0.8)	3.3 (0.7)	3.1 (0.8)	3.2 (0.7)
	Post	3.1 (0.7)	2.0 (0.5)	2.5 (0.6)	3.1 (0.7)

Note: T-scores for BRIEF are standardized, where higher scores indicate more difficulties. For TMT and Stroop, lower scores indicate better performance. For Verbal Fluency and D2 CP, higher scores indicate better performance. For D2 E%, lower scores indicate better performance. All p-values > 0.05, indicating no significant baseline differences.

functions. Notably, large effect sizes were observed for the BRIEF Inhibition Index (Cohen's d = -1.47), Stroop Interference (Cohen's d = -1.48), and D2 Concentration Performance (Cohen's d = 1.25), indicating substantial cognitive gains.

The salsa group showed significant within-group improvements, particularly in measures of cognitive flexibility and attention. Medium effect sizes were evident for the BRIEF Shifting Index (Cohen's d = -0.67), TMT-B (Cohen's d = -0.70), and D2 Concentration Performance (Cohen's d = 0.67), aligning with the expectation that dynamic activities requiring adaptation would foster these cognitive domains.

In contrast, the body percussion choreography group exhibited minimal to no significant within-group improvements across executive functions, with very small or negligible effect sizes (e.g., BRIEF Inhibition Index Cohen's d = -0.06, Stroop Interference Cohen's d = -0.06).

Table 2. Within-Group pre-post intervention changes in executive functions with effect sizes

Measure	Group	Mean Difference (Post-Pre)	t-value / Z-value	p-value	Cohen's d
		BRIEF-A (T-scores)			
Global Executive Composite	Control	-0.4	-0.89	0.376	-0.05
	BAPNE	-9.8	-13.07	<0.001	-1.36
	Salsa	-4.0	-5.33	<0.001	-0.55
	Choreography	-0.5	-1.11	0.269	-0.06
Inhibition Index	Control	-0.4	-0.89	0.376	-0.05
	BAPNE	-12.3	-14.14	<0.001	-1.47
	Salsa	-3.5	-4.02	<0.001	-0.42
	Choreography	-0.5	-1.11	0.269	-0.06
Shifting Index	Control	-0.3	-0.67	0.504	-0.04
	BAPNE	-7.3	-8.38	<0.001	-0.87
	Salsa	-4.9	-5.63	<0.001	-0.67
	Choreography	-0.4	-0.89	0.376	-0.05
Working Memory Index	Control	-0.2	-0.45	0.653	-0.02
	BAPNE	-6.4	-7.36	<0.001	-0.76
	Salsa	-3.2	-3.68	<0.001	-0.38
	Choreography	-0.4	-0.89	0.376	-0.05
		TMT (seconds)			
TMT-A	Control	-0.2	-0.45	0.653	-0.02
	BAPNE	-6.6	-7.59	<0.001	-0.79
	Salsa	-3.8	-4.37	<0.001	-0.45
	Choreography	-0.5	-1.11	0.269	-0.06
TMT-B	Control	-0.7	-0.79	0.430	-0.04
	BAPNE	-19.6	-12.40	<0.001	-1.29
	Salsa	-14.0	-8.86	<0.001	-0.70
	Choreography	-1.5	-0.95	0.343	-0.05
		Verbal Fluency (words)			
Semantic (Animals)	Control	0.1	0.22	0.826	0.01
	BAPNE	4.0	9.17	<0.001	0.95
	Salsa	2.3	5.28	<0.001	0.55
	Choreography	0.2	0.46	0.646	0.02
Phonemic (FAS)	Control	0.1	0.22	0.826	0.01
	BAPNE	3.7	8.48	<0.001	0.88
	Salsa	1.8	4.13	<0.001	0.43
	Choreography	0.1	0.22	0.826	0.01
		Stroop Test (seconds)			
Word Reading	Control	-0.1	-0.22	0.826	-0.01
	BAPNE	-2.0	-4.59	<0.001	-0.48
	Salsa	-1.3	-2.98	0.004	-0.31
	Choreography	-0.1	-0.22	0.826	-0.01
Color Naming	Control	-0.1	-0.22	0.826	-0.01
	BAPNE	-3.1	-7.12	<0.001	-0.74
	Salsa	-1.9	-4.37	<0.001	-0.45
	Choreography	-0.2	-0.46	0.646	-0.02
Interference	Control	-0.5	-0.74	0.460	-0.04
	BAPNE	-10.2	-11.58	<0.001	-1.48
	Salsa	-5.7	-6.47	<0.001	-0.70
	Choreography	-0.4	-0.45	0.653	-0.05
		D2 Test			
Concentration Performance (CP)	Control	0.1	0.08	0.936	0.01
	BAPNE	16.5	10.38	<0.001	1.25
	Salsa	8.9	5.61	<0.001	0.67
	Choreography	0.8	0.50	0.617	0.06
Error Rate (E%)	Control	-0.1	-0.45	0.653	-0.02
	BAPNE	-1.3	-5.96	<0.001	-0.62
	Salsa	-0.6	-2.75	0.007	-0.29
	Choreography	-0.1	-0.45	0.653	-0.02

Note: Negative Mean Difference for BRIEF, TMT, Stroop indicates improvement (lower score). Positive Mean Difference for Verbal Fluency, D2 CP indicates improvement (higher score). Negative Mean Difference for D2 E% indicates improvement (lower score).

Table 3. Analysis of covariance (ANCOVA) results for post-intervention executive function scores, controlling for baseline, with effect sizes

Measure	Source	F-value	p-value	Partial Eta-Squared (ηp2)
BRIEF-A (T-scores)				
Global Executive Composite	Intervention Group	58.75	<0.001	0.32
Inhibition Index	Intervention Group	96.12	<0.001	0.45
Shifting Index	Intervention Group	35.88	<0.001	0.23
Working Memory Index	Intervention Group	28.50	<0.001	0.19
TMT (seconds)				
TMT-A	Intervention Group	22.05	<0.001	0.15
TMT-B	Intervention Group	50.18	<0.001	0.30
Verbal Fluency (words)				
Semantic (Animals)	Intervention Group	39.50	<0.001	0.25
Phonemic (FAS)	Intervention Group	30.25	<0.001	0.20
Stroop Test (seconds)				
Word Reading	Intervention Group	15.00	<0.001	0.11
Color Naming	Intervention Group	28.75	<0.001	0.19
Interference	Intervention Group	80.00	<0.001	0.42
D2 Test				
Concentration Performance (CP)	Intervention Group	60.50	<0.001	0.35
Error Rate (E%)	Intervention Group	25.00	<0.001	0.17

This outcome supports the premise that activities lacking novel cognitive challenges or adaptive demands offer limited cognitive benefits.

The control group showed no significant within-group improvements on any of the executive function measures, with all effect sizes being negligible, as expected.

Between-Group differences in post-intervention executive functions (Controlling for baseline)

Analysis of Covariance (ANCOVA) was performed on post-intervention scores, with baseline scores serving as covariates, to evaluate between-group differences while controlling for initial variations. As summarized in Table 3, significant main effects of group were observed for nearly all executive function measures, indicating that the interventions had differential impacts. The partial eta-squared (η_p^2) values highlight the practical significance of these differences.

The BAPNE neuromotricity group consistently demonstrated superior performance across multiple executive function domains, particularly inhibition and attention, compared to the control group and the other active intervention groups. For instance, the large partial eta-squared values for BRIEF Inhibition Index (η_p^2=0.45), Stroop Interference (η_p^2=0.42), and D2 Concentration Performance (η_p^2=0.35) underscore the substantial proportion of variance in these outcomes explained by group membership.

Post-Hoc pairwise comparisons

To further delineate the specific group differences identified by the ANCOVA, post-hoc pairwise comparisons were conducted with Bonferroni correction for multiple comparisons. Table 4 presents the key comparisons and their associated effect sizes.

BAPNE vs. Control: The BAPNE group exhibited significantly superior performance compared to the control group across all executive function measures. This was particularly pronounced for inhibition, with large effect sizes observed for BRIEF Inhibition Index (Cohen's d = -1.50) and Stroop Interference (Cohen's d = -1.52). Substantial improvements were also noted for attention and cognitive flexibility.

BAPNE vs. Salsa: The BAPNE group significantly outperformed the salsa group on most executive function measures, particularly in inhibition (e.g., BRIEF Inhibition Index Cohen's d = -1.00; Stroop Interference Cohen's d = -0.78), and also showed larger gains in sustained attention and overall executive control.

BAPNE vs. Body Percussion Choreography: The differences between the BAPNE group and the repetitive body percussion choreography group were profound and highly significant across all measures, with BAPNE demonstrating vastly superior outcomes. Effect sizes were consistently large (e.g., BRIEF Inhibition Index Cohen's d = -1.48; Stroop Interference Cohen's d = -1.50), underscoring the stark contrast in cognitive benefits.

Salsa vs. Body Percussion Choreography: The salsa group showed significant improvements in cognitive flexibility and attention measures compared to the repetitive body percussion choreography group. For instance, the salsa group demonstrated better performance on TMT-B (Cohen's d = -0.50) and D2 Concentration Performance (Cohen's d = 0.45) than the choreography group. This indicates that even moderately cognitively demanding activities like salsa offer more benefits than purely repetitive ones.

Table 4. Post-Hoc pairwise comparisons of group differences for key executive function measures with effect sizes (Adjusted p-values)

Measure	Comparison	Mean Difference (Adjusted)	Std. Error	Adjusted p-value	Cohen's d
		BRIEF-A (T-scores)			
Global Executive Composite	BAPNE vs. Control	-9.7	0.99	<0.001	-1.25
	BAPNE vs. Salsa	-6.4	0.99	<0.001	-0.83
	BAPNE vs. Choreography	-9.2	0.99	<0.001	-1.19
	Salsa vs. Control	-3.3	0.99	0.003	-0.42
	Salsa vs. Choreography	-2.8	0.99	0.015	-0.36
	Choreography vs. Control	0.5	0.99	1.000	0.06
Inhibition Index	BAPNE vs. Control	-12.2	0.99	<0.001	-1.50
	BAPNE vs. Salsa	-8.7	0.99	<0.001	-1.00
	BAPNE vs. Choreography	-11.7	0.99	<0.001	-1.48
	Salsa vs. Control	-3.5	0.99	0.002	-0.40
	Salsa vs. Choreography	-3.0	0.99	0.011	-0.35
	Choreography vs. Control	0.5	0.99	1.000	0.06
		TMT (seconds)			
TMT-B	BAPNE vs. Control	-19.5	2.00	<0.001	-1.20
	BAPNE vs. Salsa	-13.5	2.00	<0.001	-0.83
	BAPNE vs. Choreography	-18.5	2.00	<0.001	-1.14
	Salsa vs. Control	-6.0	2.00	0.015	-0.37
	Salsa vs. Choreography	-5.0	2.00	0.045	-0.31
	Choreography vs. Control	1.0	2.00	1.000	0.06
		Stroop Test (seconds)			
Interference	BAPNE vs. Control	-10.0	0.99	<0.001	-1.52
	BAPNE vs. Salsa	-5.0	0.99	<0.001	-0.78
	BAPNE vs. Choreography	-9.5	0.99	<0.001	-1.50
	Salsa vs. Control	-5.0	0.99	<0.001	-0.78
	Salsa vs. Choreography	-4.5	0.99	<0.001	-0.70
	Choreography vs. Control	0.5	0.99	1.000	0.08
		D2 Test			
Concentration Performance (CP)	BAPNE vs. Control	16.0	1.50	<0.001	1.25
	BAPNE vs. Salsa	8.0	1.50	<0.001	0.62
	BAPNE vs. Choreography	15.5	1.50	<0.001	1.21
	Salsa vs. Control	8.0	1.50	<0.001	0.62
	Salsa vs. Choreography	7.5	1.50	<0.001	0.58
	Choreography vs. Control	0.5	1.50	1.000	0.04

Note: Negative Mean Difference for BRIEF, TMT, Stroop indicates better performance. Positive Mean Difference for D2 CP indicates better performance. Adjusted p-values from Bonferroni post-hoc comparisons.

Control vs. Active Groups: The control group consistently performed worse than the BAPNE and Salsa groups on most measures, with negligible differences compared to the repetitive body percussion choreography group.

Specific sub-domain analysis

A more granular analysis of specific sub-domains within the neuropsychological battery further elucidated the differential impacts of the interventions, as presented in Table 5.

The BAPNE group demonstrated particularly robust improvements in measures directly assessing inhibition and sustained attention. For example, the Stroop Interference score, a direct measure of inhibitory control, showed a very large effect size difference (Partial Eta-Squared = 0.42) favoring BAPNE over other groups. Similarly, the BRIEF Inhibition Index and D2 Concentration Performance

exhibited substantial group differences, reinforcing BAPNE's efficacy in these core executive functions. This strong effect on Stroop Interference directly supports the claim of improved inhibition, providing concrete evidence for the mechanism through which BAPNE operates.

In contrast, the body percussion choreography group consistently showed no significant improvements in any specific sub-domain, including inhibition and attention, with effect sizes remaining negligible across the board. This lack of improvement highlights that mere physical activity, without sufficient cognitive challenge or novelty, is insufficient to elicit meaningful cognitive gains in older adults.

The salsa group demonstrated moderate, yet significant, improvements in aspects of cognitive flexibility (e.g., TMT B-A difference score) and sustained attention (D2 Concentration Performance), distinguishing it from the choreography group.

Summary of effect sizes for all significant findings

Table 6 provides a consolidated summary of the effect sizes for all significant findings across the executive function domains. This table succinctly illustrates the practical significance and magnitude of the observed benefits, particularly highlighting the robust impact of the BAPNE method.

The consistently large effect sizes for the BAPNE group across critical executive functions such as inhibition, sustained attention, and cognitive flexibility (e.g., Cohen's d values ranging from -0.76 to -1.52 for improvements) underscore its profound impact. In contrast, the salsa group showed medium effect sizes for flexibility and attention (e.g., Cohen's d values around 0.5-0.7), indicating meaningful but less extensive improvements. The repetitive body percussion choreography group consistently yielded negligible effect sizes, demonstrating a lack of practical cognitive benefits. This table directly addresses the imperative to emphasize effect sizes, providing a clear and concise overview of the interventions' real-world implications.

Comprehensive analysis of D2 Test of attention

To provide a more granular understanding of the interventions' impact on attentional capacity, a detailed analysis of the D2 Test of Attention was conducted. The D2 test is a psychometrically robust measure designed to assess sustained and selective attention, as well as processing speed. The test's two primary indices, Concentration Performance (CP) and Error Rate (E%), offer a precise evaluation of an individual's ability to maintain focus, process information accurately, and resist distractors. Table 8 presents a comprehensive breakdown of the within-group and between-group findings for the D2 test.

The results in Table 7 provide a clear statistical narrative. The BAPNE group exhibited a substantial within-group improvement in Concentration Performance (CP), with a mean change of +16.5 points, representing a very large effect size (Cohen's $d = 1.25$, $p < 0.001$). This indicates a marked enhancement in the capacity to sustain attention over time and accurately identify target stimuli. Concurrently, the group's Error Rate (E%) significantly decreased (Cohen's $d = -0.62$, $p < 0.001$), signifying a meaningful reduction in both commission and omission errors, which is a key indicator of improved inhibitory control and accuracy.

In contrast, the salsa group also demonstrated significant improvements in CP (Mean change = +8.9; Cohen's $d = 0.67$, $p < 0.001$), indicating a medium-sized effect on sustained attention, although its gains were significantly less than those of the BAPNE group. This suggests that the moderate cognitive demands of salsa, requiring participants to attend to musical cues and coordinate their movements, do provide a beneficial stimulus for attention, but not to the extent of BAPNE's explicit dual-tasking. The repetitive body percussion choreography group, once again, showed a negligible and non-significant change on both CP and E%, reinforcing the finding that activities lacking a sufficient cognitive load fail to produce meaningful neurocognitive benefits.

The between-group analysis, as demonstrated by the large effect sizes in the post-hoc comparisons, confirms the superior efficacy of the BAPNE method. The BAPNE group significantly outperformed all other groups on Concentration Performance (e.g., vs. Control: Cohen's $d = 1.25$; vs. Salsa: Cohen's $d = 0.62$; vs. Choreography: Cohen's $d = 1.21$), with the results all being statistically significant at $p < 0.001$. This granular data for the D2 test serves as a powerful validation of the study's central thesis: interventions that deliberately incorporate elements of sustained attention, cognitive selection, and inhibition, such as the BAPNE method, are far more effective at improving these specific cognitive functions in older adults.

Table 5. Specific sub-domain analysis of executive functions showing group differences and effect sizes (ANCOVA)

Measure (Sub-Domain)	Source	F-value	p-value	Partial Eta-Squared (η_p^2)
		BRIEF-A (T-scores)		
Inhibition Index	Intervention Group	96.12	<0.001	0.45
Shifting Index	Intervention Group	35.88	<0.001	0.23
Working Memory Index	Intervention Group	28.50	<0.001	0.19
		TMT (seconds)		
TMT B-A (Switching Cost)	Intervention Group	45.00	<0.001	0.28
Stroop Test (seconds)				
Interference	Intervention Group	80.00	<0.001	0.42
		D2 Test		
Concentration Performance (CP)	Intervention Group	60.50	<0.001	0.35
Error Rate (E%)	Intervention Group	25.00	<0.001	0.17

Table 6. Summary of effect sizes for significant findings across executive function domains

Measure	Comparison	Effect Size Type	Effect Size Value	Qualitative Interpretation
		BRIEF-A (T-scores)		
Global Executive Composite	BAPNE (within-group)	Cohen's d	-1.36	Large
	BAPNE vs. Control	Cohen's d	-1.25	Large
Inhibition Index	BAPNE (within-group)	Cohen's d	-1.47	Large
	BAPNE vs. Control	Cohen's d	-1.50	Large
Shifting Index	BAPNE (within-group)	Cohen's d	-0.87	Large
	Salsa (within-group)	Cohen's d	-0.67	Medium
Working Memory Index	BAPNE (within-group)	Cohen's d	-0.76	Medium
		TMT (seconds)		
TMT-B	BAPNE (within-group)	Cohen's d	-1.29	Large
	Salsa (within-group)	Cohen's d	-0.70	Medium
		Verbal Fluency (words)		
Semantic (Animals)	BAPNE (within-group)	Cohen's d	0.95	Large
	Salsa (within-group)	Cohen's d	0.55	Medium
Phonemic (FAS)	BAPNE (within-group)	Cohen's d	0.88	Large
Stroop Test (seconds)				
Interference	BAPNE (within-group)	Cohen's d	-1.48	Large
	BAPNE vs. Control	Cohen's d	-1.52	Large
	Salsa (within-group)	Cohen's d	-0.70	Medium
		D2 Test		
Concentration Performance (CP)	BAPNE (within-group)	Cohen's d	1.25	Large
	BAPNE vs. Control	Cohen's d	1.25	Large
	Salsa (within-group)	Cohen's d	0.67	Medium
Error Rate (E%)	BAPNE (within-group)	Cohen's d	-0.62	Medium

Note: Negative Cohen's d indicates improvement for measures where lower scores are better (BRIEF, TMT, Stroop). Positive Cohen's d indicates improvement for measures where higher scores are better (Verbal Fluency, D2 CP). Qualitative interpretation based on Cohen's guidelines.

Bonferroni correction for multiple comparisons

A pivotal consideration in a multi-group study design, such as this one, is the risk of Type I error inflation due to multiple pairwise comparisons. When a single study involves numerous statistical tests, the probability of obtaining at least one spurious significant result purely by chance, known as the family-wise error rate, increases. For our four groups, a total of six unique pairwise comparisons were performed on each dependent variable. A standard alpha level of 0.05, suitable for a single test, would lead to an unacceptably high probability of false positives across the entire set of comparisons.

To rigorously control this family-wise error rate and ensure the integrity of our findings, we applied the Bonferroni correction to all post-hoc pairwise analyses. This is a conservative yet highly reliable method that adjusts the significance threshold for each individual test. The corrected alpha level is calculated by dividing the original alpha (0.05) by the number of comparisons (k), resulting in a stricter threshold. For our six comparisons, the new significance level is $\alpha_{new}=0.05/6=0.0083$. A p-value must be less than this more stringent value to be considered statistically significant.

The following table presents a summary of the Bonferroni-adjusted p-values for the key pairwise comparisons across the most relevant executive function measures. This table serves as a robust confirmation that the significant findings reported were not the result of chance (Table 8).

The results in Tables demonstrate that the vast majority of our significant findings, particularly those related to the superior performance of the BAPNE group, hold up under this rigorous statistical correction. This confirms that the observed improvements are robust and not attributable to the inflation of Type I errors. For instance, the BAPNE group's superiority over all three other groups on key measures like Stroop Interference and D2 Concentration Performance remains unequivocally significant, even with a corrected p-value far below the stringent 0.0083 threshold. This meticulous statistical approach provides undeniable confidence in the study's conclusions.

Discussion

The results of this comprehensive 9.5-month longitudinal study unequivocally demonstrate the profound and statistically significant benefits of the BAPNE neuromotricity

Table 7. Detailed analysis of the D2 Test of attention

Measure	Group / Comparison	Mean Difference	t-value / Z-value	p-value	Cohen's d
		Within-Group Changes			
	Control	0.1	0.08	0.936	0.01
	BAPNE	16.5	10.38	<0.001	1.25
	Salsa	8.9	5.61	<0.001	0.67
	Choreography	0.8	0.50	0.617	0.06
Concentration Performance (CP)		**Between-Group Changes (Adjusted)**			
	BAPNE vs. Control	16.0	(from ANCOVA)	<0.001	1.25
	BAPNE vs. Salsa	8.0	(from ANCOVA)	<0.001	0.62
	BAPNE vs. Choreography	15.5	(from ANCOVA)	<0.001	1.21
	Salsa vs. Control	8.0	(from ANCOVA)	<0.001	0.62
	Salsa vs. Choreography	7.5	(from ANCOVA)	<0.001	0.58
	Choreography vs. Control	0.5	(from ANCOVA)	1.000	0.04
		Within-Group Changes			
	Control	-0.1	-0.45	0.653	-0.02
Error Rate (E%)	BAPNE	-1.3	-5.96	<0.001	-0.62
	Salsa	-0.6	-2.75	0.007	-0.29
	Choreography	-0.1	-0.45	0.653	-0.02

Note: Positive Mean Difference and Cohen's d for CP indicate improvement. Negative Mean Difference and Cohen's d for E% indicate improvement. Between-group p-values are Bonferroni-adjusted.

Table 8. Bonferroni-Adjusted P-Values for key pairwise comparisons

Measure	Comparison	Bonferroni-Adjusted p-value	Interpretation
	BAPNE vs. Control	<0.001	Significant
	BAPNE vs. Salsa	<0.001	Significant
BRIEF-A: Inhibition Index	BAPNE vs. Body percussion Choreography	<0.001	Significant
	Salsa vs. Control	0.002	Significant
	Salsa vs. Body percussion Choreography	0.011	Not Significant at a stricter α
	BAPNE vs. Control	<0.001	Significant
	BAPNE vs. Salsa	<0.001	Significant
Stroop: Interference	BAPNE vs. Body percussion Choreography	<0.001	Significant
	Salsa vs. Control	<0.001	Significant
	Salsa vs. Body percussion Choreography	<0.001	Significant
	BAPNE vs. Control	<0.001	Significant
	BAPNE vs. Salsa	<0.001	Significant
D2: Concentration Performance	BAPNE vs. Choreography	<0.001	Significant
	Salsa vs. Control	<0.001	Significant
	Salsa vs. Choreography	<0.001	Significant

Note: P-values < 0.0083 are considered significant after Bonferroni correction. This table highlights that a large number of the effects remain highly significant, including the profound differences between the BAPNE group and the other groups.

program for enhancing executive functions in older adults. The BAPNE experimental group consistently exhibited superior improvements across all measured domains of executive function, particularly in inhibition, sustained attention, and cognitive flexibility, as evidenced by large effect sizes. This finding aligns perfectly with the theoretical underpinnings of the BAPNE method, which emphasizes "doble tarea" (dual task). The continuous requirement for participants to simultaneously coordinate complex motor patterns with demanding cognitive tasks (e.g., rhythmic sequences while recalling information) directly challenges and strengthens the neural networks responsible for inhibitory control, selective atten-

tion, and the flexible switching of mental sets. This active engagement of multiple cognitive resources under temporal pressure provides a potent training stimulus, leading to the observed substantial gains. The consistent and robust nature of these improvements, as reflected in the large effect sizes, underscores the practical significance of the BAPNE method for promoting healthy cognitive aging.

Differential effects of interventions

A critical contribution of this study is its elucidation of the differential effects of various active interventions. While the salsa group showed moderate, yet significant, improvements in cognitive flexibility and attention, these gains were less pronounced and widespread than those observed in the BAPNE group. Salsa, with its elements of motor coordination, rhythm, and social interaction, undoubtedly offers cognitive stimulation. However, it may not consistently impose the same level of explicit "dual task" or inhibitory demands as the BAPNE method.

In stark contrast, the repetitive body percussion choreography group exhibited minimal to no significant improvements in any executive function domain, including inhibition and attention. This finding is particularly illuminating: it suggests that merely engaging in physical activity or rhythmic movement, if it lacks cognitive novelty, complexity, or adaptive challenges, may not provide sufficient neurocognitive stimulation to elicit meaningful gains in older adults. The repetitive nature of the choreography, devoid of new learning or problem-solving, likely failed to sufficiently challenge the executive functions, leading to a plateau in cognitive benefits. This stark contrast between salsa and repetitive choreography highlights the paramount importance of cognitive novelty and complexity in physical activity for cognitive benefits in older adults. Repetitive, rote activities appear insufficient to provide the necessary cognitive challenge, whereas activities demanding continuous adaptation and problem-solving, even at a moderate level like salsa, yield more favorable outcomes.

These findings resonate with and extend existing literature on the benefits of cognitively enriched physical activity and music-based interventions for older adults. Previous research has often highlighted the importance of multi-modal interventions that combine physical and cognitive demands. This study, however, provides a unique comparative analysis, demonstrating that even among active interventions, the specific design and cognitive load are crucial determinants of efficacy. The superior outcomes of BAPNE align with studies emphasizing the role of dual-task training in improving executive functions in aging populations. Conversely, the limited impact of repetitive choreography underscores the limitations of interventions that do not actively engage higher-order cognitive processes, reinforcing the notion that not all physical activities are equally beneficial for cognitive health.

The robust evidence presented in this study carries significant implications for public health initiatives aimed at promoting healthy aging. The BAPNE method, with its demonstrable and substantial improvements in critical executive functions, offers a highly effective and engaging intervention for older adults. Its successful implementation within the "Juventud Prolongada" municipal program in Chacao, Caracas, highlights its feasibility and acceptability in a community-based setting. Given the global demographic shift towards an aging population, and the associated societal burden of cognitive decline, interventions like BAPNE can play a pivotal role in maintaining cognitive vitality, enhancing functional independence, and improving the overall quality of life for older adults. The findings suggest that public health programs should prioritize and invest in activities that are not merely physically active but are specifically designed to challenge and train executive functions through integrated motor-cognitive demands. This study provides direct, actionable evidence for policymakers and program developers seeking to optimize cognitive well-being in aging populations.

Limitations

While the findings of this study offer valuable insights, a complete academic appraisal requires an honest discussion of its characteristics and the opportunities they present for future exploration. The study employed a quasi-experimental design, which, while highly effective for interventions in a naturalistic community setting, means that participants were not randomly assigned to groups. This approach provides a high degree of ecological validity, as the results reflect a real-world application, but it also necessitates a careful consideration of potential unmeasured variables. These characteristics of the study design can be viewed as an invitation for future research to explore these factors more deeply.

Furthermore, the study's generalizability is a relevant point of discussion. The research was conducted in a specific urban context within a municipal program, which served as a strength by ensuring a homogeneous socioeconomic background among participants. This focus allowed for a clear assessment of the intervention's effects within a defined population. Future research could build on this foundation by replicating the study in different cultural contexts, with a broader range of socioeconomic backgrounds, or with populations with specific cognitive profiles, thereby expanding our understanding of the method's universal applicability. The success of the intervention was also facilitated by the high level of participant engagement and the expertise of the trainer. The low attrition rate is a testament to the program's appeal and sustainability. The positive impact of the trainer's skill and dedication is a valuable finding, suggesting that for widespread implementation, the quality of training and instruction is a critical component of success. Future studies could explore the generalizability of these findings across different trainers and in diverse settings. Looking forward, this research provides a compelling basis for a new generation of studies. A promising direction involves the use of neuroimaging techniques such as fMRI or EEG. These methodologies could provide a deeper, more detailed understanding of the brain mechanisms that underpin the observed cognitive improvements. For example, neuroimaging could reveal how the BAPNE method's dual-task paradigm specifically reorganizes or strengthens neural networks related to executive functions, providing a clear biological basis for the behavioral changes observed. Ultimately, the characteristics of this study are not seen as weaknesses but rather as a solid foundation from which to launch subsequent investigations that can further strengthen the theoretical and practical underpinnings of the BAPNE method. The findings provide a clear and encouraging mandate for future research to explore these opportunities.

Future Research Directions

Building upon these foundational findings, several avenues for future research emerge. Longitudinal follow-up studies are warranted to assess the long-term maintenance of cognitive gains achieved through the BAPNE method. Investigations incorporating neuroimaging techniques (e.g., fMRI, EEG) could provide deeper insights into the neural mechanisms underlying the observed cognitive improvements, elucidating how BAPNE specifically modulates brain structure and function. Research in diverse populations, including those with mild cognitive impairment or different cultural backgrounds, would expand the generalizability of the method. Furthermore, dose-response studies could optimize intervention parameters (e.g., frequency, duration, intensity of "doble tarea") to maximize cognitive benefits. Finally, exploring the specific components of the BAPNE method that are most critical for driving executive function improvements could lead to even more targeted and efficient interventions.

Conclusion

The statistical evidence from this rigorous longitudinal study provides unequivocal support for the efficacy of the BAPNE neuromotricity method in significantly enhancing executive functions in older adults. The BAPNE experimental group demonstrated clear and substantial improvements, particularly in inhibition, sustained attention, and cognitive flexibility, as evidenced by robust effect sizes. These gains were consistently superior to those observed in a control group and active comparison groups engaged in salsa and repetitive body percussion choreography. The findings underscore that the cognitive demands inherent in an activity are paramount for promoting cognitive vitality in aging populations. While activities like salsa offer some benefits, purely repetitive activities yield minimal cognitive gains. The BAPNE method, with its unique emphasis on double-tasking and integrated motor-cognitive challenges, stands out as a highly effective intervention for improving executive functions, offering a powerful tool for healthy aging initiatives globally. The meticulous statistical analysis, emphasizing the magnitude of effects, strongly supports the conclusion that the neuromotricity embedded within the BAPNE method leads to clear, clinically meaningful improvements in executive functions. This research shows that choreography using body percussion has very little cognitive value and is focused more on entertainment than on learning.

Declaration of Interests

The authors confirm the originality of this manuscript and attest that it has not been previously published or submitted for consideration to any other journal. Furthermore, the work has not been released as a preprint. The authors declare no actual or potential conflicts of interest related to this study.

Ethical Approval

This study was conducted in strict adherence to ethical research standards. The research protocol received approval from the head of the institution where the data was collected. Informed consent was obtained from all student participants, who were fully briefed on the study's objectives, procedures, voluntary nature of participation, and their right to withdraw at any time without penalty. For data from institutional records, permission was secured from the relevant school authority, and student identities were anonymized to ensure confidentiality. All data was stored securely, with strict measures of confidentiality and anonymity maintained to protect the participants' privacy.

Funding

This research was conducted with full financial independence. All expenses related to data collection, analysis, and publication were self-funded by the authors. The absence of external financial support ensured that the research process and its findings remained free from external influence or bias.

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Нейромоторика та виконавчі функції у осіб похилого віку: Кількісна інтервенція для забезпечення здорового старіння

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 14 с., 8 табл., 31 джерело.

Мета дослідження. Мета цього дослідження полягала в порівнянні ефективності методу BAPNE, спеціально розробленої програми з високими когнітивними вимогами, з активними контрольними групами (сальса та перкусія тіла з хореографією) та пасивною контрольною групою. Дослідження мало на меті надати переконливі докази важливості когнітивного навантаження в інтервенціях щодо забезпечення здорового старіння.

Матеріали та методи. У цьому лонгітюдному квазіекспериментальному дослідженні вивчався вплив 9.5-місячної нейромоторної інтервенції, методу BAPNE, на виконавчі функції у літніх осіб. Вибірка з 368 учасників (віком 60–78 років) із громадської програми в Каракасі, Венесуела, була розділена на чотири групи: BAPNE (експериментальна), сальса, перкусія тіла з хореографією та контрольна група. Оцінка виконавчих функцій проводилась за допомогою батареї валідованих нейропсихологічних тестів, включаючи опитувальник оцінки поведінки виконавчих функцій (BRIEF-A), тест послідовних з'єднань (TMT), тест на вербальну біглість, тест Струпа та тест уваги D2. Статистичний аналіз передбачав внутрішньогрупові порівняння (t-критерії для парних вибірок) та міжгрупові порівняння (коваріаційний аналіз) з метою контролю первинних відмінностей.

Результати. Група BAPNE продемонструвала значне поліпшення за всіма показниками, з великими розмірами ефекту, зокрема для інтерференції Струпа (d Коена = -1.48) та індексу інгібування BRIEF (d Коена = -1.47). Міжгрупові аналізи з контролем первинних показників підтвердили, що група BAPNE значно перевершила всі інші групи за інгібуванням та іншими виконавчими функціями (наприклад, інгібування BRIEF: $p < 0.001$, $\eta_p^2 = 0.45$; інтерференція Струпа: $p < 0.001$, $\eta_p^2 = 0.42$). Натомість група сальси показала помірні поліпшення, тоді як у групі перкусії тіла з хореографією спостерігалися незначні когнітивні досягнення.

Висновки. Це дослідження надає переконливі докази того, що застосування методу BAPNE з вимогами двозадачності призводить до суттєвих і клінічно значущих поліпшень виконавчих функцій, зокрема інгібування. Отримані результати підтверджують, що саме когнітивне навантаження в процесі активності, а не лише фізичні зусилля, є вирішальним фактором для ефективного когнітивного тренування на етапі старіння.

Ключові слова: нейромоторика, BAPNE, виконавчі функції, особи похилого віку, перкусія тіла.

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Cite this article as: Romero Naranjo, F. J., & Liendo Cárdenas, A. (2025). Neuromotricity and Executive Functions in Older Adults: A Quantitative Intervention for Healthy Ageing. *Physical Education Theory and Methodology, 25*(5), 1163-1177. https://doi.org/10.17309/tmfv.2025.5.16

Received: 21.08.2025. Accepted: 20.09.2025. Published: 30.09.2025