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Association between use of internet and the cognitive function in older adults, populational longitudinal study EpiFloripa Idoso

Associação entre o uso de internet e a função cognitiva de idosos, estudo longitudinal populacional Epifloripa Idoso

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ABSTRACT: *Objective:* To estimate the association between the internet and the gain or loss cognite along of four years in older adults. Methods: Longitudinal study, a population-based, with older adults residents in a capital of southern Brazil (≥ 60 years) surveyed in 2009-10 (*baseline*) and in 2013-14 (follow-up). The outcome was assessed by clinically significant gain or loss of four or more points in the score of the Mini Mental State Examination between the two interviews. The use of internet was measured longitudinally (maintained or not internet usage, stop use of internet, started using the internet, retained the use of internet). Odds Ratios (OR) were estimated adjusted for sex, age, household income, education level and cognitive screening at *baseline*. *Results:* Respondents were 1.705 older adults in 2009-10 and 1.197 in 2013-14. There was a significant association between keep using internet and cognitive performance, with greater chance of cognitive gain (OR = 3.3; 95%CI 1.1 – 9.8) and lower cognitive impairment (OR = 0.39; 95%CI 0.17 – 0.88) for older adults who kept using the internet. *Conclusion:* Older adults who continue using the internet were more likely to gain significant cognitive and lower cognitive loss. To promote the internet use in older adults can help a strategy for cognitive stimulation in older adults.

Keywords: Computers. Cognition. Aged.

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RESUMO: *Objetivo:* Estimar a associação entre o uso de internet e o ganho/perda cognitivo ao longo de quatro anos em idosos. *Método:* Estudo longitudinal, de base populacional, com idosos residentes em uma capital do sul do Brasil (≥ 60 anos), entrevistados em 2009-2010 (*baseline*) e em 2013-2014 (seguimento). O desfecho foi avaliado pelo ganho/perda clinicamente significativo de quatro pontos ou mais no escore do mini exame do estado mental (MEEM) entre as duas entrevistas. O uso de internet foi avaliado de forma longitudinal (manteve o não uso de internet; deixou de usar; passou a usar; manteve o uso). Foram estimadas razões de chances (OR) ajustadas por sexo, idade, renda familiar, escolaridade e rastreamento de déficit cognitivo no *baseline*. *Resultados:* Entrevistaram-se 1.705 idosos em 2009-2010 e 1.197 em 2013-2014. Houve associação significativa entre manter-se usando internet e o desempenho cognitivo, com chance maior de ganho cognitivo (OR = 3,3; IC95% 1,1 – 9,8) e menor de perda cognitiva (OR = 0,39; IC95% 0,17 – 0,88) para os idosos que se mantiveram usando a internet. *Conclusão:* Idosos que se mantiveram utilizando a internet tiveram chance significativamente maior de apresentar ganho cognitivo e menor de apresentar declínio cognitivo. Promover o uso da internet em idosos pode ser uma estratégia para estimular a função cognitiva nessa população.

Palavras-chave: Computadores. Cognição. Idosos.

INTRODUCTION

Individuals aged 60 years or older have a higher risk of cognitive decline due to the greater exposure to risk factors[1,2] and impairment in mechanisms of perception, reasoning, memory[1,3], praxia, language, attention[4], and learning[5].

Cognitive decline can significantly impair memory, learning, language, orientation, executive functions, speed of information processing, autonomy, and functional independence, affecting the quality of life and health in this population[5], in addition to being an important risk factor for disability, dementia, and death[6].

In this perspective, cognitive interventions are being studied and encouraged. They are considered important for prevention, health and quality of life promotion, and independence of older adults with cognitive problems[7]. Consistent evidence in controlled and randomized clinical trials, through meta-analyses and systematic reviews, demonstrates that several forms of cognitively stimulating activities delay cognitive decline[4,8-10].

Among the many kinds of cognitive maintenance, stimulation, and rehabilitation, the use of computers – through the Internet – is one of the most effective and considered a good alternative therapy in groups of older adults[1,11,12]. A systematic review by Diamond and Ling[4], which analyzed 84 studies to assess different types of cognitive rehabilitation programs, demonstrated that the use of computers improves creativity, cognitive flexibility, attention, performance of tasks, and other cognitive abilities. Internet use is a modifiable behavior that has proved to be effective in protecting cognitive function[12].

Use of computers also seems to influence the prevention of dementia[8-10] and the decrease in physical, mental, and socioeconomic limitations associated with aging, improving the

practice of citizenship, health, education, work, leisure, and socialization[13,14], and reducing the number of diseases. Consequently, it provides more autonomy and quality of life[11,12,15], in addition to lowering the risk of impairment in activities of daily living[16].

Therefore, it is important to promote and encourage preventive public policies focused on known risk factors and cognitive stimulation programs, which seem to have the power of mitigating cognitive decline and its consequences[11]. Some studies suggest that Internet use reduces the risk of cognitive decline and dementia, but none has a representative and longitudinal sample of a city. Thus, this study aims to estimate the association between Internet use and cognitive gain/loss among older adults over four years.

METHOD

TYPE OF STUDY

This is a longitudinal household-based population study, originated from the project "Health Conditions of Older Adults from Florianópolis," called EpiFloripa Idoso (www.epifloripa.ufsc.br).

POPULATION AND SAMPLE

The research was conducted with older adults aged 60 years or older living in the urban area of Florianópolis, Santa Catarina (SC). The baseline data collection occurred from September 2009 to June 2010, and the follow-up, from November 2013 to November 2014.

The software Epi Info (version 6.04) determined the baseline sample size, based on the calculation of prevalence according to the following parameters: population size (44,460 inhabitants older than 60 years), confidence interval (95%CI), unknown prevalence of phenomenon (50%), sampling error (4 percentage points), and sample design effect (estimated at 2 percent), with an increase of 20% for estimated losses and 15% for association studies, resulting in a minimum sample of 1,599 individuals. Due to the design effect and available funding, the sample was expanded to 1,911 older adults.

The baseline sample selection was clustered in two stages. The units of the first stage were the 420 urban census tracts of Florianópolis stratified by increasing income, with 80 of them being systematically selected (8 tracts for each income decile). The units of the second stage were the households, which ranged from 61 to 725 per tract. Small tracts were grouped according to geographical location and corresponding income decile, and vast tracts, divided, to reduce the coefficient of variation from 52.7% (n = 80 tracts) to 35.2%

(n = 83 tracts). According to the 2000 Census, the mean number of residents per household in Florianópolis was 3.1, and the age group of interest represented approximately 11% of the population. Therefore, the mean number of older adults per census tract was one for every three households. Sixty systematically selected household visits were estimated per sector. The 83 census tracts comprised a total of 22,846 households. In this scenario, the study considered 1,911 older adults eligible, excluding institutionalized individuals (nursing homes, hospitals, prisons). Thus, the final sample consisted of 1,705 older adults interviewed (response rate of 89.1%).

In the follow-up of the study (2013-2014), the number of eligible older adults resulted from the identification of deaths and subsequent attempt to update addresses. Some personal information of the subjects (name, mother's name, and date of birth) was used to check the Mortality Information System (*Sistema de Informações sobre Mortalidade* – SIM) database of the Ministry of Health, according to place of residence (Santa Catarina), for the years 2009, 2010, 2011, 2012, and 2013. Based on the information collected, the older adults with a full address received a letter informing them about the new stage of the research. Next, they were contacted by phone to update their registry data. When communication was not possible, the team tried to update the information through the InfoSaúde System (Health System of Florianópolis/SC), social networks, phone book, and contact with neighbors, relatives, and friends. The study also excluded two older adults unintentionally registered twice in the database and another with incompatible age (individual younger than 60 years of age, mistakenly interviewed at baseline).

In both moments, losses corresponded to older adults not found after four visits in different periods and refusals in person after a visit to the household and attempt to interview. At follow-up, individuals who moved from town or were hospitalized were also considered losses. Therefore, 1,197 older adults were interviewed with longitudinal information collected in the period between 2009–2010 and 2013–2014.

INSTRUMENTS AND DATA COLLECTION

Data were collected through a face-to-face interview conducted by previously trained interviewers with the aid of personal digital assistants (baseline) and netbooks (follow-up). Standardized questionnaires preferably used instruments validated and tested in pilot studies, which were applied to 99 individuals at baseline and 76 at follow-up. The baseline administered 276 questions and the follow-up, 655. Data consistency was verified weekly, and quality control was performed by a reduced phone survey with approximately 10% of randomly selected interviewees. The reproducibility of the questions presented acceptable to good agreement (baseline – Kappa between 0.6 and 0.9; and follow-up – Kappa between 0.5 and 0.9). Studies by Confortin et al.[17] and d'Orsi et al.[18] have more information about data collection and instruments used at baseline and follow-up.

STUDY VARIABLES

The outcome was the cognitive deficit screening assessed longitudinally by the gain/loss of four or more points in the mini-mental state examination (MMSE) score between the two interviews. Cognitive improvement or decline of four points is considered clinically significant, as it represents a gain or loss of at least 20% in cognitive function[19]. MMSE is a cognitive assessment scale that ranges from 0 to 30 points[20].

The independent variables were: gender (female, male); age (complete years); per capita household income in Brazilian reais (R$) at the time of interview; schooling (years of schooling); Internet use after four years, assessed in a longitudinal way (continued not using the Internet; stopped using the Internet; started using the Internet; continued using the Internet); and cognitive decline at baseline – those who reached values lower than 19/20 (without schooling) and 23/24 points (with formal education)[21].

DATA ANALYSIS

Interviews were downloaded from personal digital assistants (baseline) and netbooks (follow-up) in csv format, and later, data were transferred to the statistical package STATA 11.0 (Stata Corporation, College Station, United States), allowing the information to be exported directly to the construction of the database, eliminating the work of typing and, therefore, reducing possible errors that occur at this stage.

All analyses in this study considered the design effect and sample weights. First, we tested the normality of the data. To characterize the study sample and outcome prevalence, we conducted descriptive statistics with absolute and relative frequencies for qualitative variables, and measure of central tendency and dispersion for quantitative ones. Dependent variables were expressed as mean with the respective 95%CI.

To estimate the association between longitudinal Internet use and cognitive function of the older adults interviewed, we used logistic regression, presenting the results in crude and adjusted (for gender, age, schooling, income, and cognitive decline at baseline) odds ratios (OR) and their respective 95%CI. The level of statistical significance for association was set at 5% ($p < 0.05$).

The outcome "gained four or more points in the MMSE score between the two interviews" excluded older adults who reached a score higher than 26 points in the 2009–2010 MMSE, as they would not be able to gain these points in the longitudinal study period (n = 560). Similarly, the outcome "lost four or more points in the MMSE score between the two interviews" excluded from the study older adults with a score lower than 4 points (n = 1,171).

ETHICAL ASPECTS

The research project of the investigation complied with ethical principles, according to Resolution No. 466 of 2012 of the National Health Council. The Human Research Ethics

Committee (HREC) of UFSC approved the baseline under protocol No. 352/2008, and the follow-up under No. 596,126. All participants signed the Informed Consent Form. They were also asked for post-informed consent for access to data previously collected by EpiFloripa Idoso 2009–2010.

RESULTS

At baseline, 1,705 older adults were interviewed (response proportion of 89.1%), of whom 217 died, 111 were not found, 48 were considered losses, and 129 refused to participate in the study again, totaling 1,197 individuals interviewed at follow-up (response proportion of 70.2%).

Table 1 shows that most older adults interviewed did not present clinically significant cognitive gain or loss, 7.3% (95%CI 5.8 – 8.8) gained 4 points in the MMSE and 13.9% (95%CI 11.9 – 15.9) lost 4 points, in addition to continuing not using the Internet, that is, they did not use the Internet in 2009–2010 and this behavior persisted in 2013–2014 (70.2%; 95%CI 67.6 – 72.8).

The final adjusted model (Table 2) demonstrated a statistically significant association between Internet use and clinically significant cognitive gain, with chances of cognitive improvement being 3.32 times higher for older adults who continued using the Internet (OR = 3.32; 95%CI 1.13 – 9.76) compared to those who have never used it. In addition, clinically significant cognitive gain was also associated with cognitive deficit at baseline, as older adults with potential cognitive deficit had 77% less chance of reaching significant cognitive improvement (OR = 0.23; 95%CI 0.13 – 0.41) when compared to their peers (Table 2).

The final adjusted model of the variable "lost four or more points in the MMSE" indicated a statistically significant association between Internet use and the outcome, with chances of cognitive decline being 68% lower for older adults who started using the Internet (OR = 0.32; 95%CI 0.11 – 0.95) and 61% lower for those who continued using the Internet (OR = 0.39; 95%CI 0.17 – 0.88) when compared to individuals who had never used it. We also found an association between the outcome and increasing age (OR = 1.10; 95%CI 1.07 – 1.13), lower schooling (OR = 0.90; 95%CI 0.86 – 0.95), and potential cognitive deficit assessed at baseline (OR = 3.69; 95%CI 2.25 – 6.04) in relation to decreasing age, higher schooling, and not having cognitive deficit at baseline (Table 3).

DISCUSSION

This study showed that most older adults interviewed did not present clinically significant cognitive gain or loss. It is known that advancing age leads to greater exposure to risk factors for cognitive problems, especially subjective memory complaints[1,2,22], which

Table 1. Descriptive analysis of cognitive gain/loss and changes in Internet use among older adults who participated in the longitudinal household study EpiFloripa Idoso. Florianópolis/SC, Brazil, 2009–2010 to 2013–2014.

Qualitative variables	N	% (95%CI)
Gained 4 MMSE points	86	7.3 (5.8 – 8.8)
Lost 4 MMSE points	164	13.9 (11.9 – 15.9)
Internet use		
Continued not using the Internet	839	70.2 (67.6 – 72.8)
Stopped using the Internet	38	3.2 (2.2 – 4.2)
Started using the Internet	90	7.5 (6.0 – 9.0)
Continued using the Internet	228	19.1 (16.8 – 21.3)

95%CI: confidence interval of 95%; MMSE: mini-mental state examination.

Table 2. Crude and adjusted analyses of the association between Internet use and clinically significant cognitive gain among older adults who participated in the longitudinal household study EpiFloripa Idoso. Florianópolis, Santa Catarina, Brazil, 2014.

Variables	Gained 4 MMSE points % (95%CI)	Crude analysis		Adjusted analysis	
		OR (95%CI)	p-value	OR (95%CI)	p-value
Gender			0.549		0.633
Female	7.1 (4.6 – 9.6)	1		1	
Male	6.0 (2.6 – 9.4)	0.84 (0.47 – 1.48)		0.88 (0.51 – 1.05)	
Age	-	1.03 (0.99 – 1.06)	0.053	1.01 (0.98 – 1.04)	0.545
Household income	-	0.99 (0.99 – 0.99)	< 0.001	1.00 (1.00 – 1.00)	0.201
Schooling	-	0.91 (0.85 – 0.97)	0.003	1.04 (0.98 – 1.12)	0.190
Cognitive Deficit at Baseline			< 0.001		< 0.001
No	2.6 (1.1 – 4.1)	1		1	
Potential	23.3 (16.4 – 4.1)	11.29 (5.89 – 21.61)		0.23 (0.13 – 0.41)	
Internet use			0.202		0.029
Continued not using	7.4 (4.7 – 10.1)	1		1	
Stopped using	8.2 (-0.7 – 17.1)	1.11 (0.38 – 3.24)		1.94 (0.49 – 7.62)	
Started using	4.9 (-0.3 – 10.2)	0.64 (0.19 – 2.13)		1.33 (0.44 – 4.02)	
Continued using	4.9 (1.1 – 8.7)	0.65 (0.30 – 1.41)		3.32 (1.13 – 9.76)	

MMSE: mini-mental state examination; OR: odds ratio; 95%CI: confidence interval of 95%.

correspond to the early stage of these problems and do not yet impair cognitive losses as much[23]. Cognitive impairment and dementia have lower prevalence rates when compared to memory complaints[23], and, in Brazil, projections indicate a prevalence of dementia in the population aged 65 years or older around 8%[24].

In addition, we found that most older adults continued not using the Internet, that is, they did not use the Internet in 2009–2010 and this behavior persisted in 2013–2014. Despite Internet being considered fundamental in modern life and used by millions of people[25], older adults are the ones who least use this technology[26]. A research conducted in 2014 showed that 81% of Brazilian older adults did not use the Internet[27], a fact that is mainly due to the high cost of equipment to access the Internet and of its connectivity, lack of access points, data security, and knowledge about the use, among many other factors, causing the process of digital exclusion[28]. Another factor that favors the exclusion is that older adults were raised in the last century when the Internet and other technological tools did not exist, which inhibits this behavior[26].

Table 3. Crude and adjusted analyses of the association between Internet use and clinically significant cognitive loss among older adults who participated in the longitudinal household study EpiFloripa Idoso. Florianópolis, Santa Catarina, Brazil, 2014.

Variables	Lost 4 MMSE points % (95%CI)	Crude analysis		Adjusted analysis	
		OR (95%CI)	p-value	OR (95%CI)	p-value
Gender			0.366		0.565
Female	14.5 (11.5 – 17.4)	1		1	
Male	12.1 (7.3 – 17.0)	0.82 (0.52 – 1.27)		1.12 (0.77 – 1.63)	
Age	--	1.11 (1.08 – 1.14)	< 0.001	1.10 (1.07 – 1.13)	< 0.001
Household income	--	0.99 (0.99 – 1.00)	0.997	1.00 (1.00 – 1.00)	0.103
Schooling	--	1.00 (0.99 – 1.00)	0.476	0.90 (0.86 – 0.95)	< 0.001
Cognitive Deficit at Baseline			0.476		< 0.001
No	14.1 (10.7 – 17.6)	1		1	
Potential	11.8 (6.6 – 17.0)	0.81 (0.45 – 1.45)		3.69 (2.25 – 6.04)	
Internet use			< 0.001		0.024
Continued not using	17.6 (13.9 – 21.3)	1		1	
Stopped using	13.6 (0.5 – 26.6)	0.74 (0.46 – 0.72)		1.14 (0.39 – 3.32)	
Started using	6.2 (-0.2 – 12.6)	0.31 (0.10 – 0.96)		0.32 (0.11 – 0.95)	
Continued using	3.9 (1.4 – 6.4)	0.19 (0.09 – 0.39)		0.39 (0.17 – 0.88)	

MMSE: mini-mental state examination; OR: odds ratio; 95%CI: confidence interval of 95%.

The present study found an association between Internet use by older adults and higher chance of clinically significant cognitive improvement in the MMSE (3.32 times higher for those who continued using the Internet) and lower chance of clinically significant cognitive decline (68% lower for the ones who started using the Internet and 61% lower for those who continued using the Internet) when compared to non-users.

Many studies revealed that Internet use can be a cognitively stimulating activity and that the non-use is a risk factor for mild cognitive disorders and dementia[1,4,8-12].

The longitudinal population study (8-year follow-up) by Xavier et al.[6] assessed 6,442 people (aged 50–89 years) and indicated stabilization and/or delay in cognitive decline resulting from daily Internet use, both in middle-aged and older adult individuals, especially those with lower cognitive ability.

Internet use is considered an appropriate form of cognitive stimulation because it can reduce socioeconomic limitations, increase socialization with other people and with modern society[29], and improve executive functions, perception mechanisms, reasoning and memory[1], praxia, language, and attention, in addition to assisting in learning[4]. Consequently, improved cognitive performance can decrease the number of diseases and provide a better quality of life[11,12,15].

In the present study, another factor associated with the gain or loss of at least four points in the MMSE score was the potential cognitive deficit diagnosed at baseline. Older adults with potential cognitive deficit had less chance of significant cognitive gain and more chance of cognitive loss when compared to those who did not have this characteristic. This result is probably due to these individuals being at a later stage of neurodegeneration[30].

Increasing age and lower schooling were associated with a clinically significant cognitive loss in relation to decreasing age and higher schooling. People aged 60 years or older have a higher prevalence of and are more exposed to risk factors for cognitive decline[1,2,22,23] due to problems related to human aging that cause metabolic, morphological, and neurophysiological changes in the brain[5]. Among these changes, we can mention: retraction of the cell body of large neurons; relative increase in the population of small neurons; cortical thinning; neuronal atrophy[31] and loss of synapses; decrease in N-methyl-D-aspartate receptor responses; and alterations in calcium homeostasis, predominantly in areas essential to cognitive function[5]. These changes can lead to difficulties in learning, memory, language, orientation, praxia, attention, and executive functions[1,2].

Low schooling stimulates cognitive impairment[32,33]. People with low schooling usually have learning difficulties and worse cognitive performance when compared to those with a higher level of education[34]. Besides, they often have lower income, social disadvantage that increases the risk of functional loss, dependency, worse quality of life, less access to healthcare services, and, consequently, higher cognitive decline and mortality[33,35].

Among the main limitations of the study, we highlight the selection bias, given the lack of evaluation of hospitalized older adults, who possibly are in worse health conditions, and the survival bias, which might have reduced the proportion of individuals with greater cognitive problems. We also emphasize the recall bias, as older adults might not remember some information. In addition, the cognitive screening instrument used in this study is not the most sensitive for this purpose.

Among the positive points of this research, we underline the type of study (population-based cohort), the design and sample calculation (a probabilistic sample considering the increase of 20% for losses), and the low proportion of selective loss of follow-up (less than 10%).

We suggest the development of randomized intervention studies to better evidence the relationship between Internet use and cognitive function in older adults, given the great power of this kind of research.

CONCLUSION

This research showed that most older adults did not use the Internet in 2009–2010 and continued to display this behavior in 2013–2014, indicating the digital exclusion of this population.

The study also found that individuals who continued using the Internet had a higher chance of cognitive improvement and a lower chance of cognitive decline compared to those who did not use this technology. Also, cognitive loss was associated with increasing age, lower schooling, and potential cognitive deficit assessed at baseline (OR = 3.69; 95%CI 2.25 – 6.04) in relation to decreasing age, higher schooling, and not having cognitive deficit at baseline.

These findings show relationships already evidenced in the literature; however, they emphasize the importance of the association between Internet use and better cognitive performance among older adults. In this regard, encouraging policies that promote digital inclusion of older adults through Internet use can help to improve or preserve cognitive function in this population, directly impacting the decrease in diseases related to cognitive impairment, resulting in better health and quality of life.

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