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The mindfulness bridge: Exploring education and cognitive performance in older adults with low educational attainment

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ABSTRACT

Background: Low literacy is associated with poor cognitive performance and it is a risk factor for dementia. Recently, research suggests an association between levels of mindfulness and cognitive performance of older adults. This study aims to analyze if levels of mindfulness mediate the relationship between years of education and cognitive performance in older adults with low education.
Methods: This is a quantitative, observational, and analytical study whose participants were cognitively healthy community-dwelling older adults. Participants were assessed through a sociodemographic questionnaire, ACE-III, Langer Mindfulness Scale – 21 items, and Geriatric Depression Scale. Descriptive and regression analyses were performed, and the significance level was set at $p<0.05$.
Results: Mean scores for cognitive performance, levels of mindfulness, and depressive symptoms were, respectively, 74.4 (±18), 104 (±17.4), and 2.5 (±1.9). The mediation analysis suggested a total effect of years of education on cognitive performance of 2.29 ($p<0.001$), a direct effect of years of education on cognitive performance, controlling for levels of mindfulness, of 1.87 ($p<0.001$), and an indirect effect of years of education on cognitive performance, via levels of mindfulness, of 0.42 (95 % Bias-Corrected and Accelerated Confidence Interval [0.09 to 0.76]).
Conclusion: Our findings suggested that levels of mindfulness mediate the relationship between years of education and cognitive performance among healthy older adults with low educational attainment.

Introduction

The number of older adults has increased considerably in the past few years. The World Health Organization [1] estimates that the proportion of older adults will double between 2000 and 2050. Aging is a complex and multifactorial process in which biopsychological changes occur [2].

As people grow old, a decline in cognitive functioning is observed [3,4]. The most affected domains seem to be executive function, attention, and memory, in addition to a reduction in inhibitory control [5,6]. Critically, changes in cognitive functioning are associated with decreased functionality, independence, and quality of life [7]. For these reasons, understanding characteristics and health determinants that may help cognitive performance and offer some protection against declines in older age seems imperative.

The assessment of cognitive performance in older adults is conducted through the use of neuropsychological instruments. This process, however, can be influenced by the individual's level of education, and there is strong evidence in the literature regarding this educational disparity. Higher levels of education have been associated with better cognitive functioning [8], as well as with higher performance in neuropsychological assessments and functional/structural brain activations in fMRI experiments [9]. On the other hand, being illiterate increases the chances of having worse memory, language, and visuospatial scores [10]. Limited education also seems to increase the chances of developing dementia [10,11].

Recently, research has been focusing on the possible associations between mindfulness and other social, emotional, and health-related outcomes in old age, such as cognitive functioning. Mindfulness is defined as the awareness that arises from paying attention to the present moment non-judgmentally [12]. A second, but interrelated, perspective understands mindfulness as the cognitive flexibility that allows people

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to recreate categories and includes components such as being open to the new, being alert to distinctions, being sensitive to different contexts, and being aware from different perspectives [13–15].

Research suggests associations between levels of mindfulness (LoM) and better mental health [16], well-being [17], executive function [18], attention [19], inhibitory control [20], and with less cognitive decline and less TAU and amyloid-Beta in the brain [21] in older populations.

Strong evidence in the literature supports the effect of education on cognitive performance among older adults [8-10,17]. Previous studies have indicated a positive association between LoM (Levels of Mindfulness) and both education [17] and cognitive performance [17–19]. However, it's important to note that these studies primarily involved participants with high educational attainment. Given the well-established link between education and cognition, and considering the associations between LoM and these two variables, we hypothesized that older adults with more years of education would exhibit better cognitive performance, and this phenomenon could be partially attributed to higher LoM scores. Currently, there is limited understanding regarding the potential mediating effect of LoM on the relationship between education and cognitive functioning among elderly individuals, particularly those with low education. Examining this effect would contribute valuable evidence to the conceptual theory of LoM, specifically its impact on enhancing cognitive performance in older adults with low levels of education.

Furthermore, as research suggests that LoM can be enhanced through mindfulness-based interventions [22], investigating this aspect would shed light on the feasibility of such interventions in older age, particularly for individuals with lower educational backgrounds. Therefore, the primary objective of this study is to investigate whether LoM acts as a mediating factor between education and cognitive performance in cognitively healthy older adults with limited education, residing in a middle-income country.

Methods

Design and sample

This is a cross-sectional, observational, and analytical study with a quantitative approach. Participants (n = 68) were Brazilian male and female community-dwelling older adults, registered in the public primary healthcare system in the urban area of Sao Carlos – Sao Paulo, Brazil.

Brazil is classified as a middle-income country experiencing a rapid aging process. One significant characteristic of its older adult population is their lower level of education [23]. In terms of the educational system, Brazilian basic education comprises primary and secondary education. Primary education, also known as fundamental education, spans 8 years of formal schooling. Secondary education, often referred to as high school, extends for an additional three years beyond primary education. Higher education encompasses degrees pursued after completing high school and typically involves 4–5 years for a bachelor's degree, 2 years for a master's degree, and 4 years for a Ph.D. degree.

Inclusion criteria were being 60 years or older, being cognitively healthy (i.e. no cognitive disorder nor a diagnosis of dementia), and being registered in primary care. Participants were excluded if they had a diagnosis of neurocognitive disorder (e.g. mild cognitive impairment, dementia), psychiatric disorders (e.g. depression, anxiety, bipolar disorder, schizophrenia) or had untreated health issues (e.g. infections) whose symptoms would negatively impact their participation in the study; had uncorrected visual/hearing deficits; presented any sequelae resulting from any clinical condition, which interfered in the assessment (e.g. hemiplegia, ataxia, aphasia); and if they were prescribed medications such as sedative-hypnotics, barbiturates, and benzodiazepines.

Recruitment and procedures

The local health department provided the main researcher with a list of older adults who were users of the primary care system, from which participants were randomly selected. For randomization, the website "random.org" was used. After selection, the older adults were invited to participate in the study by telephone. If they did not have a phone, or if they did not answer it, visits were made, and the invitation to join the study was made face-to-face.

Before the assessment began, participants underwent a screening process to determine their eligibility for participation in this study. This screening involved asking yes/no questions to ascertain whether participants did not meet exclusion criteria, for example, if they had been diagnosed with neurocognitive disorders (such as mild cognitive impairment or dementia), psychiatric disorders (including depression and anxiety disorders), or were currently prescribed medications that could affect the central nervous system. During this phase, all information was self-reported by the participant. As part of the screening process, both the whisper test [24] and the Jaeger card were used to verify hearing and visual capacity, respectively. Instructions on how to use these assessments are provided elsewhere [23,24].

Data acquisition occurred between February 2021 and May 2022 and took place at the older adults' house, in a calm place and without interference from third parties, on a previously scheduled day and time. Due to the condition imposed by the COVID-19 pandemic, researchers followed the recommended hygiene protocols, using personal protective equipment (gloves, masks, face shield, lab coat), in addition to hygiene products (such as alcohol gel). In addition to that, a two-meter interpersonal distance was respected.

Sample size calculation

Considering a significance level of α=0.05, power of 0.8, and a medium effect size (f^2) of 0.15, a total of 68 participants was required for the regression analysis with 2 predictors. G Power (version 3.1) was used to calculate the sample size [25].

Instruments

The instruments were used in the following order: sociodemographic questionnaire, Addenbrooke's Cognitive Examination – III, Langer Mindfulness scale, and Geriatric Depression Scale.

Sociodemographic questionnaire: questions about age (in years), gender (male/female), education (in years), marital status (single, married, divorced, widowed), work status (active; retired; off work; retirement age but no income) and practice of physical activity (yes or no; years of practice).

Langer Mindfulness Scale-21 items (LMS-21): this instrument evaluates levels of mindfulness, and it is divided into four dimensions: novelty production, novelty search, engagement, and flexibility. Its scores vary from 21 to 147 points, and the higher the result, the higher the level of trait mindfulness. The scale was developed by Pirson [14] and has been validated for the Brazilian population by Fernandes [26] and shows good reliability in its Brazilian version (α=0.83) [26].

Addenbrooke's Cognitive Examination – III (ACE-III): it is a cognitive screening battery that accesses participants' global cognitive functioning [27]. In addition to that, it also provides information on 5 cognitive functions/domains: attention (maximum score is 18), memory (maximum score is 26 points), verbal fluency (max score is 14 points), language (max score of 26), and visuospatial ability (max score is 16). The final total score ranges from 0 to 100, and the higher the score, the better the cognitive functioning of the participant [28]. ACE-III's validation for the Portuguese language shows good reliability (α=0.914) and great accuracy in differentiating cognitively normal older adults from dementia patients (sensitivity= 100 %; specificity= 78.57 %) [28].

Geriatric Depression Scale-15 items (GDS-15): this instrument aims to

screen depressive symptoms among older adults through 15 yes or no questions. Its scores vary according to the following categories: <5 points – no depressive symptoms; 5 to 10 points- mild depressive symptoms; and >11 severe depressive symptoms. The questionnaire was developed in 1986 by Sheikh and Yesavage [29] and has been validated for the Brazilian population by Almeida and Almeida [30]. The Brazilian version has the potential to be used both for clinical diagnosis of depression and for monitoring symptom severity over time, and it has good reliability (α=0.81) [30].

Ethical approval

This study was conducted following the 1964 Declaration of Helsinki and with the Resolution 466/12 of the Brazilian National Health Council, whose recommendations approach the ethical aspects of research involving human beings. Ethical approval was given by the Ethics Committee of the Federal University of São Carlos under registration number 4.507.575. Data acquisition only started after the signature of the Informed Consent Form.

Data analyses

Firstly, the participants' characteristics are described. Categorical variables are shown as percentages and continuous variables are expressed by means and standard deviations. Participants were stratified according to their gender. To test the difference of the means, Student's *t*-test was performed for continuous measures and chi-square tests for categorical data.

After descriptive analysis, mediation analysis was performed. To test the hypothesis that LoM mediates the effect between years of education and cognitive performance, we performed a bivariate regression analysis between the independent variable (i.e. years of education) and the dependent variable (i.e. cognitive performance) to obtain the total effect (c). The second analysis (a) was the regression of the potential mediator (i.e. levels of mindfulness) on the independent variable. Finally, the last analysis was a multiple regression of years of education and levels of mindfulness on cognitive performance. It provided both the effect of LoM on cognitive performance (b) and the direct effect of years of education on cognitive performance (c'). To verify the significance of the mediation effect, boost-strapping confidence intervals (CI) were adopted due to their robustness [31]. Fig. 1 shows an illustrative explanation for the model.

All analyses were conducted in IBM SPSS Statistics, version 28, and PROCESS v 4.1, and statistical significance was assumed when $p<0.05$, for the indirect effect, statistical significance was assumed if the CI did not include 0.

Results

Characteristics of the older adults

From the total sample (n = 68), 82.4 % were female. Most of the participants had few years of education (M = 6.5; SD= ±4.9), had approximately 2 diagnosed health problems (SD= ±1.5), were widowed (39.7 %), retired (83.8 %), and practiced physical activity (64.2 %), on average, for 6.8 years (SD= ±10.9). Regarding clinical variables, the mean cognitive performance score was 74.4 (SD= ±18), levels of mindfulness were 104 (SD= ±17.4), and 2.5 (SD= ±1.9) points on GDS (depressive symptoms), which indicates participants had a good overall cognitive performance (i.e., above cut-off score), a high level of mindfulness, and did not present depressive symptoms. Both groups did not differ for most of the outcomes; only work status was different between male and female participants. Even though the category "retired" did not contribute to the difference in this variable (i.e. work status), the other two categories (i.e. off work and retirement age, no income) explained the significant difference between the groups ($\chi^2 = 11.26$; $p = 0.01$). Table 1 shows the demographic and clinical characteristics of the total sample.

Mediation analysis: lom as a mediator of the relationship between years of education and cognitive performance

To test the potential mediator effect of LoM in the relationship between years of education and cognitive performance, some analyses were conducted beforehand. The first linear regression suggested a significant total effect (c) of years of education on cognitive performance (b = 2.29, 95 %CI [1.59 to 2.99], t = 6.53, $p<0.0001$, $R^2=0.393$). Additionally, years of education predicted levels of mindfulness (b =

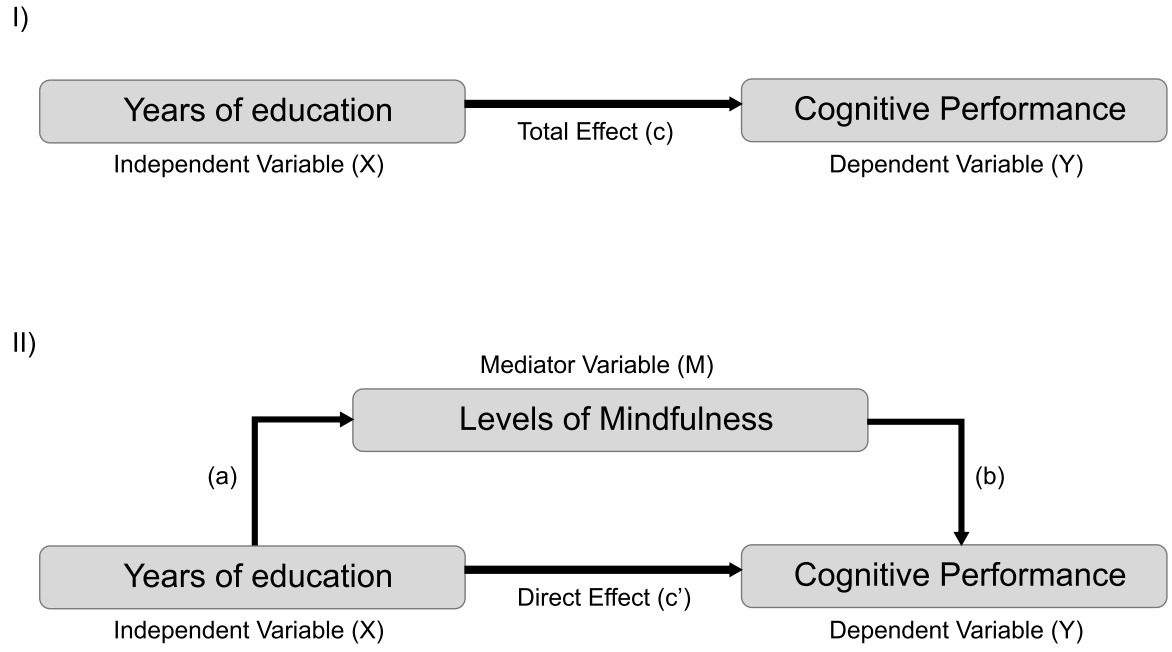

Fig. 1. The general structure of the model used to verify the potential mediation of Levels of Mindfulness in the effect that years of education have on cognitive performance. "I" illustrates the bivariate regression to verify if X predicts Y. "II" represents the regression of M on X, and the regression of Y on X, controlling for M.

Table 1
Demographic characteristics and clinical variables of the full sample stratified by gender. Values are expressed as means and SD in brackets, or percentages.

	Total sample (n = 68)	Female (n = 56)	Male (n = 12)	Female vs Male*	95 % CI
Gender,%	–	82.4 %	17.6 %	–	–
Age, in years	71.6 (6.1)	71.5 (6.1)	72 (6.2)	0.81	(−3.39 to 4.35)
Education, in years	6.5 (4.9)	6.7 (5.1)	5.5 (4)	0.38	(−4 to 1.95)
Number of current diagnosed health problems	2.4 (1.5)	2.4 (1.5)	2.3 (1.7)	0.79	(−1.28 to 1)
Marital Status,% (n)	–	–	–	0.3	–
Married	36.8 (25)	33.9 (19)	50 (6)	–	–
Divorced	14.7 (10)	12.5 (7)	25 (3)	–	–
Widowed	39.7 (27)	44.6 (25)	16.7 (2)	–	–
Single	8.8 (6)	8.9 (5)	8.3 (1)	–	–
Work status,% (n)	–	–	–	0.01	–
Active	1.5 (1)	0	8.3 (1)	–	–
Retired, retirement income	83.8 (57)	83.9 (47)	83.3 (10)	–	–
Off work§	1.5 (1)	0	8.3 (1)	–	–
Retirement age, no income△	13.2 (9)	16.1 (9)	0	–	–
People practicing physical activity regularly,%	64.2 (43)	61.8 (34)	75 (9)	0.39	–
Mean of years practicing physical activity	6.8 (10.9)	6.2 (10.7)	9.2 (12.2)	0.44	(−5.10 to 11.21)
Global Cognition, ACE-III	74.4 (18)	73.9 (19)	76.4 (12.6)	0.57	(−6.63 to 11.69)
Levels of Mindfulness, LMS-21	104 (17.4)	103 (17)	108.6 (19.4)	0.37	(−7.28 to 18.48)
Depressive Symptoms, GDS-15	2.5 (1.9)	2.5 (2)	2.8 (1.4)	0.43	(−0.62 to 1.39)

CI= Confidence interval; ACE-III= Addenbrooke's Cognitive Examination – III; LMS-21 – Langer Mindfulness Scale – 21 items; GDS-15= Geriatric Depression Scale – 15 items.

§ Off work= the participant is currently employed, but is not active due to being on sick leave;.

△ Retirement age, no income= the participant has reached the legal retirement age, but did not contribute to a retirement account and has no income;.

* p-value for group comparison.

1.27, 95 % CI [0.46 to 2.08], $t = 3.12$, $p = 0.003$, R^2=0.129). Controlling for LoM, years of education showed a significant direct effect (c') on cognitive performance (b = 1.87, 95 % CI [1.18 to 2.57], t = 5.36, p<0.0001). In this model, LoM also had a significant effect on cognitive performance ($b = 0.33$, 95 % CI [0.13 to 0.53], $t = 3.31$, $p = 0.001$, R^2= 0.480). Finally, the mediation effect (indirect effect) was statistically significant (b = 0.42, 95 % Bias-Corrected and Accelerated Confidence Interval [0.09 to 0.76]). As shown in Fig. 2, levels of mindfulness mediated approximately 18.3 % of the relationship between years of education and cognitive performance.

Discussion

As people grow old, changes in cognitive functioning can be observed and educational level has a significant effect on cognitive aging [32]. Despite that, and due to the heterogeneity observed throughout the aging process, other factors also seem to participate in this relationship, mitigating the negative impact of low educational attainment on cognitive performance. In this sense, this study aimed to identify the potential mediation effect of LoM between years of education and cognitive performance among cognitively healthy older adults. The hypothesis was that levels of LoM mediate the effect of education on the cognitive performance of older adults. Therefore, it was expected that older adults with higher years of education would have better cognitive performance and this would be partially explained due to higher LoM scores. To the best of our knowledge, this is the first study to investigate this relationship. Our findings suggest the existence of such an effect (i.e., mediation effect), which, therefore, confirms our hypothesis.

Results from this study reveal the effect of education on the cognitive performance of older adults. Specifically, it was observed that a higher educational level predicts better cognitive performance. Robust evidence in the literature points in the same direction [33,34]. Interestingly, it has been observed that as the level of education increases (e.g. from primary to high school, from high school to college degree), older adults score higher on cognitive assessments when compared to individuals from lower educational levels [9].

Possible explanations for the reasons why educational levels are associated with cognitive performance are available in the literature. First, the theory of cognitive reserve claims that higher schooling provides individuals with higher reserve capacity, which may result in better scores on cognitive assessments and may even attenuate cognitive decline in older adulthood [35,36]. Another fact that may explain better cognitive performance among highly educated older adults is that they are likely to actively use and challenge their cognitive domains through daily tasks, such as on work-related activities [35]. Therefore, undoubtedly, strong evidence already shows the existence of an effect of educational level on cognitive functioning, and this study corroborates such evidence.

Regarding education, our findings are particularly relevant for low- and middle-income countries, where the number of low-educated elderly is considerably high [37]. Low education has been associated with poor cognitive performance and with higher chances of developing dementia [36,37]. Hence, finding factors that, despite low education, could contribute to maintaining cognitive performance is an important step toward cognitive health prevention and promotion.

In this sense, our results suggested LoM predicts the cognitive performance of older adults with low educational attainment. Previous research has also found associations between levels of mindfulness and

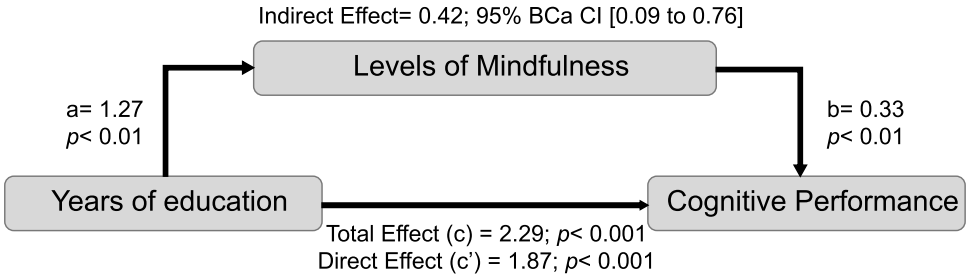

Fig. 2. Model of years of education as a predictor for cognitive performance, mediated by levels of mindfulness. 95 % Bias-Corrected and Accelerated Confidence Interval (BCa CI) was obtained through Bootstrapping analysis (5000 samples).

cognitive performance in the same population (i.e. older adults) [17–21], however, their sample had high educational level. Our findings contribute to the literature by providing evidence for this relationship among older adults with low education.

Changes in cognitive performance throughout the aging process have been widely addressed [38]. Specifically, executive functions, attention, and some aspects of memory tend to decline as people grow old [5,39]. Research also indicates that older adults may present diminished ability in inhibitory control [40,41]. Interestingly, studies report an influence of mindfulness on the inhibitory control of older adults, and people with higher levels of mindfulness have shown better performance in this cognitive function (i.e. inhibitory control) [17,20,42]. These findings can provide support for a potential explanation as to why seniors with higher levels of mindfulness exhibit enhanced cognitive performance. Nevertheless, additional research is necessary to delve deeper into this matter and ascertain whether and to what degree LoM influence cognitive performance through improved inhibitory control. Moreover, gaining a comprehensive understanding of the underlying mechanisms behind this process may provide researchers with valuable insights to further advance this field.

Finally, the effect of years of education on cognitive performance remained robust after inserting LoM in the analysis. Also, the indirect effect (mediation effect) of LoM in the relationship between years of education and cognitive performance was confirmed in this study. This reveals a partial mediation of LoM in this relationship.

Our findings raise several important questions that should be explored in future research. Given that levels of mindfulness can be enhanced through the practice of meditative mindfulness [22], it is worth investigating whether mindfulness-based interventions (MBIs) would have a more pronounced positive impact on the cognitive performance of older adults with low education. If such interventions prove to be effective, they could serve as compelling evidence for health professionals and policymakers to consider implementing MBIs as feasible interventions to enhance cognition in this population.

This line of inquiry is particularly relevant because social determinants of health, such as educational level, have a significant influence on the cognitive abilities of older adults. Therefore, identifying factors that can improve cognitive function in older adults with low educational backgrounds is of utmost importance.

These questions highlight the need for further investigation into the impact of MBIs on cognition in older adults and the importance of addressing social determinants of health. Future research in these areas will contribute valuable insights and advance our understanding of interventions to enhance cognitive function and promote healthy aging.

This study provides further support for the notion that elderly individuals with lower education levels exhibit poorer cognitive performance. It evidences the need to prioritize this population and integrate routine cognitive screening into healthcare services. This is crucial because these individuals are at a higher risk of developing neurocognitive disorders [11]. Additionally, the underdiagnosis of MCI and dementia is a significant concern, especially in low and middle-income countries where educational attainment is limited [43,44].

Some limitations should be acknowledged. Firstly, the cognitive performance and LoM responses might be negatively biased due to the study's timeframe coinciding with the coronavirus pandemic. Data collection began after the lockdown in Brazil, but was later halted due to subsequent virus variants and restrictions. Additionally, our sample showed limited variability in depressive symptoms, and thus, we did not include them as a factor in our model. Also, this study solely used LMS-21 as the assessment for LoM. It's worth noting that this assessment doesn't encompass the contemplative aspects of mindfulness, such as awareness and present-focused attention. Future research should explore the advantages of incorporating additional assessments that can encompass a wider spectrum of mindfulness attributes. Furthermore, it is important to note that this study primarily centered its analyses on participants' years of education. Existing research has pointed out that years of formal education may provide an incomplete assessment of the quality of education [45,46]. Therefore, it is advisable to also consider measures of literacy and educational experiences in future investigations. Future research should focus on demographics and consider depressive symptoms as a variable influencing cognitive performance. Furthermore, future studies could explore the potential mediating effect of LoM on the relationship between years of education, cognitive performance, and the impact of mindfulness-based interventions in older adult populations.

In conclusion, results from this study reaffirm evidence that years of education predict cognitive performance in older adults. LoM also predicted the performance of older adults in cognitive assessment. Our particular contribution to the literature relies on the fact that LoM was found to mediate the relationship between years of education and cognitive performance in cognitively healthy older adults with low educational attainment.

Ethical principles

The authors affirm having followed professional ethical guidelines in preparing this work. These guidelines include obtaining informed consent from human participants, maintaining ethical treatment and respect for the rights of human or animal participants, and ensuring the privacy of participants and their data, such as ensuring that individual participants cannot be identified in reported results or from publicly available original or archival data.

Ethical approval

This study was conducted following the 1964 Declaration of Helsinki and with the Resolution 466/12 of the Brazilian National Health Council, whose recommendations approach the ethical aspects of research involving human beings. Ethical approval was given by the Ethics Committee of the Federal University of São Carlos under registration number 4.507.575. Data acquisition only started after the signature of the Informed Consent Form.

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Author contributions

LNCP was responsible for the conception and design of the study, acquisition of data, analysis, interpretation of data, and major writing of the manuscript. ADCN was responsible for the acquisition of data, and writing of the manuscript. RAPR was responsible for the conception and design of the study, and revising the manuscript critically for important intellectual content. All authors have read and approved the submission of the manuscript in its current form.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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