Neuropsychological Functioning, Lifestyle and Mental Health in the Aging Process

Funcionamiento neuropsicológico, estilo de vida y salud mental en el proceso de envejecimiento

Jorge Oliveira[1]
Manuel Domingos[2]
Marta Barata[1,2]
Sofia Borges Sousa[1,2]
Marta Raimundo[1,2]
Tania Gaspar[1,2]

[1]Digital Human-Environment Interaction Lab, School of Psychology and Life Sciences, Lusófona University, Lisbon, Portugal
[2]Portuguese Laboratory for Healthy Workplaces, Lisbon, Portugal

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Abstract:

There are multiple factors that influence cognitive functioning during ageing.
This phase of life is associated with several biopsychosocial changes, which make individuals more vulnerable to the development of mental health problems such as depressive and anxiety disorders. This study was conducted to provide initial validation of a new neuropsychological screening instrument and to examine its relationship with psychological constructs related to quality of life and well-being. A total of 614 participants was recruited from various institutions throughout the country, mainly day care centers and residential structures for older adults. The majority of the participants were female (n = 453; 73,8%), widowed (n = 220; 35,8%), and had children (n = 485; 78.9%). Most participants were living in their own homes (n = 326; 53,1%), and were retired (n = 445; 72,5%). In terms of education, most participants had completed 4 years of schooling, corresponding to the basic education level (n = 156; 25,4%). Regarding age, the average age of the sample was 69,61 (SD = 17,15) ranging from 24 to 99 years.
The evaluation of neuropsychological functions was conducted by psychologists using a neuropsychological assessment questionnaire comprising tests that assess various cognitive functions, including orientation, attention, memory, language, gnosis, praxis, visuoconstructive ability, and executive functions (pre-frontal tests and the clock test).
An in-depth psychometric study of the neuropsychological assessment battery in its different dimensions and its relationship with other lifestyle and mental health variables was carried out. The results revealed adequate psychometric properties for the neuropsychological instrument, suggesting also a relationship between neuropsychological functioning with quality of life and physical activity in older adults.
In conclusion, these data suggest that the neuropsychological instrument is a valid and practical measure for assessing neuropsychological functioning. The correlations between neuropsychological performance in this test and physical activity, as well as quality of life, emphasize the importance of these factors in promoting active and healthy aging.

Keywords:

evaluation; neuropsychological functions; ageing; lifestyle; mental health; quality of life.

Resumen:

Existen múltiples factores que influyen en el funcionamiento cognitivo durante el envejecimiento. Esta fase de la vida se asocia a varios cambios biopsicosociales, que hacen a los individuos más vulnerables al desarrollo de problemas de salud mental, como los trastornos depresivos y de ansiedad. Este estudio se llevó a cabo para proporcionar una validación inicial de un nuevo instrumento de cribado neuropsicológico y examinar su relación con constructos psicológicos relacionados con la calidad de vida y el bienestar. Se reclutó a un total de 614 participantes de diversas instituciones de todo el país, principalmente centros de día y estructuras residenciales para adultos mayores. La mayoría de los participantes eran mujeres (n = 453; 73,8%), viudas (n = 220; 35,8%) y tenían hijos (n = 485; 78,9%). La mayoría de los participantes vivían en su propia casa (n = 326; 53,1%) y estaban jubilados (n = 445; 72,5%). En cuanto a la educación, la mayoría de los participantes habían completado 4 años de escolarización, correspondientes al nivel de educación básica (n = 156; 25,4%). En cuanto a la edad, la edad media de la muestra era de 69,61 años (DE = 17,15) y oscilaba entre los 24 y los 99 años. La evaluación de las funciones neuropsicológicas fue realizada por psicólogos mediante un cuestionario de evaluación neuropsicológica compuesto por pruebas que evalúan diversas funciones cognitivas, como la orientación, la atención, la memoria, el lenguaje, la gnosis, la praxia, la capacidad visoconstructiva y las funciones ejecutivas (pruebas prefrontales y prueba del reloj). Se realizó un estudio psicométrico en profundidad de la batería de evaluación neuropsicológica en sus diferentes dimensiones y su relación con otras variables de estilo de vida y salud mental. Los resultados revelaron propiedades psicométricas adecuadas para el instrumento neuropsicológico, sugiriendo también una relación entre el funcionamiento neuropsicológico con la calidad de vida y la actividad física en adultos mayores. En conclusión, estos datos sugieren que el instrumento neuropsicológico es una medida válida y práctica para evaluar el funcionamiento neuropsicológico. Las correlaciones entre el funcionamiento neuropsicológico en esta prueba y la actividad física, así como la calidad de vida, enfatizan la importancia de estos factores en la promoción de un envejecimiento activo y saludable.

Palabras claves:

evaluación; funciones neuropsicológicas; envejecimiento; estilo de vida; salud mental; calidad de vida.

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Correspondencia: Tânia Gaspar: tania.gaspar.barra@gmail.com

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Introduction

Cognition is due to the continuous interaction among several regions of the central nervous system, integrating functions such as orientation, attention, memory, language, gnosis, praxis, visual perception, visual construction, executive functions, and more (Almeida, 2010; Malloy et al., 2010; Zuccolo et al., 2010). This interaction gives rise to an individual's perception of themselves and their environment, their connection to the past, future, environment, and others, and their overall behavior (Almeida, 2010; Navarro et al., 2018).

Although accumulated knowledge and acquired skills generally remain stable in older individuals, the process of ageing is known to bring structural and functional changes in brain (Murman, 2015). These changes increase the risk of cognitive decline (Brewster et al., 2014; Murman, 2015; Pengpid et al., 2019; Shen et al., 2021; Zaninotto et al., 2018). Normal ageing involves relevant changes in several cognitive domains, including attention (World Health Organization [WHO], 2015), memory (especially episodic memory), executive functions, and processing speed (Foo et al., 2019; Mattos & Junior, 2010; Paula et al., 2014; Salech et al., 2012). It is worth noting that cognitive functioning tends to decline with age, and the decline becomes more rapid and pronounced after the age of 80 (Shen et al., 2021).

A longitudinal study conducted by Zaninotto et al. (2018), demonstrated a progressive decline in memory, processing speed, executive functions and global cognition as individuals age. Moreover, certain diseases have been identified as promoters for neuronal dysfunction and cognitive decline, often resulting in a significant impairment of daily functioning for affected individuals (Murman, 2015).

There are multiple factors that influence cognitive functioning during ageing (Hsu & Bai, 2022). This phase of life is associated with several biopsychosocial changes (Chalise, 2019), which make individuals more vulnerable to the development of mental health problems such as depressive and anxiety disorders (Finnerty, 2020; Gaspar et al., 2023; Manungkalit & Sari, 2020). Depressive symptoms at this stage of life is a risk factor for cognitive decline (Huang et al., 2022; Wu et al., 2021), and may even predict a decline in executive functions (Wu et al., 2021). Conversely, a decline in cognitive functions may predict an increase in depressive symptoms (Gao et al., 2022; Zou et al., 2018), highlighting that a decrease in processing speed may predict the onset of such symptoms (Wu et al., 2021). Recent studies have also indicated a relationship between cognitive deterioration and lifestyle factors (WHO, 2019), emphasising that adopting healthy lifestyle reduces the risk of cognitive decline associated with ageing (Murman, 2015). Consequently, it is evident that an unhealthy diet can be a risk factor for cognitive deterioration (WHO, 2019) and that appropriate nutrition serves as a protective factor for cognitive functioning in older individuals (Sequeira et al., 2018).

In addition, the lack of physical activity can also contribute to a decline in cognitive functioning (WHO, 2019; Zaninotto et al., 2018). In a longitudinal study conducted by Zaninotto et al. (2018) it was observed that sedentary participants showed a greater degree of decline in memory and global cognitive function throughout the study, when compared to physically active participants. Hence, it can be concluded that engaging in physical activity acts as a protective factor against cognitive decline (Li & Li, 2022; Lor et al., 2023; Sequeira et al., 2018), regardless of an individual's mental state (Xu et al., 2023). Despite this, it is worth noting that a majority of elderly individuals do not meet the recommended levels of physical activity (McPhee et al., 2016), and the older the age, the less likely the individual is to engage in regular physical activity (McPhee et al., 2016; Sun et al., 2013).

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Sleep patterns often undergo changes with age, including a decrease in nightly sleep duration and sleep efficiency, as well as an increase in night-time awakenings and frequency of naps (Li et al., 2018). Consequently , there is a significant and inverse correlation between sleep quality and age, with sleep quality gradually decreasing as age advances (Landry et al., 2015; Madrid-Valero et al., 2017; Mander et al., 2017).

Despite the presence of certain inconsistencies in the scientific literature, it is evident that the existence of negative changes at this level is associated with impaired cognitive functioning (Dzierzewski et al., 2018). According to Casagrande et al. (2022), the frequency and severity of sleep problems appear to coincide with the progression of cognitive impairments, if such impairments exist. Thus, it should be noted that maintaining a regular and healthy sleep pattern may act as a protective factor for cognitive functioning in this age group and lead to improvements at this level (Hu et al., 2021; Sequeira et al., 2018).

With regard to alcohol consumption, some studies show that frequent alcohol consumption tends to be higher among individuals aged 65 and above, when compared to other age groups (Britton et al., 2015; Geels et al., 2013). Furthermore, alcohol and tobacco consumption have been identified as risk factors for cognitive decline in this particular age group (Li & Li, 2022; WHO, 2019; Zaninotto et al., 2018).

Studies show that cognitive functioning is significantly related to quality of life during the ageing process (Fardshad et al., 2021; Saputri et al., 2020). According to Saputri et al. (2020), maintaining cognitive functioning at this stage of life can prevent a decline in the individuals' quality of life. Therefore, it is crucial to assess cognitive functions to understand their impact on an individual's quality of life and to develop interventions aimed at promoting it (Brandão et al., 2020; Schoenberg & Scott, 2011).

Neuropsychological assessment allows collecting information about the individual's cognitive and behavioural functioning. Its primary purpose is to describe the individual's neuropsychological status, identify cognitive and behavioral deficits to assist in making diagnoses (e.g. neurocognitive disorders), plan and design interventions or treatments (medical, surgical, behavioural, etc.) and monitor and evaluate the effects of interventions, treatments, and changes in cognitive functions over time. Additionally, it provides valuable insight into how a specific disease, injury, or treatment affects the subject's cognitive and behavioral functioning, thereby influencing their quality of life and performance of daily activities (Schoenberg & Scott, 2011). Given its crucial role, it is imperative to develop assessment methods that effectively analyze these problems (Borgnis et al., 2022) and thoughtfully select assessment instruments, prioritizing those with reliability and validity (Sherman et al., 2011). Therefore, the objective of this study was to provide initial validation of a new neuropsychological screening instrument for older adults and to examine the relationship between neuropsychological functioning and psychological constructs related to quality of life and well-being.

Method

Participants

The sample for this study was recruited from various institutions throughout the country, mainly day care centers and residential structures for older adults. The majority of the participants were female (n = 453; 73,8%), widowed (n = 220; 35,8%), and had children (n = 485; 78.9%).

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Most participants were living in their own homes (n = 326; 53,1%), and were retired (n = 445; 72,5%). Table 1 presents a detailed overview of the sociodemographic characteristics of the sample. In terms of education, most participants had completed 4 years of schooling, corresponding to the basic education level (n = 156; 25,4%), as shown in Figure 1. Regarding age, the average age of the sample was 69,61 (SD = 17,15) ranging from 24 to 99 years.

Table 1

Sociodemographic characteristics of the sample

	F	%
Gender		
Women	453	73,8
Men	161	26,2
Marital status		
Single	90	14,6
Union of Fact	32	5,2
Married	199	32,4
Separated	4	0,6
Divorced	70	11,4
Widowed	220	35,8
Had children?		
Yes	485	78,9
No	130	21,1
Professional activity		
Active professional activity	138	22,5
Retired	445	72,5
Retired with active professional activity	13	2,1
Unemployed	1	0,2
Residence		
Own home	326	53,1
Children's home	41	6,7
Rented house	89	14,5
Institution	132	21,5
Other	26	4,2

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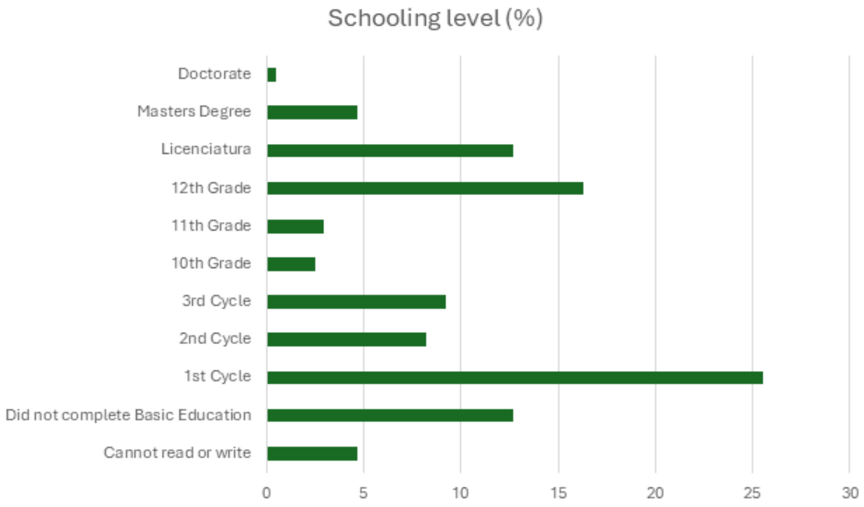
Figure 1

Schooling level of the sample in percentage



Measures

Sociodemographic, clinical and personal questionnaire

A questionnaire in the form of an interview was administered to gather information about the participants, including socio-demographic, clinical, personal, and family data. This questionnaire enables the collection of various details about the individuals, such as age, gender, marital status, number of children, level of education, professional situation, place of residence, personal and family medical history, presence of chronic diseases or other health conditions, medication usage, ongoing therapies, and other relevant individual-related data.

Neuropsychological evaluation questionnaire

The evaluation of neuropsychological functions was conducted using a neuropsychological assessment questionnaire comprising tests that assess various cognitive functions, including orientation, attention, memory, language, gnosis, praxis, visuoconstructive ability, and executive functions (pre-frontal tests and the clock test). The overall score obtained from the neuropsychological assessment questionnaire ranges from 0 to 112 points, with 1 point for each successful task or well-performed element. The higher the total score, the better the individual's performance in terms of neuropsychological functions (Gaspar et al, 2021).

Quality of Life Questionnaire (WHOQOL-BREF)

Quality of Life (QL) was assessed using the WHOQOL-bref (WHOQOL, 1998), namely its version translated and adapted to the Portuguese population by Canavarro et al. (2007) and Vaz Serra et al. (2006). The WHOQOL-bref consists of a reduced version of the WHOQOL-100 scale, and is a generic, multidimensional and multicultural instrument used to assess individuals' perception of their quality of life. The questionnaire is composed of a total of 26 items, two of

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which refer to the overall perception of quality of life and overall perception of health and the remaining 24 are organised into four dimensions: physical QoL (7 items), psychological QoL (6 items), social QoL (3 items) and environmental QoL (8 items). The answers vary on a 5-point Likert-type scale, and the higher the score, the better the QoL. As regards the psychometric characteristics of the WHOQOL-Bref, the internal consistency, as measured by Cronbach's alpha, shows acceptable values, both as regards the four dimensions (0.79) and the 26 items that make up the instrument (0.92), and as regards each individual dimension (ranging from 0.64 to 0.87) (Vaz Serra et al., 2006).

General Health Questionnaire (GHQ28)

Mental health was assessed using the 28-item General Health Questionnaire (GHQ28) validated for the Portuguese population by Pais Ribeiro and Antunes (2003). The GHQ28 is a self-completion questionnaire created by Goldberg and Hillier in 1979, based on the initial version of the General Health Questionnaire (GHQ) (Goldberg, 1972). The GHQ was designed to identify the inability to perform the activities of daily living in healthy individuals and the emergence of new phenomena that cause stress. This instrument does not aim at detecting stable traits, but rather changes in the individual's normal functioning, assessing his/her mental health and psychological well-being (Pais Ribeiro & Antunes, 2003). The GHQ28 is composed of four subscales: Somatic Symptoms, Anxiety and Insomnia, Social Dysfunction and Major Depression, each composed of 7 items. The answers are given through a Likert-type scale ranging from 0 to 3. The values of each subscale may vary between 0 and 21 and the total values of the questionnaire may vary between 0 and 84. The presence of higher values is indicative of worse mental health. The internal consistency of the original instrument was assessed using Cronbach's alpha, with an internal consistency of 0.94 for the GHQ-28 scale, 0.85 for the subscale Somatic Symptoms, 0.88 for the subscale Anxiety and Insomnia, 0.83 for the subscale Social Dysfunction and 0.89 for the subscale Major Depression (Pais Ribeiro & Antunes, 2003).

Lifestyle Indicator Questionnaire

Lifestyle was assessed through the Lifestyle Indicator Questionnaire, translated and adapted from the Simple Lifestyle Indicator Questionnaire by Godwin et al. This questionnaire consists of 12 items, integrated into 5 components: Diet (3 items), Physical Activity (3 items), Alcohol Consumption (3 items), Smoking Behaviours (2 items) and Stress Level (1 item). The higher the score obtained, the healthier the individual's lifestyle. The internal consistency of the original instrument, measured through Cronbach's alpha, is 0.58 for the questions regarding diet and 0.60 for the questions regarding physical activity. The instrument's reliability was assessed through the test-retest method, with a coefficient of 0.87 for alcohol consumption, 0.97 for smoking behaviour, 0.75 for stress level, 0.63 for diet, and 0.74 for physical activity (Godwin et al., 2008).

Sleep Quality Index

Sleep was assessed using the Pittsburgh Sleep Quality Index (PSQI), developed by Buysse et al. (1989) and validated for the Portuguese population by João et al. (2017). This instrument con-

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sists of 19 self-completion questions that analyse the different factors of sleep quality grouped into seven components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep changes, use of sleeping medication and daytime dysfunction. Each of the components is assigned a score ranging from 0 (no difficulty) to 3 points (severe difficulty). The seven components are added together to obtain an overall score, ranging from 0 (no difficulty) to 21 (severe difficulty in all areas). The author of the scale proposes a cut-off point of 5, an index equal to or greater than 5 being an indicator of poor-quality sleep.

Statistical analysis

The statistical analysis was conducted using SPSS v.28 (IBM Statistics) for Mac. The significance level for all statistical procedures was set at alpha 0.05, corresponding to a 95% confidence level. The purpose of the analysis was to evaluate the reliability and validity of the neuropsychological instrument. The analysis began with a description of the sample in terms of clinical characteristics to define the type of sample and potential vulnerability issues related to the sample. A reliability analysis was then performed to assess the internal consistency of the neuropsychological instrument in assessing global cognitive ability through Cronbach's alpha and inter-item correlations. Correlations between each task of the neuropsychological instrument and the total score were also calculated. The tasks were grouped into proposed cognitive domains, and correlation analysis was performed to understand the associations between cognitive domains and the total score. To assess the external validity of the instrument, associations between the total score and other psychological constructs were examined. Normative scores were provided for global cognitive functioning as assessed with the neuropsychological instrument, according to age and education. Finally, the effects of lifestyle variables on neuropsychological functioning were determined using an analysis of covariance (ANCOVA), controlling for age effects.

Results

Clinical characteristics of the participants

Clinical information was obtained through a structured interview format, which included questions about chronic health conditions, medication use, and family medical history. Additionally, a speech production analysis was conducted as part of this evaluation. The results showed that most participants had a chronic health condition (n = 359; 58,5%). Content analysis to open-ended questions related to the clinical history revealed that stroke and cardiovascular diseases were the most frequently occurring issues. A visual inspection to Figure 2 illustrates the most common issues reported by the participants. Regarding medication use, most participants used pharmacological drugs for their health conditions (n = 329; 53,6%), but the majority of the sample only took one medication per day (n = 125; 20,4%) primarily for cardiovascular diseases. The speech analysis revealed that most participants had a coherent and fluent speech (n = 439; 71,5%).

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Figure 2

Clinical history

Reliability of the neuropsychological instrument

The reliability was calculated using the Cronbach's alpha that was considered good (alpha = 0,809) from a total of 21 items. No items would increase internal consistency of this instrument if were removed. The summary of inter-item correlations revealed a mean correlation between items of r = 0,168, while the minimum correlation was r = -0,077 and the maximum was r = 0,576. The individual item statistics are provided in Table 2 for the mean, standard deviation and minimum and maximum scores.

Table 2

Item statistics

	Min.	Max.	Mean	SD
Orientation	0	5	4,72	0,731
Attention	0	10	9,15	2,342

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Immediate Memory	0	5	4,80	0,583
Interference Memory	0	10	9,46	2,040
Recall Memory	0	5	3,50	1,517
Visual Memory	0	5	2,90	1,787
Language: Comprehension	0	5	4,94	0,352
Language: Naming	1	4	3,98	0,197
Language: Repetition	0	1	,92	0,271
Language: Reading	0	1	,97	0,180
Language: Writing	0	1	,84	0,367
Gnosis: Naming	0	6	5,91	0,454
Gnosis: Identification	0	6	5,95	0,400
Praxis: Ideomotor	0	3	2,96	0,235
Praxis: Ideative	0	3	2,96	0,252
Praxis: Oral-lingual-facial	0	3	2,74	0,546
Visuo-motor skills	0	3	2,69	0,781
Prefrontal Tests: grocery list	0	20	17,27	4,569
Luria's Series	0	3	2,02	1,167
Criticism of absurd situations	0	3	2,46	0,944
Clock drawing test	0	10	6,64	3,412

Correlation between each item with the total score of the neuropsychological instrument

The item-total correlations were calculated using Pearson r correlation coefficient. The correlation matrix showed significant correlations for all tasks with the total score of the neuropsychological instrument, with exception for immediate memory which did not show a significant correlation. The remaining correlations were all positive reflecting a positive (direct) contribution to the total score. The strongest correlation was found for the item related to prefrontal functions: grocery list (fluency task: $r = 0,759$; $p < 0,001$), followed by the Clock Drawing Test ($r = 0,719$; $p < 0,001$) and the Luria motor series test ($r = 0,659$; $p < 0,001$). Only the item related to immediate memory was not significantly correlated with the total score (Table 3).

Table 3

Item-total correlations

	Total score
Orientation	0,622**
Attention	0,551**
Immediate Memory	0,046
Interference Memory	0,529**
Recall Memory	0,639**
Visual Memory	0,626**

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Language: Comprehension	0,125**
Language: Naming	0,122**
Language: Repetition	0,240**
Language: Reading	0,338**
Language: Writing	0,475**
Gnosis: Naming	0,173**
Gnosis: Identification	0,116**
Praxis: Ideomotor	0,153**
Praxis: Ideative	0,263**
Praxis: Oral-lingual-facial	0,408**
Visuo-motor skills	0,573**
Prefrontal Tests: grocery list	0,759**
Luria's Series	0,659**
Criticism of absurd situations	0,592**
Clock drawing test	0,719**

** p < 0,01; * p < 0,05

Correlation between each subtest with the total score of the neuropsychological instrument

The correlation indices between each cognitive domains and the total score of the neuropsychological instrument were calculated using Pearson r coefficients. The specific domains assessed using this instrument were Orientation, Attention, Memory, Language, Gnosis/praxis and Pre-frontal functions that were computed according to the sum of the individual scores on each cognitive domain. The total score was computed by the sum of each cognitive domain. This analysis showed strong to moderate positive correlations with the total score (all p's < 0,001), where Pre-frontal subtest revealed the strongest correlation (r = 0,848), followed by Memory (r = 0,674), Language (r = 0,364), Attention (r = 0,282), Gnosis/praxis (r = 0,256), and Orientation (r = 0,255).

External validity of the neuropsychological instrument

The external validity was assessed according to the correlations between the performance in the neuropsychological instrument with psychological constructs as anxiety and depressive symptomatology and quality of life. The associations were conducted using bivariate correlations with Pearson r coefficient. The correlations revealed a significant negative correlation with depression symptoms (r = -0,145; p < 0,001), but anxiety did not correlate with cognitive performance (p > 0.05). As regards to quality of life, the correlations were significant for the domains of quality of life namely for physical (r = 0,155; p < 0,001), psychological (r = 0.180; p < 0.001), environmental (r = 0,144; p < 0,001) and total quality of life (r = 0,178; p < 0,001), but not for the social domain of quality of life (p > 0,05), as shown in Table 6.

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Table 6

Correlations with psychological constructs

	Total score
QoL Physical domain	0,121**
QoL Psychological domain	0,162**
QoL Social domain	0,115*
QoL Environmental domain	0,157**
QoL Total	0,168**
Depression symptoms	-0,145**
Anxiety symptoms	0,003

** p < 0,01; * p < 0,05

Normative data and cut-offs according to age and education

The normative data was calculated according to age and education as these have been considered important confounders of neuropsychological performance. Firstly, the correlations were computed between age and education with total score of the neuropsychological instrument. Secondly, a linear regression was conducted to compute effects sizes for these variables on neuropsychological performance and a table with normative data according to age and education was produced with the scores for 1 SD, 1,5 SD and 2 SD units from the mean for each score.

The bivariate correlations revealed statistically significant associations for both age and education in the expected directions, specifically, age correlated negatively with cognitive performance (r = - 0,338; p < 0,001) and education correlated positively with cognitive performance (r = 0,469; p < 0,001). The effects sizes were determined by a multiple linear regression through Beta coefficients. The regression using the stepwise extraction method revealed that a model including both variables as predictors was significant (F(2, 554) = 80,917; p < 0,001). Both variables were significant predictors: education (t= 8,912; Beta = 0,408; p < 0,001) and age (t= -2,275; Beta = -0,104; p < 0,05). The effect of education was stronger than age but in an opposite direction. Higher education levels were associated with better performance, whereas higher age was associated with worse performance in the neuropsychological instrument. Therefore, the normative data were provided according to these variables in Table 7.

Table 7

Normative data for the neuropsychological instrument according to age and education groups

Schooling	Age groups	Mean	n	SD
W/o basic education	up to 65 years inclusive	0,78	12	0,14
	66 to 80 years inclusive	0,79	26	0,15
	81 years or older	0,76	47	0,13
	Total	0,77	85	0,14

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Basic education	up to 65 years inclusive	0,90	34	0,07
	66 to 80 years inclusive	0,88	108	0,10
	81 years or older	0,81	90	0,12
	Total	0,86	232	0,11
Secondary education	up to 65 years inclusive	0,92	80	0,05
	66 to 80 years inclusive	0,94	37	0,04
	81 years or older	0,84	10	0,13
	Total	0,92	127	0,06
Higher education	up to 65 years inclusive	0,92	66	0,03
	66 to 80 years inclusive	0,94	32	0,05
	81 years or older	0,81	8	0,09
	Total	0,92	106	0,05
Total	up to 65 years inclusive	0,91	192	0,07
	66 to 80 years inclusive	0,89	203	0,10
	81 years or older	0,80	155	0,13
	Total	0,87	550	0,11

The scores obtained from the neuropsychological instrument were multiplied by 100 for better interpretation. Table 8 displays the total scores for 1 SD, 1.5 SD, and 2 SD units below the mean score.

Table 8

Cut-offs from converted total scores

		1 SD	1,5 SD	2 SD
W/o basic education	up to 65 years inclusive	64	57	50
	66 to 80 years inclusive	64	56	49
	81 years or older	63	56	49
	Total	63	56	49
Basic education	up to 65 years inclusive	83	80	77
	66 to 80 years inclusive	78	73	68
	81 years or older	69	63	57
	Total	75	69	64
Secondary education	up to 65 years inclusive	87	84	82
	66 to 80 years inclusive	90	88	85
	81 years or older	72	65	59
	Total	86	83	79
Higher education	up to 65 years inclusive	89	87	86
	66 to 80 years inclusive	89	86	84
	81 years or older	72	68	63
	Total	86	84	81

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Total	up to 65 years inclusive	84	81	77
	66 to 80 years inclusive	78	73	68
	81 years or older	67	61	54
	Total	76	70	65

Age and education effects on neuropsychological functioning

The effects of age and education were analyzed according to a linear regression analysis, where age and education were entered as predictors of neuropsychological performance in the total score of the neuropsychological battery. The linear regression analysis was performed using the stepwise method that revealed that both predictors were included in the model explaining 22% of the variance (Adjusted R2 = 0,224), being statistically significant (F(2, 554) = 80,917; p < 0,001). The effect sizes were the following: Education (Beta = 0,409; t = -8,912; p < 0,001); and Age (Beta = -0,104; t = 2,275; p < 0,05). These results suggest that neuropsychological performance is lower in people with lower levels of education or with higher age.

Relationship between neuropsychological functioning and quality of life

The goal of this analysis was to determine the association between neuropsychological performance in the battery with quality-of-life (QoL) domains as assessed using the Quality of Life Questionnaire (WHOQOL-BREF). This analysis was done using a hierarchical linear regression analysis controlling for age with the criterion variable being the total score of the neuropsychological questionnaire and the predictors the dimensions of WHOQOL-BREF, namely, physical QoL, psychological QoL, social QoL, environmental QoL, and total QoL. Using stepwise extraction, only age and psychological QoL explained neuropsychological performance (Adjusted R2 = 0,237) in a significant model (F (3, 459) = 48,530; p < 0,001). The effect sizes were the following: Education (Beta = 0,360; t = 7,077; p < 0,001); Age (Beta = -0,159; t = -3,099; p < 0,01); and Psychological QoL (Beta = 0,149; t = 3,600; p < 0,001).

Lifestyle impact in cognitive performance controlling for age and education effects

This analysis aimed to investigate whether neuropsychological performance varied based on lifestyle variables related to exercise and sleep habits. The independent variables used in the analysis were coded as dichotomous data, with physical exercise (yes/no) and sleep quality (poor/good) being examined.

The analysis revealed a significant effect of the confounding variables, namely, age (F(1, 152) = 17,603; p < 0,001) and education (F(1, 152) = 11,557; p < 0,001) as well as a significant effect of physical exercise as an independent variable (F(1, 152) = 15,126; p < 0,001), while controlling for age and education effects. However, no significant effects of sleep quality were found in this analysis, and no interaction was found between the dependent variables (p > 0.05). The adjusted R2 of the model was 0.281. The results suggested that participants who reported higher levels of physical activity had better scores on the total neuropsychological instrument score.

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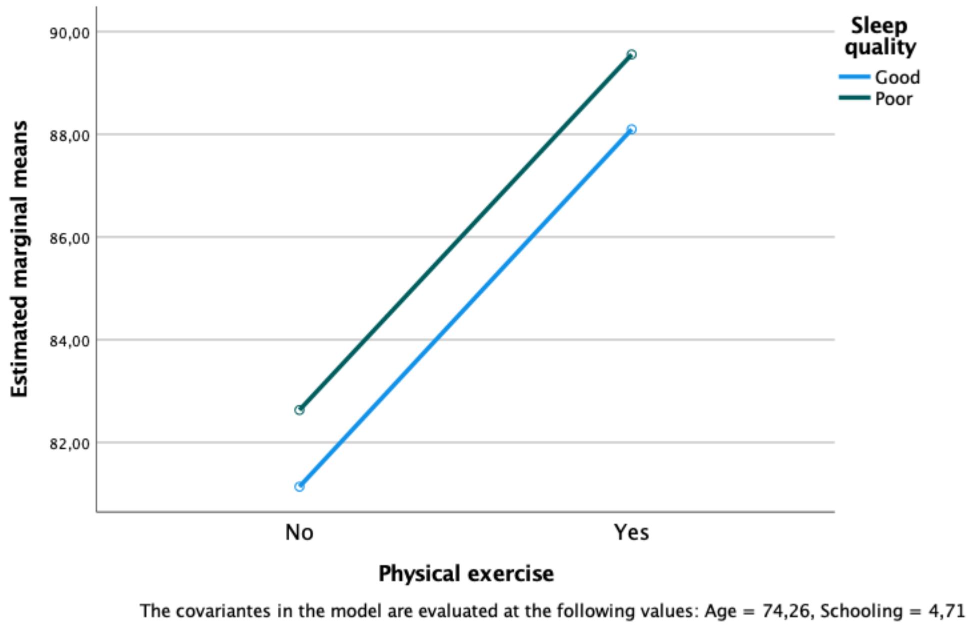
Figure 3

ANCOVA controlling age for describing the effects of physical exercise and sleep quality in the total score of the neuropsychological instrument.



Discussion

The field of neuropsychology heavily relies on robust and validated assessments to evaluate cognitive functioning in different populations. A crucial aspect of developing a neuropsychological battery of tests is the validation process, which involves examining the psychometric properties and reliability of the battery. Therefore, this study aimed to validate a neuropsychological battery of tests designed to assess cognitive abilities in adults. A comprehensive sample of participants was recruited, including individuals with known neurological disorders, healthy controls, and individuals with diverse demographic backgrounds. The battery consisted of a range of tests targeting various cognitive domains, such as attention, memory, executive function, and language.

The results of this study suggested that the neuropsychological battery used in the study was a reliable and valid instrument for assessing neuropsychological performance in the adult population. The data indicated good internal consistency, with a Cronbach's alpha of 0.81. The validity was assessed by examining correlations with constructs related to psychological adjustment. The results showed significant, albeit low, correlations between neuropsychological performance and depressive symptomatology, as well as most domains of quality of life, namely physical, psychological, environmental, and global quality of life. No correlations were found for anxiety and the social domain of quality of life. The procedures also included an analysis of the normative data considering age and education, as these variables are typically considered potential confounders in cognitive tests. The analysis of the normative values revealed that scores varied according to these variables. The linear regression analysis indicated a stronger effect of education than age on neuropsychological performance. These findings align with existing literature suggesting that cognitive functioning tends to decline with age (Shen et al., 2021).

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Another intriguing result was related to the impact of lifestyle on neuropsychological functioning. The results suggested that participants who reported higher levels of physical activity exhibited better scores on the neuropsychological instrument. This finding is consistent with prior studies (e.g., Zaninotto et al., 2018), which reported greater declines in cognitive functioning associated with poor physical function, lack of physical activity, and smoking in an 8-year longitudinal study. It highlights the importance of physical activity as a protective factor for maintaining cognitive function in older individuals (Li & Li, 2022; Lor et al., 2023; Sequeira et al., 2018). However, no significant association was found with sleep. In fact, several studies suggest that sleep patterns change with age, indicating a decrease in sleep quality as age increases (Landry et al., 2015; Madrid-Valero et al., 2017; Mander et al., 2017), and these changes may be linked to impaired cognitive functioning (Casagrande et al., 2022; Dzierzewski et al., 2018).

On the other hand, when impairments in cognitive functioning exist, the quality of life may also be affected due to the aging process (Fardshad et al., 2021; Saputri et al., 2020). Our data suggests a relationship with the quality of life, specifically with the psychological domain, which was the most affected. Cognitive decline with age is associated with poor psychological health, which includes aspects such as self-image, self-esteem, negative thoughts, learning, memory, and concentration (WHOQOL, 1998). This finding aligns with prior research (e.g., Fardshad et al., 2021; Saputri et al., 2020).

However, these results should be interpreted with caution given the study's limitations. One main limitation was that this study did not include a clinical study with older individuals diagnosed with mild cognitive impairment or major cognitive impairment, in order to compare their performance with a group without impairment. This would have allowed for a comparison of performance between the groups and the calculation of the ability of the neuropsychological instrument to differentiate between them, while also providing cut-off scores for these analyses.

Another point relates to the lack of test-retest assessments. The absence of a second assessment for this sample prevented the calculation of test-retest scores, which would have provided information on the instrument's temporal stability. We anticipate that future research will further explore this neuropsychological instrument in greater detail, including investigations into its temporal stability and other psychometric data for this test.

In conclusion, these data suggest that the neuropsychological instrument is a valid and practical measure for assessing neuropsychological functioning. The correlations between neuropsychological performance in this test and physical activity, as well as quality of life, emphasize the importance of these factors in promoting active and healthy aging.

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