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Job demands may determine cognitive and physical aging after retirement

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Abstract

During adulthood, we spend most of our time and **effort** at work, **but** the impact of employment **on aging** is poorly explored. Our study addressed how job demands can affect **aging** after retirement. **We developed** a descriptive observational study carried out in 367 older adults with a mean age of 73.9 years (66.5% women and 33.5% men), measuring cognition and functional status. **According to our** results, older adults who had high mental demands in their jobs **showed** better scores in cognition**, but** they **showed** poor functional development of **the** basic and instrumental activities of daily life ($p<0.05$). In contrast, **adults whose work included** high physical demands, **showed** lower scores in cognition and lower functional performance in instrumental activities ($p<0.05$). Work activities **thus appear to** contribute to cognitive and physical decline after retirement. Healthy aging should **thus** include interventions that consider **influence of employment characteristics** on age impairment.

Keywords: Cognitive impairment; Aging; Job occupation; Mini-mental state examination, MMSE; Functional impairment

What this paper adds:

- Job demands **influence aging** process after retirement

- High cognitive job demands tend to preserve cognition during aging, **but could** have a negative impact on functional performance

- High physical job demands seem to worsen cognition and performance in instrumental activities during aging

Applications of study findings:

- Work **experience** contributes to cognitive and physical decline after retirement

- Healthy aging interventions should consider the influence **of job demands**

- Work activities must be supplemented to ensure a successful aging

Introduction

According to estimates of intense demographic change will reach 129.8 million adults over 65 years **by 2050**, increasing **the** dependency level more than 50 % with important economic, health and social consequences (Eurostat, 2020). **Correlated** with this increase in life expectancy, the prevalence of cognitive impairment is also **intensifying**. Preservation of cognitive and physical health has become a growing concern among older adults (Finkel et al., 2009). **The** scientific community **has engaged in significant efforts to** identify factors that could help to maintain cognitive (Meng et al., 2017) and functional status (Jekel et al., 2015), **to promote** a healthy aging (São José et al., 2017), and greater longevity (Ekerdt et al., 2017). It is proven that cognitive function declines with age. However, **various** cognitive skills in older adults **seem** to be related to success in the workplace and in everyday life (Hughes et al., 2018).

Chronic diseases and multimorbidity are increasing health challenges for t**he** **aging** population (Calvo et al., 2022). Managerial positions and the exhaustion **among** emergency teams affect mental and physical health, with an increase of some chronic pathologies (Salvagioni et al., 2017). **Some** studies have **thus** shown that up to 75% of workers with stressful jobs also **suffer** from at least one chronic illness, which reveals a strong association between stress and other important health problems (Botha et al., 2015).

Retirement could be associated with greater cognitive decline due to **the** disconnection from highly challenging activities (Hamm et al., 2020). Workplace-related mental demands (WPMDs) are considered protective factors **for** cognitive health in old age and are related to **dementia prevention** (Hussenoeder et al., 2019). Complex environments, characterized by convoluted occupational demands, can preserve cognitive function and could be one of the many factors that explain individual differences in cognitive performance in seniority (Smart et al., 2014). **Several studies have investigated a variety of WPMDs, including complex data, management of people, or objects, intellectual demands, or job control in relation to cognitive function** (Hussenoeder et al., 2019). High job complexity has been related to better executive functioning and general cognition during **the** working life and slower decline after retirement (Vélez-Coto et al., 2021). Older adults **who** retired from jobs with WPMDs can maintain their cognitive advantage over those with **lower** cognitive demands (Carr et al., 2020). **The concept of cognitive reserves explains how an intellectually stimulating job carries a cognitive advantage during retirement, because early intellectual stimulation by occupational cognitive demands drives a lower risk of cognitive problems later on** (Pool et al., 2016). **The** "use it or lose it" hypothesis proposes that cognitive functioning deteriorates when we are not **being** challenged or mentally stimulated, as frequently occurs after retirement (Meng et al., 2017). Therefore, mental stimulation through processing novel information at work could cushion cognitive deterioration afterwards (Staudinger et al., 2020). Similarly, educational level also influences cognitive function in old age (Lövdén et al., 2020) and may have a critical role as a prerequisite for achieving a job with WPMDs (Finkel et al., 2009).

Apart from WPMDs, physical demands during **working** life also influence how we age. High physical work demands in older adults have been linked to long-term sickness absence (Andersen et al., 2021) and constitute a well-documented risk factor for poor health (Andersen et al., 2016). Cumulative occupational mechanical exposures during working life, **increase** the risk of disability (Sundstrup et al., 2017); it has been shown that interventions in the workplace would reduce the cumulative duration of sickness absence (van Vilsteren et al., 2015). **Job characteristics may be associated with the course of cognitive functioning (Fisher et al., 2014). In fact, older workers with more physically demanding jobs tend to have poorer cognitive function after retirement (Choi et al., 2022).**

Although most people spend a substantial part of their lives at work, our understanding of the relationship between occupational activities and cognition is limited, and the impact of retirement on cognitive abilities and physical skills during aging **has received scant exploration**. **Our study therefore analyzed** aging in older adults who had different cognitive and physical job demands prior to retirement.

Materials and Methods

Participants

An observational descriptive study was carried out in a primary care **center** in Spain. The sample size has been calculated with **a confidence level of** 95% to estimate the mean of the Spanish version of the Mini-Mental State Examination (MEC-35) in the population, considering a deviation of 3 points and allowing an error of approximately 0.3. **A total of** 367 participants, with a mean age of 73.9±6.0 years (66.5% women and 33.5% men), were included in the study. The inclusion criteria were being over 64 years old and retired, and scoring between 24 and 35 points **on the** MEC-35 (Lobo et al., 1999). The exclusion criteria were being institutionalized, suffering neurological diseases, or have received cognitive stimulation in the last year. The participants were recruited from a primary care **center**, where they received the usual medical and nursing care. Participants were recruited by referrals from family doctors (who previously received an informative clinical session about the study) and from informative posters placed on the doors of all medical consultations.

Ethical Considerations

The study was approved by the Ethics Committee **for** Clinical Research from our government. Personal data protection rules were kept. All participants were informed of the objectives of the study and signed the informed consent. Deontological norms recognized by the Declaration of Helsinki and the norms of good clinical practice were followed.

Assessments

Sociodemographic variables **were record through an interview; these included** sex**;** age**;** (as a numerical variable, asking the exact age, and then we established two groups)**;** educational level (Primary/High level)**;** marital status (single, married, widowed, separated)**;** and cognitive and physical job demands (low, medium, and high based on Grotz criteria and according to American Occupational Therapy **Association**) (Grotz et al., 2018). Cardiovascular conditions such as high blood pressure, diabetes, hypercholesterolemia, obesity, or cerebrovascular accident were also collected by self-**report**.

Evaluation of global cognition and the different cognitive domains **was** carried out using MEC-35, one of the most **widely** used cognitive tests for the study of cognitive abilities in primary care. It evaluates eight items: temporo-spatial orientation (10 points), fixation memory (3 points), attention (3 points), calculation (5 points), short-term memory (3 points), **and** language and praxis (11 points). Its sensitivity is 85**%**–90% and its specificity is 69% (Lobo et al., 1979). Cognitive classification is based on scores: 30–35 points for normal cognition; 25–29 points for cognitive deficits; 20–24 points for mild cognitive impairment; 15–19 points for moderate cognitive impairment; **and** ≤14 points for severe cognitive impairment (Lobo et al., 1999).

Verbal fluency was measured by **the set**-test. This test has been proposed as a diagnostic tool in older patients with dementia, with a cut-off of 27 points, with a lower score indicating dementia. **The set**-test has a documented sensitivity of 79% and specificity of 82% (Pascual et al., 1990). The test **analyzes** verbal fluency in four different categories: **colors**, animals, fruits, and cities; and the scores **range from** 0 **to** 40.

To determine the relationship between physical occupation and activities of daily living (ADLs), **the** Barthel Index (Bernabeu-Wittel et al., 2019) and Lawton and Brody scale (Pfeffer et al., 1982) **were used** as functional assessments. Independence in ten basic ADLs was evaluated by **the** Barthel Index. The maximum score is 100 points, and scores over 60 indicate mild dependence. The test's sensitivity ranges between 76% (in the item "ambulation + stairs") and 99.8% (in the item "feeding") and its specificity is between 46% (in the item "defecation") and 97% (in the item "ambulation + stairs") in scores ≥ 90 points for fragility screening (Bernabeu-Wittel et al., 2019). Autonomy in eight instrumental activities of daily living (IADLs) necessary to live independently was assessed by Lawton and Brody scale. Scores range from 0 (dependent) to 8 (independent).

The scale's sensitivity is 57%, **with a specificity of** 82% when an informant observes dependence in three activities (Pfeffer et al., 1982).

The evaluation process was carried out by occupational therapists, after receiving a month-**long** training, to guarantee the homogeneous evaluation.

Statistical analysis

Statistical analysis was performed with the IBM SPSS Statistics v.25 package (SPSS Inc., Chicago, IL, USA). The normality of the variables was verified through the Kolmogorov-Smirnov test. Descriptive statistics are shown according to the nature of each variable: mean (m) and standard deviation (**SD**) or by the number of participants per category (n) and the proportion of participants over the total (%). For the analysis of cognitive characteristics by age and by cardiovascular conditions, the non-parametric Mann-Whitney U test was used, and the **Kruskal-Wall H** was used to measure cognitive characteristics according to cognitive and physical job demands. A significance level of 5% was used. **Mann-Whitney post hoc Bonferroni correction for multiple comparisons was used to examine differences between the cognitive demands and physical demands groups. The significance level used for post hoc analyses was 0.0167 (0.05/3 paired comparisons).**

Results

Socio-demographic characteristics of the participants

A total of 244 women and 123 men participated in the study (Table 1). Half of them (53.7%) corresponded to the **64-75** years group and 46.3% **were** over 75 years old; most participants were married. Physical job demands were low in 20.2% of the participants, medium in 43.6% and high in 36.2%. Cognitive job demand was low **for** 59.1% of the participants, medium **for** 35.1%, and high **for** 5.7%. Regarding cardiovascular conditions, participants **suffered** high blood pressure (48.8%), hypercholesterolemia (37.9%), diabetes (14.2%), obesity (13.6%), and cerebrovascular accident (6.5%). **Significant** differences in marital status (p = 0.001), hypercholesterolemia (p = 0.008) and obesity (p = 0.002) were found between age groups.

Cognitive and physical assessments

The comparative analysis of global cognition by age group showed that the group aged 64 to 75 years had MEC-35 scores significantly higher than other groups (p=0.008) (Table 2). Analyzing the different cognitive domains of **the** MEC-35, **differences were observed for** temporal orientation (p = 0.002), spatial orientation (p = 0.007), and short-term memory (p = 0.001) that were statistically **significantly** in favor of the group of aged 64-75 years. Verbal fluency measured by **the set**-test was significantly higher in the group aged 64-75 years (p <0.001). **In the analysis of the functional level by age, the group aged 64-75 years presented higher scores for both ADLs (p = 0.001) and IADLs (p <0.001).**

Analyzing cognitive and functional characteristics by level of cognitive demands, global cognition **scores were** significantly higher for older adults with high cognitive job demands (p <0.001) (Figure 1). By cognitive **domain**, temporal orientation ($p = 0.034$), attention ($p < 0.001$), calculation ($p = 0.003$), and language ($p < 0.001$) scores were significantly affected by different cognitive job demands. **Older adults with low cognitive job demand had lower scores in attention, calculation, and language compared to those with medium and high cognitive job demands ($p = 0.0167$) (Table 2).** At a functional level, older adults with low and medium cognitive demands presented better functional performance in both ADLs ($p = 0.026$) and IADLs ($p < 0.001$). **Older adults with low physical job demand presented higher scores in temporal orientation, calculations, and short-term memory compared to those with medium and high physical job demands ($p = 0.0167$).**

According to physical occupation, participants with high physical job demands had lower scores on the MEC-35 ($p = 0.001$) and in temporal orientation ($p = 0.01$), calculation ($p = 0.014$) and language ($p = 0.049$) domains (Figure 1). Similarly, high physical job demands were correlated with lower verbal fluency in **the set**-test ($p = 0.004$) and lower functional performance in IADLs ($p = 0.005$).

Evaluation of cardiovascular conditions

Cardiovascular conditions could influence aging. Two positive association were obtained between hypertension and spatial orientation ($p = 0.028$), and between hypercholesterolemia and verbal fluency ($p = 0.047$) (Table 3). On the other hand, a negative association was observed between obesity and fixation memory ($p = 0.012$). At the functional level, diabetes was negatively related to ADLs performance (p = 0.040) and cerebrovascular accident with both ADLs (p = 0.032) and IADLs (p = 0.029) performance.

Discussion

Retirement is a key decision that may affect later life. Ending professional activity in the beginning of late adulthood may cause a deeper decline of cognitive functions, poorer adaptive adjustment to the aging process, and higher dissatisfaction (Sarabia-Cobo et al., 2020). Here, we **considered** how cognitive and physical demands during **the employment** period may determine aging after retirement. **The** cognitive and functional profiles of older adults by age group and physical and mental job demands were analyzed.

Our results **showed** that global cognition decreases with age, especially **in** cognitive domains **such** as temporal-spatial orientation, short**-term** memory, and verbal fluency. These results are in line with the **concept of** cognitive reserve, as the group aged 64-75 years **was closer to their time of employment** than the group over 75 years. In **line with this**, several studies have described decreased performance in delayed recall and in temporal and spatial orientation, which predicted the presence of cognitive impairment **two** years later (Ercoli et al., 2003). Moreover, significant deficits in temporal and spatial orientation tasks (Ariel &Moffat, 2018; Zivony et al., 2020) have also been **shown** in older adults, which do not occur in younger adults (Davranche et al., 2011). Conversely, some studies did not observe differences by age in temporal (Chauvin et al., 2016) or spatial orientation (Muffato et al., 2020). It has been suggested that temporal orientation could be preserved in healthy aging **via** compensatory mechanisms

(Chauvin et al., 2016). Similarly, several studies have also described a differential effect **of** age in short-term memory, which would affect coding and recall more than information storage (Muffato et al., 2020). Some older adults have also been shown to retain their ability to improve memory performance through attention and the external environmental context; therefore, strategies **that focus on harnessing** these preserved abilities could help maintain short-term memory performance during aging (Mitchell & Cusack, 2018).

Decrease in verbal fluency with age has also been identified by González-Burgos et al. (2019), **who showed** that other cognitive functions, **such** as executive functions, could no longer compensate **for** the loss of verbal fluency. These findings could be relevant to personalize age-specific cognitive interventions using specific cognitive stimulation and/or rehabilitation materials. Older adults could benefit from cognitive interventions to improve their current cognitive function or delay cognitive decline (Smart et al., 2017).

On the other hand, high cognitive job demands seem to contribute to global cognitive maintenance, especially **for** some specific domains such as time orientation, attention, calculation, and verbal fluency after retirement. These benefits could be explained by brain plasticity mechanisms acquired through occupation (Fisher et al., 2017). In **line with this**, some studies **have** found differences in verbal fluency and in several cognitive domains after retirement (Sabbath et al., 2016). However, these cognitive effects have not been extrapolated to ADLs performance. Conversely, **individuals with** high physical job demands **showed decreased** global cognitive functions after retirement, especially **in** temporal orientation, short-term memory, calculation, language, and verbal fluency, **as well as** greater deterioration in IADLs performance. **Other** studies have also **agreed on this point and** demonstrated that older workers with physically demanding jobs tend to have poorer cognitive function (Choi et al., 2022).

The main job occupation throughout life is related to cognitive impairment and dementia. In fact, older adults who predominantly **engaged in** manual work activity have a higher risk of suffering cognitive impairment and dementia than those who had occupations with higher intellectual requirements (Gracia Rebled et al., 2016). **High** physical job demands **actually increased** the risk of dementia (Anttila et al., 2002), **and** high physical stress is **also** associated with increased periods of absence due to prolonged illness (Holtermann et al., 2012) and with low physical function and muscle strength in older adults (Smith et al., 2016). However, moderate occupational physical demands in middle age are associated with a lower risk of **ADLs disability** in older age (Rydwik et al., 2013). **The** evidence indicates opposite effects of occupational physical activity and physical activity in leisure time, **because** the latter contributes to the improvement of overall cognitive and functional health (Holtermann et al., 2012). Thus, some studies **have highlighted** the importance of encouraging sedentary workers to do physical activity during or outside working hours due to the associated risks of physical inactivity (Rydwik et al., 2013). A recent study **has also indicated** the need to support people during their retirement transition process, to help them develop healthy habits (Spiteri et al., 2022). **The** time of retirement **also** seems to be also important. The prevalence of multimorbidity may be lower in people who retired late from full-time work compared to those who retired earlier (Calvo et al., 2022).

Another important aspect to consider is the long-term antecedents of cognitive health in old age. In general, evidence **supports the existence of** age-related cognitive declines, but there are wide individual differences and variations in the timing and extent of **such declines** (Greenfield & Moorman, 2019). Thus, low childhood socioeconomic status (SES) was associated with lower cognitive function and greater cognitive decline in mid and later life (Liu & Lachman, 2019). SES seems to be an important predictor of neurocognitive performance, particularly language and executive function (Hackman & Farah, 2009). These results contribute to a call for social policies and programs to support optimal brain health at multiple phases throughout the life course, especially among people of lower **SES** (Greenfield & Moorman, 2019). On the other hand, the literature **notes** that those **with higher SES tend to** have more material and non-material resources, including education, occupational prestige, and **neighborhood** quality.

In relation to cardiovascular conditions, it is observed that, in the present study, the group aged 64-75 years presented more hypercholesterolemia and obesity and, there was a strong association with some cognitive domains and, in particular, functional performance. Cardiovascular conditions are more influenced by lifestyle factors than by age (Colpani et al., 2018); however, they have been related to cognitive deficits and increased risk of dementia (Sabbath et al., 2016).

Prevention of cognitive impairment in older adults living in the community would be based on the development of multidomain interventions that **increase an active lifestyle** through physical activity carried out **during** free time (Loitz et al., 2015), control of cardiovascular risk factors (Lipnicki et al., 2019), and cognitive interventions (Smart et al., 2017), **that start early** before more pronounced structural brain changes occur (Stephen et al., 2019). These interventions must consider cognitive domains, age groups, and previous job demands. Introducing cognitive challenges and moderate physical activity during adulthood could help to maintain cognitive and functional abilities in old age (Fisher et al., 2017). It is also necessary to underline the importance of reducing physical occupational exposures throughout working life to prevent absenteeism due to illness and premature exit from the **labor** market (Sundstrup et al., 2017).

Interventions based on mindfulness and aerobic exercise (Restrepo & Lemos, 2021) could reduce work stress and/or exhaustion of staff working in emergency departments (Xu et al., 2020). Finally, it is necessary to highlight that the most recent literature **suggests** that occupational therapy could allow active and healthy aging through understanding work experience and how this can help older workers to find a balance between work and other areas of life (Eagers et al., 2019), **as well as in choosing** meaningful retirement activities (Eagers et al., 2020).

Conclusions

Physical and cognitive job occupational demands seem to determine the **course of** aging in terms of cognitive and functional impairment. At work, a moderate level of physical occupation could prevent both cognitive and functional deterioration. Likewise, introducing cognitive challenges **in** specific domains could increase the cognitive capacity of older adults, especially in cognitive domains that decrease with the loss of work routine (time orientation, attention, calculation, and language). **After retirement, multimodal interventions that combine the physical and cognitive domains most affected by age and work experience should be considered.**

Study limitations

The first limitation of this study is that **the** whole **employment history** and cause of retirement were not considered; we **only considered** the job **to** which they had dedicated the most years **prior to retirement**. The possible cumulative advantage/disadvantage **were thus not contemplated**. **However, we have considered the most durable job, so the cumulative advantage would be based on a population group that has mostly worked in a single company and in the recent working years, there were cognitive advantages due to job promotions, which at the same time implied a decrease in physical demands.**

Second, the participants were recruited from a primary care **center** in a specific **neighborhood** and not randomly drawn by the community. We **did not consider** if the sociodemographic parameters would coincide, extrapolate, and generalize to other population groups and city areas. **The selected neighborhood is a working-class neighborhood, with sociodemographic characteristics similar to other neighborhoods in the city. The city in this study is roughly average for the country in terms of socioeconomic characteristics. We therefore consider that our results could be extrapolated to other contexts.** We also have not considered psychosocial factors such as burnout or stress, which **could also have influenced the results.** Finally, **individual SES was** not considered as influential in subsequent cognitive health. **All these factors should be contemplated in future studies.**

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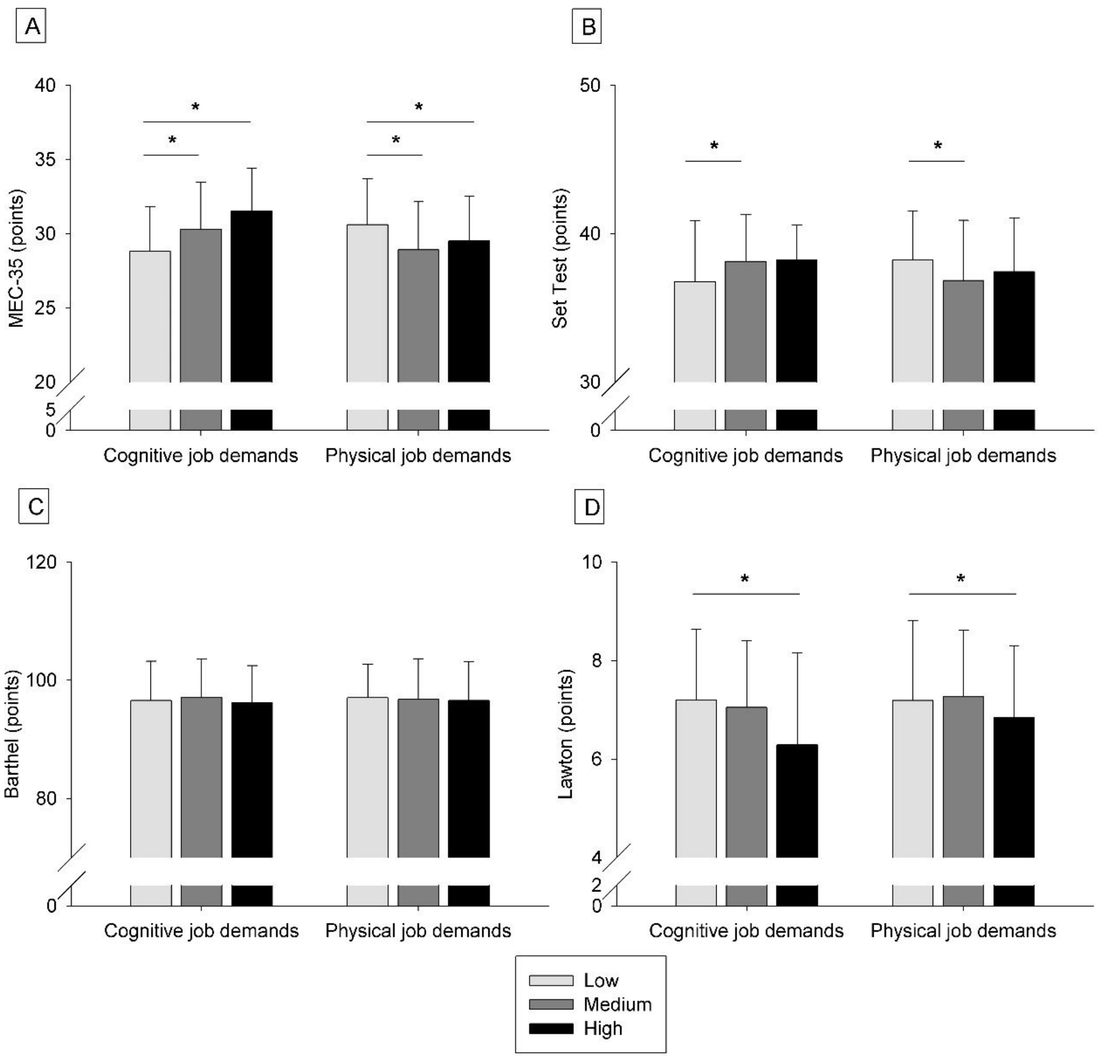
LEGENDS

Figure 1. Cognitive and physical assessment scores by physical and cognitive job demands.



Mann-Whitney post hoc Bonferroni correction for multiple comparisons was used to examine differences between cognitive and physical demands groups. * p = 0.0167

A. Global cognition scores by the MEC-35, Spanish version of Mini-Mental State Examination. B. Verbal fluency was measured by the set test. C. Functional assessment of activities of daily living was measured by the Barthel Index. D. Autonomy in instrumental activities of daily living was assessed by the Lawton and Brody scale.

TABLES:

Table 1. Socio-demographic and clinical characteristics of participants.

	Total (n = 367)	64-75 years (n = 197)	≥75 years (n = 170)	p-value
	n (%)	n (%)	n (%)	
Level of education				
Primary Level	282 (76.8%)	144 (73.1%)	138 (81.2%)	0.067
High Level	85 (23.2%)	53 (26.9%)	32 (18.8%)	
Civil status				
Single	19 (5.2%)	10(5.1%)	9(5.3 %)	0.001*
Married	246 (67%)	145 (73.6%)	101(59.4%)	
Widowed	90 (24.5%)	33(16.8%)	57(33.5%)	
Separated	12(3.3%)	9(4.6%)	3 (1.8%)	
Physical occupation				
Low	74 (20.2%)	43 (21.8%)	31 (18.2%)	0.455
Medium	160 (43.6%)	88 (44.7%)	72 (42.4%)	
High	133 (36.2%)	66 (33.5%)	67 (39.4%)	
Mental occupation				
Low	217 (59.1%)	112 (56.9%)	105 (61.8%)	0.424
Medium	129 (35.1%)	75 (38.1%)	54 (31.8%)	
High	21 (5.7%)	10 (5.1%)	11 (6.5%)	
HBP				
Yes	179 (48.8%)	88 (44.7%)	91 (53.5%)	0.090
No	188 (51.2%)	109 (55.3%)	79 (46.5%)	
Diabetes				
Yes	52 (14.2%)	30 (15.2%)	22 (12.9%)	0.531
No	315 (85.8%)	167 (84.8%)	148 (87.1%)	
Hypercholesterolemia				
Yes	139 (37.9%)	87 (44.2 %)	52 (30.6%)	0.008*
No	228 (62.1%)	110 (55.8%)	118 (69.4%)	
Obesity				
Yes	50 (13.6%)	37 (18.8%)	13 (7.6%)	0.002*
No	317 (86.4%)	160 (81.2%)	157 (92.4%)	
CVA				
Yes	24 (6.5%)	13 (6.6%)	11 (6.5%)	0.960
No	343 (93.5%)	184 (93.4%)	159 (93.5%)	

p-value obtained by Pearson's Chi square test; *p<0.05

HBP: high blood pressure, CVA: cerebrovascular accident.

Table 2. Cognitive and functional scores by age and job demands.

	Age groups				Cognitive job demands groups				Physical job demands groups			
	Total (n=367)	64 -75 years (n=197)	Over 75 years (n=170)	p-value	Low (n=217)	Medium (n=129)	High (n=21)	p-value	Low (n=74)	Medium (n=160)	High (n=133)	p-value
MEC-35	29.48 (3.18)	29.89 (3.20)	29.00 (3.11)	0.008*	$28.80^{\#,\$}$ (3.02)	30.28 (3.19)	31.52 (2.87)	<0.001**	$30.62^{\#,\$}$ (3.10)	28.91 (3.25)	29.52 (2.99)	0.001*
Temporal Orientation	4.39 (0.92)	4.51 (0.88)	4.26 (0.96)	0.002*	4.33 (0.94)	4.47 (0.85)	4.62 (1.12)	0.034*	$4.53^{\$}$ (0.97)	4.29 (0.93)	4.44 (0.88)	0.01
Spatial Orientation	4.66 (0.62)	4.74 (0.54)	4.56 (0.69)	0.007*	4.63 (0.63)	4.70 (0.59)	4.71 (0.56)	0.577	4.74 (0.49)	4.59 (0.66)	4.69 (0.62)	0,156
Fixation Memory	3.00 (0.52)	2.99 (0.07)	3.00 (0.00)	0.353	3.00 (0.00).	2.99 (0.09)	3.00 (..00)	0.398	3.00 (0.00)	2.99 (0.79)	3.00 (0.00)	0,524
Attention	1.74 (1.22)	1.70 (1.22)	1.79 (1.22)	0.480	$1.53^{\#,\$}$ (1.20)	2.03 (1.18)	2.24 (1.14)	<0.001**	1.95 (1.24)	1.64 (1.21)	1.76 (1.22)	0.227
Calculation	4.38 (1.00)	4.40 (1.02)	4.35 (0.99)	0.378	$4.27^{\#,\$}$ (1.05)	4.48 (0.97)	4.86 (0.36)	0.003*	$4.61^{\$}$ (0.81)	4.24 (1.07)	4.41 (1.01)	0,014
Short-term memory	1.60 (1.09)	1.78 (1.03)	1.38 (1.13)	0.001*	1.53 (1.09)	1.68 (1.11)	1.76 (1-04)	0.334	$1.91^{\$}$ (1.02)	1.48 (1.10)	1.56 (1.09)	0,021
Language	5.28 (0.84)	5.32 (0.80)	5.24 (0.88)	0.501	$5.16^{\#,\$}$ (0.85)	5.42 (0.84)	5.71 (0.46)	<0.001**	5.42 (0.84)	5.32 (0.82)	5.17 (0.86)	0.049
Praxis	4.42 (0.70)	4.46 (0.70)	4.38 (0.70)	0.162	4.35 (0.76)	4.50 (0.60)	4.62 (0.59)	0.105	4.49 (0.63)	4.33 (0.78)	4.49 (0.62)	0,302
Set Test	37.34 (3.79)	38.51 (2.29)	35.98 (4.64)	<0.001**	$36.77^{\$}$ (4.13)	38.14 (3.17)	38.24 (2.36)	0.002*	$38.22^{\$}$ (3.31)	36.84 (4.07)	37.44 (3.61)	0,004*
Barthel	96.76 (6.54)	97.61 (5.81)	95.78 (7.17)	0.001*	96.59 (6.63)	97.15 (6.45)	96.19 (6.30)	0.026	97.06 (5.72)	96.78 (6.87)	96.58 (6.58)	0,970
Lawton	7.10 (1.45)	7.38(1.22)	6.76 (1.62)	<0.001**	$7.20^{\#}$ (1.44)	7.05 (1.36)	6.29 (1.87)	<0.001**	7.19 (1.62)	$7.27^{\#}$ (1.35)	6.84 (1.45)	0.005*

Results are expressed as mean (standard desviation). Mann-Whitney post hoc Bonferroni correction for multiple comparisons was used. #Significant differences when compared to high cognitive or physical demands group; $Significant differences when compared to medium cognitive or physical demands group. p = 0.0167. MEC-35: Spanish version of Mini-Mental State Examination.

Table 3. Cognitive and functional assessments scores by cardiovascular conditions.

		HBP			Diabetes			Hypercholesterolemia			Obesity			Cerebrovascular accident		
	Total	No	Yes		No	Yes		No	Yes		NO	Yes		No	Yes	
	(n=367)	(n=188)	(n=179)	p-value	(n=315)	(n=52)	p-value	(n=228)	n=139)	p-value	(n=317)	(n=50)	p-value	(n=343)	(n=24)	p-value
MEC-35	29.48 (3.18)	29.37(3.15)	29.59 (3.23)	0.501	29.47(3.15)	29.50 (3.39)	0.945	29.45 (3.18)	29.53 (3.21)	0.811	29.50 (3.15)	29.32 (3.41)	0.749	29.51(3.18)	29.00 (3.27)	0.480
Temporal Orientation	4.39 (0.92)	4.35 (0.98)	4.44 (0.85)	0.028*	4.38 (0.95)	4.48 (0.70)	0.885	4.38 (0.89)	4.42 (0.97)	0.320	4.41 (0.91)	4.30 (0.99)	0.356	4.41 (0.92)	4.21 (0.98)	0.263
Spatial Orientation	4.66 (0.62)	4.60 (0.63)	4.72 (0.60)	0.506	4,64 (0.64)	4.77 (0.47)	0.208	4.66 (0.58)	4.65 (0.68)	0.613	4.66 (0.62)	4.66 (0.59)	0.968	4.66 (0.62)	4.63 (0.57)	0.593
Fixation Memory	3.00 (0.52)	2.99 (0.73)	3.00 (0.00)	0.329	3.00 (0.06)	3.00(0.00)	0.685	3.00 (0.07)	3.00 (0.00)	0.435	3.00 (0.00)	2.98 (0.14)	0.012*	3.00 (0.05)	3.00 (0.00)	0.791
Attention	1.74 (1.22)	1,75 (1.21)	1.74 (1.23)	0.469	1.73 (1.23)	1.81(1.14)	0.632	1.72 (1.20)	1.78 (1.25)	0.734	1.76 (1.22)	1.66 (1.26)	0.587	1.75 (1.21)	1.67(1.30)	0.711
Calculation	4.38 (1.00)	4.40 (1.01)	4.35 (1.01)	0.896	4,38 (0,99)	4.37 (1.10)	0.942	4.40 (0.98)	4.33 (1.05)	0.599	4.38 (1.03)	4.36 (0.85)	0.381	4.38 (0.99)	4.29 (1.27)	0,791
Short-term memory	1.60 (1.09)	1.58 (1.11)	1.61(1.08)	0.791	1.61 (1.10)	1.52 (1.04)	0.522	1.54 (1.13)	1.68 (1.04)	0.285	1.61 (1.10)	1.54 (1.07)	0.667	1.60 (1.09)	1.58 (1.06)	0.915
Language	5.28 (0.84)	5,28 (0.86)	5.29 (0.83)	0.947	5.30 (0.84)	5.21 (0.89)	0.564	5.25 (0.85)	5.33 (0.83)	0.365	5.28 (0.84)	5.30 (0.89)	0.729	5.27 (0.84)	5.42 (0.88)	0.292
Praxis	4.42 (0.70)	4,39 (0.73)	4.45 (0.66)	0.590	4.45 (0.69)	4.25 (0.76)	0.069	4.47 (0.68)	4.33 (0.72)	0.057	4.41 (0.71)	4.50 (0.65)	0.401	4.43 (0.70)	4.21 (0.66)	0.067
Set Test	37.34 (3.79)	37.06 (3.84)	37.62 (3.72)	0.088	37.43 (3.76)	36.73 (3.93)	0.126	37.00 (4.13)	37.88 (3.07)	0.047*	37.29 (3.84)	37.64 (3.45)	0.564	37.41(3.70)	36.21 (4.83)	0.631
Barthel	96,76 (6.54)	97.18 (6,01)	96.33 (7.04)	0.318	96.98 (6.47)	95.48 (6.88)	0.040*	96.50 (6.52)	97.19 (6.57)	0.053	96.95 (6.37)	95.60 (7.47)	0.186	96.98(6.22)	93.75 (9.70)	0.032*
Lawton	7.10 (1.45)	7.13 (1.41)	7.06 (1.49)	0.464	7.12 (1.46)	6.96 (1.44)	0.201	7.035 (1.46)	7.20 (1.44)	0.241	7.07 (1.49)	7.26 (1.16)	0.838	7.14 (1.43)	6.50 (1.72)	0.041*

Results are expressed as mean (standard deviation). p-value obtained by U de Mann Whitney; *p<0.05

MEC-35: Spanish version of Mini-Mental State Examination, HBP: high blood pressure, CVA: cerebrovascular accident.

Dear Editor,

We submit the revision of our manuscript ID JAG-21-0649.R1 entitled “Job demands may determine cognitive and physical aging after retirement”. We want to thank you and the reviewers for the attention and work. We appreciate the comments and suggestions and we have modified our manuscript accordingly. Below, there is a point-by-point responses and all changes have been highlighted in bold in the manuscript. In addition, the manuscript has been professionally edited for grammar and English usage. We have uploaded a certificate documenting that a professional editing service has corrected the manuscript as a supplementary file.

We hope that those changes have improved the quality of our work and now it will be suitable for publication in the *Journal of Applied Gerontology*.

Your sincerely,

Dr Latorre

Reviewers' Comments to Author:

Reviewer: 1

Comments to the Author

The authors should be commended for their work revising the manuscript. Overall, several critical changes were made that improved the manuscript. The writing still lacks clarity in several areas. It makes it difficult to discern some of their more critical points, I fear. Their limitations section is much improved. It could be further enhanced by addressing how these limitations may have affected the findings and what one might expect if this data had been collected. Some additional comments:

We appreciate the reviewer comments. The manuscript has been professionally edited for clarification and we hope the reading has been improved. We have added your suggestions on limitations section.

Page 3: Line 6: A hallmark of gerontological writing does not need to provide such an introduction. I would recommend the authors remove the sentence starting with 'Nowadays.' It does not feel appropriate.

We have removed the sentence

Page 3, Line 23: I will just point this out as one location that needs further refinement.

We have rewritten the sentence for clarification.

Page 3, Line 42-47: I have no idea what this sentence, ending pathologies, is trying to state. Please clarify.

We have rewritten the sentence for clarification.

Page 4: Sentences ending Hussenoeder are unclear. I think it is the term 'concepts.'

We have rewritten those sentences for clarification.

Page 15: Rather than interesting, consider making this a potential next step and recommending it. It. One thing I still see as lacking as the following steps from this – what do we do with this information.

We have rewritten the sentence. We have explained the impact of our results in the discussion section: 1) To consider job demands during adulthood to be able to complement them to ameliorate aging decline later on, and 2) design interventions during old age based on work experience

Reviewer: 2

Comments to the Author

Thank you for the opportunity to review manuscript R1. I would suggest the following ways in which the manuscript could be improved.

We thank the reviewer for the suggestions.

1) Replace in the sentence: The test analyses verbal fluency in four different categories: colors, animals, fruits, and cities, and the scores vary between 0–40.

Replace "vary" with "range from 0 to 40."

We have accordingly changed.

2) In the Cognitive and physical assessments section:

I suggest rewriting the first paragraph:

Exclude: Table 2 shows the comparative study of the cognitive and functional variables by age, cognitive and physical job demands.

Replace:

e.g., The comparative analysis of the global cognition by age group showed that the group aged 64 to 74 years had the MEC-35 score significantly higher than other groups (p=0.008).

We have replaced the sentence.

3) Rewrite: At the functional level, the group from 64 to 75 years old presented a higher score in both ADLs (p = 0.001) and IADLs (p 0001br />e.g., At the analysis of the functional level by age, the group from 64 to 75 years presented a higher score in both ADLs (p = 0.001) and IADLs (p 0001br />

We have rewritten the sentence.

4) Replace symbol > for = in the parenthesis (p00167br />

We have amended the mistake.

5) I suggest not to start the sentences indicating where the results are. The result is the highlight and not where you show it. Please, review all Result section

e.g.: As figure 1 shows, in relation to physical occupation, participants with high physical job demands had lower scores in MEC-35 (p = 0.001) and in temporal orientation (p = 0.01), calculation (p = 0.014) and language (p = 0.049) domains.

Rewrite as:

According to physical occupation, participants with high physical job demands had lower scores in MEC-35 (p = 0.001) and in temporal orientation (p = 0.01), calculation (p = 0.014) and language (p = 0.049) domains (Figure 1).

We have rewritten the starting sentences for results section.

6) Two sentences are initiated with "post hoc analysis reveal." Again, start the sentence with your results. And post hoc analysis should be in the statistical section. Please indicate this analysis in this section.

We have rewritten those sentences and added post hoc analysis to statistical section.

7) In the Evaluation of Cardiovascular conditions, have the sentence initiating by "Table 3 shows the". Please, rewrite.

We have rewritten the sentence.

Please see (and follow) the tables examples (title and notes) in this study published in JAG: https://journals.sagepub.com/doi/pdf/10.1177/07334648221112425

8) In Figure 1, the notes should be below the image. And don´t use bold letters. Use the article as an example (link above)

We have accordingly changed the notes positions. The bold letters are used to indicate the changes in the manuscript, and they will no be in the final version.

9) In table 1, the authors "mix" the title with notes:

Table 1. Socio-demographic and clinical characteristics of participants. p-value:

Pearson's Chi-square; HBP: high blood pressure; CVA: cerebrovascular

accident. *p005br />Title: Socio-demographic and clinical characteristics of participants.

Notes should be at the bottom of the table. And the authors should separate the statistical methods and the abbreviation.

e.g.:

*p-value: Pearson's Chi square. The authors highlighted p-value 0.05.

HBP: high blood pressure; CVA: cerebrovascular accident.

We have reordered the notes.

10) Rewrite the Table 2 title.

Title: Cognitive and functional scores by age and job demands.

This information - Results are expressed as mean (standard deviation) – should be in the additional line in the table below the subgroups of the variables. Observe that the grammatical of the "standard deviation" must be corrected.

We have reordered the notes and corrected "standard deviation".

11) The text below Figure 1 and Table 2 must be described in the statistical section. Cite just the statistical test. Follow the example (link) indicated above.

We have accordingly changed the notes for Figure 1 and Table 2 and added the information to the statistical section.

12) Use the same layout as in Table 2 in Table 3.

We have changed the layout of the tables

13) Rewrite the Title as indicated above:

Title: Table 3 Cognitive and functional assessment scores by cardiovascular conditions.

Insert a line above the variables: Results are expressed as mean (standard deviation). Follow the example (link) indicated above.

We have reordered the notes and changed the title.

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