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# The effects of the BAILAMOS Dance Program on hippocampal volume in older Latinos: a randomized controlled pilot study

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## Abstract

Hippocampal atrophy is associated with cognitive decline. Physical activity (PA) can reverse the hippocampal loss. This study investigated the effects of the 4 month BAILAMOS dance program on hippocampal volume and self-reported PA in Latinos. Participants were randomized to the BAILAMOS dance program or waitlist control group ($N = 14$, $n = 10$ intervention, $n = 4$ waitlist, 67 ± 6.1 years old, 70% female). Hippocampal volumes were derived from Magnetic Resonance Imaging whole-brain T1-weighted images. Participants self-reported PA through the Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for older adults. There were no statistically significant changes in hippocampal volume preintervention to postintervention ($F[1, 8] = .077$, $p = .79$, $d = .05$) and no associations between PA change and hippocampal volume ($F[4, 13] = .71$, $p = .61$). However, dance participants self-reported more PA ($d = .54$) compared to the control. These findings demonstrate that the BAILAMOS dance program did not decrease hippocampal atrophy; however, it increased self-reported PA. Future studies should include longer and more cognitively demanding interventions to determine whether dance can reduce cognitive decline through hippocampal changes.

## Keywords

Physical activity, Dance, Latinos, Cognition, Magnetic resonance imaging

**Implications**

**Practice:** Latin dance is a culturally appropriate physical activity (PA) modality that can increase lifestyle PA in older and middle-aged Latinos but requires closer monitoring of dance duration and complexity.

**Policy:** PA can be increased through community-based programs, and policymakers can be aware of such available evidence-based programs.

**Research:** Future research should include longer interventions or more cognitively demanding dance programs to determine whether it is a duration or complexity issue for brain structure changes.

## INTRODUCTION

Twelve percent of older Latinos are diagnosed with Alzheimer's disease (AD) [1], and it is estimated that the number will increase by 832% by 2060 [2]. Latinos are about 1.5 times as likely to have AD compared to non-Latino whites [3]. Thus, there is an increasing need to find ways to prevent pathological cognitive decline and dementia in this population. One of the hallmarks of pathological aging, particularly as it relates to AD, includes hippocampal atrophy [4]. Hippocampal atrophy results in problems with learning and memory, as well as spatial navigation [5]. A 5 year longitudinal study with participants aged 26–82 years suggested that the mean rate of hippocampal atrophy in adults aged 50 and older is 1.23% per year, double the rate (0.51%) from younger individuals under 50 years of age [6]. To date, few cross-sectional studies have examined hippocampal differences among Latinos [7, 8]. DeCarli et al. [7] found a significant interaction between ethnic and racial groups and diagnosis of dementia in which Latinos who were cognitively intact and with dementia had, on average, smaller hippocampal volumes than non-Latino whites and African American counterparts. Furthermore, Latinos and African Americans were diagnosed with dementia significantly younger compared to non-Latino whites, suggesting that structural changes may manifest at a younger age among Latinos [6]. Similarly, when looking at the associations between hippocampal volume and cognitive performance, larger hippocampal volumes were more strongly associated with better memory in non-Latino whites than in Latinos [8]. Longitudinal and intervention studies are needed to test hippocampal associations and whether preserving hippocampal volume can reduce the risk of AD in Latinos.

Research shows that physical activity (PA) can influence hippocampal volume [4, 9] and is a protective factor against cognitive decline and dementia [10, 11]. Early research with rodents served as a basis for understanding the effects of PA on the hippocampus. After months of exercise, there was an increase in vascularization of different brain regions, including the hippocampus, which increased the proliferation of cells and capillaries [12, 13]. Exercise also increased neuronal synapses and enhanced the rate of gene expression for molecules associated with learning and memory [12]. Such neurogenesis is evidence of the plasticity of the hippocampus. In humans, PA has been identified as a protective factor against cognitive impairment and dementia [10]. Furthermore, Erickson et al. [9] found that, after 1 year of aerobic exercise training in cognitively intact older adults, the left and right hippocampi increased by 2.12% and 1.97%, respectively, whereas the stretching exercise control group showed bilateral decreases. Thus, it appears that aerobic PA could be a promising intervention for preventing normal age-related cognitive decline. Unfortunately, little is known about the role of PA on hippocampal structure within the Latino population.

Research suggests that dancing is a culturally acceptable form of PA in older Latinos [14, 15]. Dancing increases sensory, motor, and cognitive demands and may have a greater impact than other forms of PA because it requires participants to plan and execute a sequence of goal-directed and complex actions [16]. An 18 month dance intervention compared to health fitness training in non-Latino whites showed similar increases in hippocampal volume in both groups [17]. To our knowledge, there are no PA interventions targeting older Latinos that examine the hippocampus as a possible target to delay cognitive decline. A previous study assessing the impact of the 4 month BAILAMOS dance intervention on cognitive function found positive changes in global cognition and episodic memory [18]. Therefore, the purpose of this study was to explore the effects of the BAILAMOS dance program on hippocampal volume and self-reported lifestyle PA in older Latinos.

## METHODS

### Participants

A small-randomized pilot study was conducted from October 2015 to June 2016. Participants were randomized to the dance group or waitlist control group. Participants were recruited from a Latino neighborhood via churches, health and church fairs, supermarkets, flyers at senior housing facilities, senior centers, and by word of mouth. The study was approved by the University of Illinois at Chicago Institutional Review Board. All participants signed written informed consent. The inclusion criteria included: (a) age ≥60; (b) Latino/Hispanic background; (c) ability to speak Spanish; (d) self-report participation in <150 min per week of aerobic exercise; (e) score of >14/21 on the modified Mini Mental State Examination [19, 20]; and (f) dancing <2×/month over the past 12 months. The exclusion criteria included self-reported: (a) uncontrolled cardiovascular disease or diabetes; (b) pacemaker or metallic implants; (c) claustrophobia; (d) stroke within the past 6 months; (e) healing or unhealed fracture(s); (f) hip or knee replacement within the past 6 months; (g) heart failure; (h) recurrent falls within the past year; (i) regular use of a walker or wheelchair; and (j) weight of 300+ pounds. The Exercise Assessment and Screening for You [21] was used to determine the need for physician consent before program enrollment. All potential participants were phone screened by a bilingual/bicultural research assistant for inclusion and exclusion criteria. All study assessments were then administered in Spanish or English. Only participants who had both baseline and postintervention Magnetic Resonance Imaging (MRI) scans were included in the present analysis.

### BAILAMOS dance program

BAILAMOS is a 4 month dance program that meets twice a week 1 hr per session, including four Latin dance styles (Merengue, Bachata, Cha Cha Cha, and Salsa). Participants progressed from Merengue, the simplest style, to Salsa the most difficult style. The aim of the dance was to offer light- to moderate-intensity PA. Each session includes a warm-up, steps for singles and couples dancing, and cooldown. See Marquez et al. for more information [22]. The dance classes took place at a senior center in a predominantly Latino neighborhood in Chicago, IL.

### Procedures

Data collection was separated into two 2 hr sessions: (a) informed consent, demographic questionnaire, self-reported PA, self-reported health conditions, height and weight measurements and (b) MRI data acquisition. The first session took place at the senior center, study site, and the second session took place at the Center for Magnetic Resonance at the University of Illinois at Chicago. Transportation was offered to participants to the imaging center and they were compensated $60 at baseline and 4 months.

### Measures

Body mass index (BMI) was calculated from height and weight. Participants were asked to self-report health conditions from a list of 32 conditions, including diabetes, high blood pressure, heart disease, dizziness, psychiatric disorders, and others. Self-reported PA was assessed using the Community Healthy Activities Model Program for Seniors (CHAMPS) Physical Activity Questionnaire for Older Adults [23], which is a change-sensitive PA scale assessing weekly frequency, duration, and intensity of lifestyle PA. The CHAMPS provides minutes per week of light and moderate-to-vigorous PA (MVPA). We reported categories of MVPA, leisure MVPA, light+MVPA, and leisure light+MVPA.

### MRI data acquisition

All-brain MRI collection was performed on a GE MR 750 Discovery 3T scanner (General Electric Health Care, Waukesha, WI). Participants were positioned supine on the scanner table, provided with earplugs to reduce noise level and padding to minimize movement. Participants were instructed to remain awake and still throughout the scan (~1 hr). The sequence relevant for the current analyses was a whole-brain high-resolution 3D T1-weighted Brain Volume (BRAVO) sequence (FOV = 22 mm; voxel size = 0.42 × 0.42 × 1.5 $mm^3$; 120 contiguous axial slices; TR/TE = 1200/5.3 ms; flip angle = 13°).

### Image processing

Images were segmented for total hippocampal volume and total intracranial volume (ICV) using Freesurfer 6.0 software. Preprocessing included motion correction, removal of nonbrain tissue, automated Talairach transformation, and segmentation of the subcortical white matter and deep gray matter volumetric structures. Lastly, images were registered to an atlas for high-resolution in vivo data segmentation.

### Intervention adherence

Attendance at each dance session was recorded. Adherence was calculated by the number of classes attended divided by the number of classes conducted (32 total).

### Data analysis

All statistical analyses were performed with SPSS software, version 26. For all analyses, total hippocampal volumes were normalized to ICV to control for head size. The total hippocampal volume change was calculated by subtracting normalized total hippocampal volume at postintervention from the total normalized hippocampal volume at baseline. Changes in self-reported PA scores were similarly calculated. Adjustment for covariates (sex, age, education, BMI, and number of health conditions) was performed in all analyses.

A mixed analysis of variance (ANOVA) was used to test the change in total hippocampal volume by group and the change in PA. Cohen's *d* values were calculated as an estimate of the effect sizes for change in total hippocampal volume by group. A multiple linear regression model was used to test the associations between total hippocampal volume change and change in PA scores adjusting for covariates and group assignment. Residual change scores were created for all PA scores and hippocampal volume/ICV ratios. Partial correlations were then used to test the associations between hippocampal volume change and change in all PA measures using the same residual change scores mentioned above and controlling for the number of classes attended in the intervention group only. Adjustment of sessions attended was included in the model to capture intervention engagement. In Model 2 of the regression, participant characteristics (sex, age, education, BMI, and number of health conditions) were added to test for its potential effects on hippocampal volume change. Cohen's *d* values were calculated for change in measures of PA by group: MVPA, leisure MVPA, light+MVPA, and leisure light+MVPA. An alpha level of .05 was used for all statistical tests.

## RESULTS

Initially, 130 potential participants were screened; of those, 86 were not eligible for reasons including work time conflicts ($n$ = 22), caregiving responsibilities ($n$ = 7), and not meeting inclusion criteria ($n$ = 57). Of those, 22 participants were eligible and randomized, 12 to the intervention group and 10 to the waitlist control. Only 14/22 participants were included in the present analysis: 10 from the intervention group and 4 from the waitlist control group. Reasons for missing MRI scans ($n$ = 8) and unequal group sizes at 4 month testing included unable to reach participants, death unrelated to the study, and refusing MRI scans—Dance: 1 unable to reach and 1 declined MRI; Waitlist: 3 unable to reach, 1 passed away, and 2 declined MRI. Participants were 67.0 ± 6.1 years of age, 72% were female, reported 8.7 years of education, had a BMI of 29.5 ± 4.1 $kg/m^2$ with 86% of the sample in the overweight or obese category, and had an average of 3.64 ± 2.0 health conditions. Intervention group participants attended a mean of 24.7 classes or 77% of the total sessions. At baseline, participant characteristics (sex, age, BMI, and education), number of health conditions, hippocampal volume, and measures of PA were not statistically different ($p$ > .05) by group. Also, when comparing baseline data of those who had only one MRI scan (not included in the analysis) with those who had two MRI scans, BMI and light+MVPA were statistically different. Participants with one MRI had slightly higher BMI (30.5 ± 8.0, $p$ = .032) and an average of 71 more minutes of light+MVPA ($p$ = .038).

The mixed ANOVA testing the change in total hippocampal volume showed that there was a significant main effect of time ($F$[1, 7] = 6.91, $p$ = .034, $\eta_p^2$ = .58). There was no significant main effect of group ($F$[1, 7] = .028, $p$ = .87, $\eta_p^2$ = .004) or Group × Time interaction ($F$[1, 7] = .083, $p$ = .78, $\eta_p^2$ = .001). The covariates sex ($F$[1, 7] = 6.98, $p$ = .03) and BMI ($F$[1, 7] = 10.9, $p$ = .013), had an effect, but not age ($F$[1, 7] = 1.50, $p$ = .26), education ($F$[1, 7] = .002, $p$ = .965), or health conditions ($F$[1, 7] = .023, $p$ = .782). The effect size for hippocampal volume was $d$ = −.05 (Table 1).

There was a medium effect size for leisure light+MVPA, ($F$[1, 8] = .017, $p$ = .899, $MSE$ = 1.46E-4, $\eta_p^2$ = .017, $d$ = .54), driven by greater increases in the intervention group compared to the waitlist control group ([Intervention, Baseline, 402.0 ± 364.8; 4 months 492 ± 241.8]; [Control, Baseline, 315.0 ± 287.2; 4 months, 326.3 ± 218.5]; Table 1). There was a small effect size for leisure MVPA ($F$[1, 8] =1.11, $p$ = .322, $MSE$ = 1.36E-4, $\eta_p^2$ = .122, $d$ = .23), driven by increases in leisure MVPA in the intervention group and decreases in the waitlist control group, ([Intervention, Baseline, 199.5 ± 269.9; 4 months, 304.5 ± 184.8]; [Control, Baseline, 120.0 ± 144.9; 4 months, 93.8 ± 88.6]).

A regression of hippocampal volume change on MVPA, leisure MVPA, light+MVPA, and leisure light+MVPA while controlling for the covariates and group assignment (Table 2) led us to select Model 1 ($F$[5,13] = 5.94, $p$ = .01), which fit significantly better than Model 2 ($F$[9,13] = 5.46, $p$ = .059). The covariates age (β = −.688, $p$ = .152), education (β = − .010, $p$ = .96), and health conditions (β = −.091, $p$ = .67) had no significant effect, while sex (β= −.688 $p$ = .005) and BMI (β = −.751, $p$ = .004) had significant and similar effects. It should be noted that the covariates sex and BMI had associations with hippocampal volume change, but changes in self-reported PA did not. When examining these correlations in the intervention group only, the results showed no correlation between hippocampal volume change and the change in any of the PA measures: MVPA ($r$ = −.78, $p$ = .12), leisure MVPA ($r$ = −.77, $p$ = .13), light+MVPA ($r$ = −.46, $p$ = .43), and leisure light+MVPA ($r$ = −.40, $p$ = .51).

## DISCUSSION

To our knowledge, this is the first study examining the impact of a Latin dance program on hippocampal volume in older Latinos. We conducted a 4 month Latin dance intervention and measured hippocampal volume and changes in lifestyle PA. We found no statistically significant changes in hippocampal volume after the dance intervention. This is in contrast to findings by Rehfield et al., in which they found increases in hippocampal volume in both dancing and fitness training programs [17]. However, their intervention involved an 18 month-long intervention, whereas our current intervention was 4 months long. Thus, the chosen duration for this intervention may have been too short to find meaningful changes in hippocampal volume. While a previous study assessing the 4 month BAILAMOS dance

**Table 1** | Hippocampal volumes and PA at baseline and 4 months by intervention status

| | Intervention group | | Control group | | |
|---|---|---|---|---|---|
| | Baseline | 4 months | Baseline | 4 months | Cohen's $d$[a] |
| Hippocampal volume (HC/ICV) | 5.46E-03 ± 7.08E-04 | 5.46E-03 ± 7.50E-04 | 5.47E-03 ± 5.43E-04 | 5.50E-03 ± 5.98E-04 | −0.05 |
| MVPA | 232.5 ± 309.5 | 304.5 ± 184.8 | 176.3 ± 255.3 | 213.6 ± 301.1 | 0.12 |
| Leisure MVPA | 199.5 ± 269.9 | 304.5 ± 184.8 | 120.0 ± 144.9 | 93.8 ± 88.6 | 0.23 |
| Light + MVPA | 661.5 ± 477.4 | 670.5 ± 370.1 | 495.0 ± 494.92 | 543.8 ± 385.8 | −0.08 |
| Leisure light + MVPA | 402.0 ± 364.8 | 492 ± 241.8 | 315.0 ± 287.2 | 326.3 ± 218.5 | 0.54 |

*HC/ICV* hippocampal volume adjusted by intracranial volume; *MVPA* moderate to vigorous physical activity.
[a]Effect sizes (small, 0.20; medium, 0.50; and large, 0.80).

**Table 2** | Summary of regression analysis for variables predicting HC/ICV change

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | $b$ | β | $\Delta R^2$ | $b$ | β | $\Delta R^2$ |
| Intercept | 0.005 | | | 0.004 | | |
| Age | −3.03E-5 | −0.328 | | −6.59E-6 | −0.071 | |
| Sex | −0.001 | −0.688[a] | | −0.001 | −0.596 | |
| Education | −9.92E-7 | −0.751 | | −3.77E-6 | −0.037 | |
| BMI | −9.02E-5 | −0.010[a] | | −8.95E-5 | −0.745 | |
| Health conditions | −2.27E-5 | −0.091 | 0.655[a] | −6.43E-5 | −0.258 | |
| MVPA | | | | 2.59E-7 | 0.061 | |
| Leisure MVPA | | | | −2.30E-6 | −0.550 | |
| Light + MVPA | | | | −1.01E-6 | −0.531 | |
| Leisure light + MVPA | | | | 1.54E-6 | 0.511 | 0.755 |

*HC/ICV* hippocampal volume adjusted by intracranial volume; *MVPA* moderate to vigorous physical activity.
[a]Indicates significant at $p < .05$.

program found positive changes in global cognition and episodic memory [18], hippocampal volumes were not assessed, and it is possible that 4 months was not sufficient to observe changes at the hippocampal level. Also, associations between lifestyle PA and hippocampal volume in that study were not assessed. Previous studies have shown that participation in dance interventions has increased engagement in PA [24, 25]. In our study, there were small and medium effect sizes for changes in leisure PA in the intervention group. Given that dancing is an appealing form of PA for older Latinos [26], it may lead to increases in other types of leisure PA. According to PA recommendations, amounts of PA greater than 150 min of moderate PA provide additional health benefits [27]. It is important to continue the promotion and dissemination of dancing programs to yield additional health benefits. Dancing has been associated with improved mood, cognition [28], gait speed, cardiovascular health [29], and social and emotional well-being [30]. Therefore, although hippocampal volume changes did not occur in this study, the benefits that dance may have in other areas should be underscored, as these have an impact on older adults' overall quality of life.

This study had several strengths. We studied an underrepresented population of low-education, Spanish-speaking Latinos using a form of PA that was culturally acceptable. Our sample included low-education older Latinos. Recruitment of older Latinos into clinical trials is important because only 1% participate in clinical trials [31]. Even though participants did not significantly increase their PA, at postintervention, there was a moderate effect on leisure MVPA, which has been associated with longer life expectancies [32] and lower-risk chronic disease and cardiovascular disease [33]; however, these results should be interpreted with caution as these findings may not be generalizable to other Latinos or populations.

Despite these strengths, there are several limitations in our study that should be considered. We had a small sample size and an even smaller number of participants in the waitlist control group who completed posttesting. Waitlist control groups might not be ideal when working with this population. Thus, we did not have the statistical power to test the associations between change in hippocampal volume and lifestyle PA change. The self-reported nature of the PA measures was also a limitation as participants can underreport or overreport PA [34]. Another limitation in this study was that we did not assess the level of difficulty or intensity of the dance classes, and these have been associated with increases in hippocampal volume. Muller et al. (2017) suggest that participants should engage in constant cognitive and motor learning dance program in order to induce neuroplasticity in the brain of older adults [35].

In conclusion, dancing as a form of PA is a fun social activity, which results in high adherence [18] and motivation [26] in older Latino adults. Future work should include longer interventions with larger sample sizes and more cognitively demanding dance programs. The BAILAMOS dance program, if modified to require a higher physical and cognitive demand from the participants, may show increases in hippocampal volume and thereby increases in hippocampal-related cognitive functions that may reduce the risk of cognitive decline and dementia in older Latino adults.

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Compliance with Ethical Standards

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