ASSESSMENT OF EXECUTIVE FUNCTION IN RETIRED FEMALE TEACHERS

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PRE-PROOF

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ABSTRACT

This study aimed to associate sociodemographic data and physical activity habits with the Executive Function (EF) of retired female teachers. This is a cross-sectional, quantitative, and inferential study. The sample was stratified into two groups: group 1, consisting of retired women without Pedagogy degree or higher education; and group 2, composed of retired female teachers. An evaluation form was used to record the participants' personal, sociodemographic data, and health indicators. To assess physical activity habits, some questions related to the frequency, duration, intensity, and type of physical activity were asked. EF was assessed through performance on the Tower of Hanoi task. The data were analyzed using descriptive and inferential statistics. The EF performance of retired female

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teachers was significantly higher compared to that of retired women without training. It was identified that the length of study explained 18.31% of the variability in the volunteers' EF. Retired participants without formal education and of older age showed poorer performance in Executive Function (EF). Finally, regular engagement in physical activity was associated with EF, with physically active participants being associated with a high prevalence of EF.
Keywords: Retirement. Education. Executive Function. Physical Activity Habits. Teachers.

INTRODUCTION

Executive Function (EF) is a set of cognitive skills that allows an individual to plan, organize, direct attention, control impulses, and monitor performance in an activity (Friedman; Robbins, 2022). These brain mechanisms are important because they help a person successfully perform complex tasks and adapt to different situations (Blair, 2017). In this sense, EF is essential for the functioning of the central nervous system in activities performed at work and in other areas of life.

Previously, it was verified that EF can be influenced by several factors (Miguel; Meaney; Silveira, 2023), including age, because as one ages, morphofunctional changes occur in the brain, such as a reduction in brain volume, neural connections, and the action of certain brain regions, resulting in a decrease in the speed of information processing, time perception, and the ability to focus attention (Turner; Spreng, 2012).

Retirement can also affect people's EF (efficiency) since they cease to have cognitive stimuli that excite the brain, causing a decrease in cognitive agility and memory (Gosselin; Boller, 2024). Furthermore, after years of preparation for work, retirement imposes changes in life dynamics for which the worker was not prepared, and in some situations, this results in the development of depressive symptoms due to the difficulties of remaking their life project in a socially useful way (Shiba et al., 2017; Arias-de la Torre et al., 2018).

Finally, the literature has shown that the lack of physical activity can lead to lower production of important neurotransmitters, such as dopamine and serotonin, which play a crucial role in regulating cognition (Cristofori, Cohen-Zimerman, Grafman, 2019; Chen;

Nakagawa, 2023). Furthermore, physical inactivity is associated with a higher risk of cerebrovascular diseases that can negatively affect executive functions (Bliss et al., 2021).

As a consequence, compromised executive functions reverberate in the difficulty in planning and organizing daily activities, memorizing information, communicating and expressing thoughts, solving problems, making important decisions, paying attention, and concentrating (Cristofori, Cohen-Zimerman, Grafman, 2019). In more extreme cases, impaired executive functions can be associated with dementia (Bliss et al., 2021). Therefore, the decline in executive functions can significantly interfere with people's daily lives, compromising their performance at work, in personal relationships, and in their autonomy.

Moreover, it is important to screen and monitor the EFs of retired people early on to promote appropriate interventions to delay or mitigate their cognitive decline. Furthermore, an unfavorable result from a cognitive screening should be carefully analyzed by a specialized professional so that a thorough cognitive assessment and intervention can be conducted (Spirduso, 2005).

EF performance can be verified through neuropsychological tests (Cristofori; Cohen-Zimerman; Grafman, 2019; Friedman; Robbins, 2022), behavioral observation (Manchester; Priestley; Jackson, 2004), interviews, and questionnaires (Suchy; Ziemnik; Niermeyer, 2017). In this context, the Tower of Hanoi (ToH) has been frequently reported to assess the EF of adults and elderly people (Humes et al., 1997; Saikia; Tripathi, 2024). The ToH is a mathematical puzzle that reflects people's ability to plan the execution of a task (Brennan, Welsh, Fisher, 1997). It is a game that consists of a tower formed by three pegs and some discs of different sizes, which are moved from one of the pegs to another, following some rules: only one disc can be moved at a time, and a larger disc can never be placed on top of a smaller disc (Goela, Pullara, Grafman, 2001).

To date, no research has been found compiling the factors that predict EF performance in retired female teachers. This is important because this is a population that has gone through an exhausting and grueling work journey over the years, marked by many hours of work outside of regular hours. In addition, historically, female teachers have had to deal with large class groups, lack of adequate infrastructure in schools, low salaries, pressure for positive results in assessments, and lack of professional recognition, which directly impacts their quality of life and their physical, emotional, and cognitive well-being (Lima; Lima-Filho, 2009).

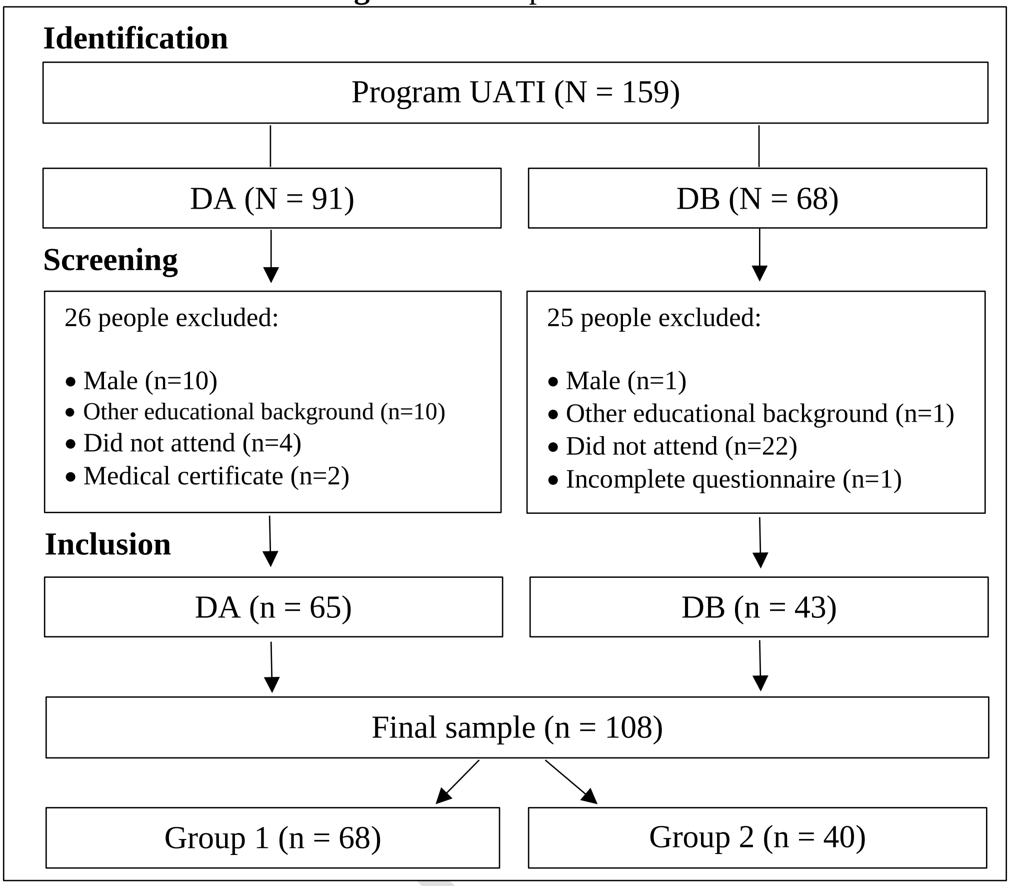
Therefore, this study aimed to associate sociodemographic data and physical activity habits with the EF performance of retired female teachers participating in a university extension project.

MATERIALS AND METHODS

This is a cross-sectional, quantitative, and inferential study in which data collection took place at the Teaching, Research, and Extension Laboratory on Aging (LEPEEn) (Department A - DA) and at a cultural space (Department B - DB), both linked to a public university.

The study population consisted of people regularly enrolled in university extension projects of the *Programa da Universidade Aberta à Terceira Idade* (Open University for the Elderly Program - UATI) of DA (N = 91) and DB (N = 68), totaling 159 subjects. All individuals were invited to participate in the study. The sample was made up of participants who volunteered to join, with 65 participants from DA and 43 from DB, aged between 58 and 88 years. The following inclusion criteria were adopted: female sex; active enrollment in UATI; being retired; lucidity (this criterion was established based on the coherence of speech); wanting to participate voluntarily in the research; Without Pedagogy degree or higher education (specific inclusion criterion for the group of women without training); Pedagogy degree or bachelor's degree (specific inclusion criterion for the group of female teachers). The exclusion criteria were: individuals with training other than Pedagogy degree or a bachelor's degree (excluding other training); who failed to complete the questionnaire and/or cognitive test; and who did not attend the data collection (Figure 1).

Figure 1 – Sample selection



Source: Author's own elaboration.

The final sample consisted of 108 people who were stratified into two groups: group 1 (n = 68), consisting only of retired women without teaching training or higher education; and group 2 (n = 40), composed only of retired female teachers.

In the week preceding data collection, the researcher presented the study proposal to the volunteers and invited them to participate in the research, using simple and clear language. Then, he presented the informed consent form and explained its importance. Data collection was carried out by the researcher from May 22 to July 12, 2023, at DA and from July 17 to 21, 2023, at DB.

After these procedures, an evaluation form was used to record the participants' personal data (date of birth and sex), sociodemographic data (self-reported skin color, religion, marital status, education, and length of study), and health indicators (use of medications, physical activity habits).

To assess physical activity habits, the following questions were asked: “Currently, how many times a week do you engage in physical activity?” (possible answers: none to seven times); “What is the duration of each physical activity session?” (possible answers: I do not exercise; less than 30 minutes – how long; between 30 and 60 minutes – how long; more than 60 minutes – how long); “What is the intensity of this physical activity?” (possible answers: I do not practice physical activity; light; moderate; and intense/vigorous); “What type of physical exercise do you currently perform?” (possible answers: water aerobics, walking; weight training; functional exercises; I do not practice physical activity; and others – open question). Based on the answers, the time spent during each physical activity session was multiplied by the number of days of the week the participant exercised. Volunteers who accumulated 150 minutes or more of moderate-to-high-intensity physical activity were classified as physically active, while those who did not reach this threshold were classified as inactive (Botero et al., 2021).

The volunteers' EF was assessed through performance on the ToH task (Brennan, Welsh, Fisher, 1997), which involves moving all discs from their primary position to a final position in a minimum number of movements without violating the rules. These rules include: (a) only one disc must be moved at a time; (b) discs must be moved only on the pegs; and (c) a larger disc cannot be placed on top of a smaller disc (Goela, Pullara, Grafman, 2001). Studies that explored the planning ability of adults and older adults used three and four discs in the ToH (Brennan, Welsh, Fisher, 1997; Sorel, Pennequin, 2008). In this study, the task with three discs was adopted. Performance measures were based on three main parameters: number of movements required, total time required to complete the task, and number of rule violations during each task (errors).

To characterize the sample in relation to sociodemographic data and some health indicators, descriptive analysis of absolute and percentage frequency was used. EF and study time were presented as mean and standard deviation. The Shapiro-Wilk test was used to verify whether the organization of the data obtained followed a normal distribution. This test serves to ensure that the inferences made are reliable. When the normal distribution was violated, the bootstrapping procedure (1000 resamples; 95% CI BCa) was adopted, as it is a reliable resampling technique used to estimate statistics about a target population, and serves to obtain information on the distribution characteristic of a random variable.

The Pearson chi-square test (χ^2) verified the association of sociodemographic variables and health indicators with EF. The median of the EF dataset was adopted to structure two groups: "high executive function" and "low executive function". When the χ^2 test was significant, the Prevalence Ratio (PR) and its respective 95% Confidence Interval (CI) were calculated to compare the prevalence of an outcome between the groups. The “Phi” score, which is a measure of the strength of association between two categorical variables, was calculated as the effect size value for the χ^2 test, and the results were interpreted as small (>0.1), medium (>0.3), and large (>0.5) (Serdar et al., 2021).

The t-test for independent samples was used to compare EF performance and study time between groups of women with and without training. Welch's correction was used when the principle of homogeneity of variances was violated. The values of “Cohen’s d” (EF) and “Glass’ delta” (study time) were calculated as a measure of effect size for the independent t-test, and the results were interpreted as small (>0.2), medium (>0.5), and large (>0.8) (Serdar et al., 2021). “Cohen’s d” (EF) and “Glass’ delta” are measures that show the standardized difference between two means and serve to estimate the practical importance of a result.

Pearson’s linear correlation and Simple Linear Regression (SLR) were used to verify, respectively, the association between age and EF, and years of study and EF of the volunteers. Pearson’s linear correlation tests the relationship between two variables; that is, it measures the degree to which two variables tend to change together. The SLR model is important because it demonstrates how one variable can explain the change (variability) of another variable. Cohen's r, which is a measure of the strength of the relationship between two numerical variables, was calculated as an effect size value for the RLS, and the results were interpreted as small (≥0.10), medium (≥0.30), and large (≥0.50) (Cohen, 1992).

The alpha adopted was 0.05. All analyses were performed using the Statistical Package for Social Sciences (SPSS) version 20.0 for Windows (IBM Inc., Chicago, IL, USA), and the graph was created using GraphPad Prism 9.0 (GraphPad Software, California, USA). Effect sizes were calculated using G*Power version 3.1.9.7.

This study met the requirements proposed by Resolution No. 466/2012 of the National Health Council and was approved by the Research Ethics Committee with human beings under opinion No. 6.253.310 and CAAE No. 70407323.3.0000.0057.

RESULTS

Table 1, stratified by groups, presents the absolute and relative frequencies (%) of sociodemographic data and health indicators of the study volunteers.

Table 1 - Sample characterization.

Variables	Classification	Group 1	Group 2
Skin color	Brown	40 (37.04%)	18 (16.66%)
	Black	7 (6.48%)	2 (1.86%)
	White	21 (19.44%)	20 (18.52%)
Religion	Catholic	49 (45.37%)	35 (32.41%)
	Evangelical	14 (12.96%)	1 (0.93%)
	Spiritist	1 (0.93%)	3 (2.77%)
	Jehovah's Witness	3 (2.77%)	0 (0%)
	No religion	1 (0.93%)	1 (0.93%)
Marital status	Married or living with someone	29 (26.85%)	19 (17.59%)
	Divorced/widowed/single	39 (36.12%)	21 (19.44%)
Education level	Did not study	7 (6.48%)	---
	Elementary School	36 (33.34%)	---
	Middle School	21 (19.44%)	---
	High School	4 (3.70%)	---
	Pedagogy degree	---	27 (25%)
	Bachelor's Degree	---	13 (12.04%)
Medication	Yes	60 (55.55%)	33 (30.56%)
	No	8 (7.41%)	7 (6.48%)
Habit of PA	Inactive	37 (34.26%)	19 (17.59%)
	Physically active	31 (28.71%)	21 (19.44%)
TOTAL		**68**	**40**

Group 1 = retired women without formal education; Group 2 = retired teachers; PA = physical activity.
Source: Author's own elaboration.

The mean age of the study participants was 68.55 ± 6.60 years (n = 108). The volunteers in group 1 were 68.53 ± 6.76 years old, while the women in group 2 were 68.58 ± 6.41 years old. This difference (Δ = 0.05 years) was not significant. On the other hand, it is important to note that the age of the participants without training, interpreted through bootstrapping procedures, was significantly associated with EF (r = 0.228; 95% CI [0.023 – 0.435]), while this relationship was not observed in the group of retired teachers (r = 0.013; 95% CI [-0.318 – 0.342]) nor in the entire group (r = 0.157; 95% CI [-0.018 – 0.342]).

Table 2 shows the measures of association of sociodemographic data and some health indicators with the EF of the volunteers. In this scenario, EF was categorized into two groups (high and low executive function) based on the median of the dataset (Median = 52.15 s). It was found that only the habit of physical activity showed a significant association with EF ($\chi^2_{(1)} = 5.341$; $p = 0.021$; Phi = 0.222).

Table 2 - Association between sociodemographic data and health indicators with executive function.

Variables	Classification	Executive function		p-value
		High	Low	
Skin color	Brown	32 (29.63%)	26 (24.07%)	0.181
	Black	2 (1.85%)	7 (6.48%)	
	White	20 (18.52%)	21 (19.45%)	
Religion	Catholic	45 (41.66%)	39 (36.11%)	0.284
	Evangelical	4 (3.70%)	11 (10.18%)	
	Spiritist	3 (2.77%)	1 (0.93%)	
	Jehovah's Witness	1 (0.93%)	2 (1.86%)	
	No religion	1 (0.93%)	1 (0.93%)	
Marital status	Married/living with someone	22 (20.37%)	26 (24.07%)	0.439
	Divorced/widowed/single	32 (29.63%)	28 (25.93%)	
Medication	Yes	44 (40.74%)	49 (45.37%)	0.164
	No	10 (9.26%)	5 (4.63%)	
Physical activity habits	Physically active	32 (29.63%)	20 (18.52%)	**0.021**
	Inactive	22 (20.37%)	34 (31.48%)	
TOTAL		**54**	**54**	---

High executive function = women with performance from 10.90 to 52.11 seconds; Low executive function = women with performance from 52.20 to 201.06 seconds.
Source: Author's own elaboration.

The PR was also used to assess the relationship between physical activity habits and the EF of the volunteers. A PR of 1.57 was found (95% CI [1.060 – 2.314]). In other words, this result suggested that physically active participants had a high prevalence of EF, approximately 60%, when compared to women with inactive physical activity habits.

Table 3 shows the means and standard deviations of EF and study time of the study participants. The Shapiro-Wilk test showed that EF ($W_{(108)} = 0.912$; $p < 0.05$) and study time ($W_{(108)} = 0.922$; $p < 0.05$) did not have a normal distribution. The t-test for independent samples, interpreted by the bootstrapping procedure, showed that the EF, evaluated in seconds, of retired female teachers was significantly better when compared to the EF of retired women without training ($t_{(106)} = 3.63$; $p = 0.001$; Cohen's d = 0.725). The t-test for independent samples, interpreted by bootstrapping and with Welch's correction for heterogeneous variances, also confirmed a significant difference in study time between the groups ($t_{(70.3)} = -15.04$; $p = 0.001$; Glass's delta = 3.396).

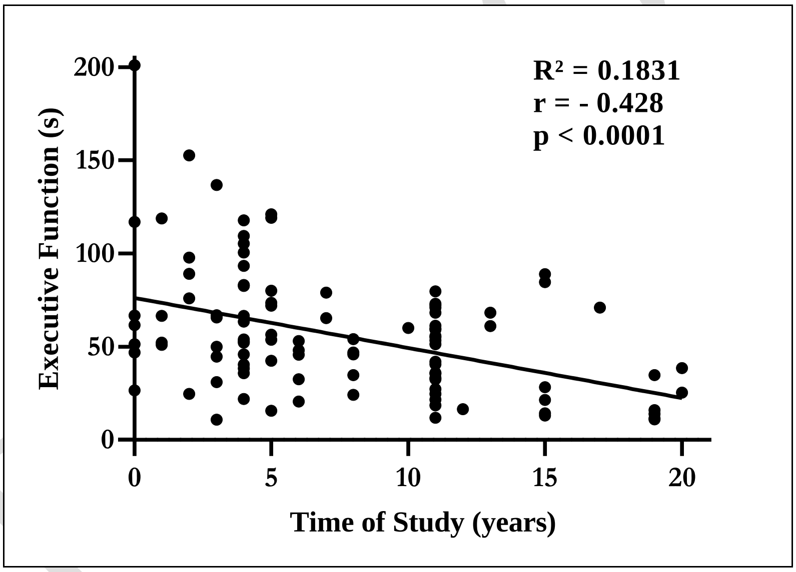
Table 3 - Executive function and study time of the volunteers.

Study Variables	Group 1	Group 2	p-value	ES
Executive Function(s)	64.20 ± 34.97	41.49 ± 23.85	0.001	0.725
Executive Function (movement)	11.07 ± 4.13	9.92 ± 2.92	0.126	0.307
Executive Function (errors)	3.04 ± 2.50	2.87 ± 2.88	0.758	0.199
Study time (years)	4.22 ± 2.68	13.32 ± 3.22	0.001	3.396

Group 1 = retired women without formal education; Group 2 = retired teachers; ES = effect size.
Source: Author's own elaboration.

After confirming the significant difference in mean years of study between the groups (Δ = 9.1 years), an SLR analysis was performed to demonstrate the relationship between EF and study time of the research participants (Figure 2).

Figure 2 - Association between executive function and study time.



Source: Author's own elaboration.

The SLR, interpreted by bootstrapping, identified that years of study were able to predict EF in the volunteers. Thus, the SLR analysis resulted in a statistically significant model in which study time explained 18.31% of the variability in EF ($F_{(1,107)} = 23.76$; $p < 0.0001$; $R^2 = 0.1831$) and was its only predictor (β = - 0.428; t = - 4.875; p < 0.0001). The predictive equation that describes this relationship is as follows: Executive Function (s) = 76.178 – 2.685 * study time (years).

DISCUSSION

The study found that retired female teachers showed better EF performance compared to retired women without formal education. This result was expected; however, according to the searches that were carried out, this is apparently the first time that research has quantified the effect of education on the EF of retired female teachers, identifying that years of study explained 18.31% of the variability in the volunteers' EF. In other words, the result indicated that a longer study period correlated with a shorter execution time on the ToH task, suggesting that years of study managed to preserve EF. Previously, it was found that higher education positively impacted EF, assessed by problem-solving and verbal fluency, in healthy adults and older adults (Rodrigues et al., 2018). However, this investigation was not carried out with people who worked in teaching.

Some evidence has also shown that higher levels of education are associated with greater cognitive reserve in adults and older people (Farina et al., 2018). This reserve, in turn, allows individuals greater neural efficiency and compensatory capacity through the recruitment of additional brain regions (Tucker; Stern, 2011) and delays cognitive decline in the normal aging process (Farina et al., 2018). In a pragmatic way, we understand that the 9.1 additional years of study of the retired teachers enhanced their cognitive reserves, which allowed them to perform the ToH task, on average, 22.71 seconds faster than retired women with less schooling. Therefore, investing in lifelong education can be an effective way to increase cognitive reserve and improve long-term brain health.

EF performance, assessed with three discs in the ToH, has been previously reported (Sorel; Pennequin, 2008). It was found that older people (68.1 ± 2.8 years), with 6.3 ± 1.66 years of education, had a performance of 45.27 ± 21.20 s on the ToH task. In our study, the performance of retired teachers (68.58 ± 6.41 years) on the ToH task was 41.49 ± 23.85 s, and they had, on average, twice as many years of schooling. On the other hand, retired volunteers without Pedagogy degree or a bachelor's degree (68.53 ± 6.76 years) had a worse performance (64.20 ± 34.97 s) on the ToH task, and their education time was shorter (4.22 ± 2.68 years).

The level of complexity in ToH increases as more discs are added to be moved in the game. When analyzing four discs, it was found that women (64.79 ± 3.22 years; 18.5% had less than 4 years of schooling; 46.6%, from 4 to 8 years; 34.9%, from high school to higher education) showed a performance of 199.21 ± 116.08 s (Soares; Diniz; Cattuzzo, 2013), which represents an increase in execution time of approximately 3.6 times compared to our sample of 108 women who performed with three discs (55.79 ± 33.08 s). Although these studies (Sorel; Pennequin, 2008; Soares; Diniz; Cattuzzo, 2013) used the same instrument to assess EF in their methodologies, it should be noted that their samples did not consist of retired teachers.

Age is another variable that affects people's EF performance (Sorel; Pennequin, 2008; Rodrigues et al., 2018). Interestingly, in our study, only the age of the participants without formal education (group 1) showed a positive and significant relationship with the execution time in the ToH puzzle; that is, the older women in group 1 took longer to perform the task. A possible explanation may lie in the fact that senescence is accompanied by a reduction in the number of synapses and cerebral vascularization, which, together, affects the speed of information processing in the brain of older individuals (Mrak, Griffin, Graham, 1997, Iskusnykh et al., 2024).

On the other hand, there was no association between age and EF in retired teachers, which seemed interesting, as this variable did not show a favorable or unfavorable effect on maintaining EF in teachers. Therefore, in this study, it remains, once again, to highlight the practical effect of the protection that the length of schooling exerted on the EF of the participants.

The dynamics of teaching work stimulate the development of EF skills over time (Correia; Navarrete, 2017), as teachers working in the classroom are constantly challenged to develop pedagogical strategies, manage time, deal with unforeseen situations, and make quick decisions (Oliveira Neta; Solon; Falcão, 2024). In addition, interaction with students, colleagues, school administrators, and parents also contributes to the improvement of communication, empathy, conflict resolution, and negotiation skills, which are related to EF. These characteristics of teaching work help explain why the retired teachers in this study obtained better performance on the ToH task.

On the other hand, retirement, understood as the stage of life marked by the end of work activities, can negatively affect executive function performance due to the loss of stimuli and challenges at work, the reduction of social interactions, and the decrease in daily routine (Vélez-Coto et al., 2021). In this sense, it has been verified that professionals who maintain complex and challenging cognitive activities throughout their lives, such as teaching work, tend to present less cognitive decline compared to individuals who retire early (Celidoni, Dal Bianco, Weber, 2017).

Finally, the study results demonstrated an association between physical activity habits and the EF of the volunteers, such that physically active women showed better performance in the ToH puzzle. This is supported by the fact that physical activity causes morphological changes in the brain, improves the efficiency and balance of cerebral neurotransmitter function, increases cerebrovascular function and integrity, and improves the pattern of restorative sleep (Spirduso, 2005). In this sense, we understand that the regular practice of physical activity causes positive adaptations in EF, as it has been shown that aerobic exercise, practiced three times a week for 20 to 90 minutes, improved EF skills in cognitively healthy older adults, especially working memory, cognitive flexibility, and inhibitory control (Xiong et al., 2021).

On the other hand, sedentary behavior, characterized by long periods of time in which a person is sitting or lying down, with low energy expenditure, negatively impacted the EF of older adults (Coelho et al., 2020). Based on the evidence regarding the relationship between physical activity habits and EF, people need to remain physically active to preserve their cognitive abilities, especially EF.

The study had some limitations: (1) the cross-sectional design prevents making claims about causality and makes it impossible to verify the factors that, over time, influence the EF of the volunteers. Therefore, we suggest that longitudinal research be carried out; (2) the use of a single instrument to track the EF of the sample may underestimate or, in other cases, overestimate the relationship with the other variables of the study; (3) the participants' retirement time was not recorded in the evaluation form, which makes it impossible to verify if there is any association with EF; (4) the study sample came from a university extension project, therefore the generalization of the results should be done with caution. Thus, further investigations are needed to ensure that the results found in this study will be valid in other contexts.

However, our research advanced in other aspects: (1) we demonstrated the effect and magnitude of years of schooling on the EF of retired female teachers; (2) the presence of the control group helped to minimize possible confounding factors that could affect the interpretation of the results; (3) the calculation of the prevalence ratio provided information on the strength of association between the variables studied; and (4) the presentation of the effect size indicated how much the independent variables (schooling, physical activity habits and age) affect the dependent variable (EF), confirming its practical importance for the study.

CONCLUSION

The study results revealed that retired female teachers participating in a university extension project showed better EF performance compared to retired women without formal education. It was also verified, for the first time, that the length of schooling was able to explain 18.31% of the variability in the volunteers' EF. Regarding physical activity habits, better EF performance was observed in physically active retired women. These findings are relevant, since no research was found that analyzed the factors affecting the EF abilities of retired female teachers, mainly because preserving these abilities can prevent loss of autonomy and impairment in performing daily activities.

Thus, we suggest that people adopt a healthy lifestyle, including regular physical activity, a balanced diet, adequate sleep, stress management, and positive social relationships, to preserve cognitive health throughout life. In addition, stimulating the brain through new skills, participating in social activities, and keeping the mind active can delay age-related cognitive decline. We also recommend conducting further cross-sectional and longitudinal studies to evaluate other cognitive abilities in retired female teachers.

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