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ORIGINAL ARTICLE

Poor physical fitness is associated with impaired memory, executive function, and depression in institutionalized older adults: a cross-sectional study

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Objective: To analyze the association between physical fitness, cognitive function, and depressive symptoms among older adults in long-term care facilities (LTCFs).
Methods: Seventy-six institutionalized male and female elderly individuals (65 years and older) living in LTCFs participated of this study. Physical fitness (aerobic capacity and strength), cognitive functions (global cognition, short-term and working and semantic memories, and executive function), and depressive symptoms were assessed. Linear regression and contingency analyses were performed. Significance was accepted at p-values $\leqslant$ 0.05.
Results: Aerobic capacity predicted 32% of variance in global cognition ($p < 0.01$) and 25% of variance in semantic fluency/executive function ($p < 0.01$). Low levels of upper limb strength, lower limb strength, and aerobic capacity were associated with semantic fluency/executive function (OR = 1.38, p = 0.01, OR = 1.26, p = 0.03, and OR = 1.07, p = 0.01, respectively) and depressive symptoms (OR = 1.06, $p < 0.01$).
Conclusion: Poor physical fitness is associated with cognition and depressive symptoms in institutionalized older adults. Low levels of strength and aerobic fitness increase the odds of presenting with impaired semantic fluency and executive function, possibly denoting an increased risk of developing dementia.

Keywords: Older adults; nursing home; physical activity; cognition

Introduction

With worldwide improvements in life expectancy, it is expected that more than 15% of the global population will be composed of individuals over age 65 by 2050, while children under age 5 will represent less than 8% of the total population.[1] As a result of this increase in life expectancy, however, several noncommunicable diseases related to unsuccessful aging are on the rise, causing concern among international organizations.

Aging is a physiological process, but unsuccessful aging increases the risk of chronic diseases and disabilities.[1] Loss of function is one of the main reasons older adults are institutionalized in long-term care facilities (LTCFs). Factors that have been related to decreased physical function and frailty include sarcopenia and cognitive decline.[2,3] Institutionalized and frail elderly have poor physical function and are at high risk of developing cognitive disorders.[4,5] As these people have few physical and cognitive challenges due to an impoverished environment (e.g., they do not use public transport, handle money, or cook their own meals), the disuse cycle may worsen their functionality and trigger depressive symptoms.[6,7]

Physical fitness is closely related to brain health. The more fit a person is, the better their brain functioning.[8] Cognition and mood are directly and positively affected by physical capabilities.[7,9] Plácido et al.[10] recently found an association among cardiorespiratory fitness, functional status, and dementia. According to this study, older adults with poor aerobic resistance (below normative scores for age) have a 10- to 14-fold higher likelihood of developing mild and moderate dementia, respectively. In addition, these authors showed that cardiorespiratory fitness scores were related to global cognition scores. Regarding depressive symptoms, there is substantial evidence showing a relationship between physical activity level and depression.[11,12]

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As institutionalized elderly are frequently frail and have both cognitive impairments and depressive symptoms,[3,6,13] the relationship between physical fitness and mental health seems to be more relevant to this population. Indeed, studies show that exercises can effectively improve everyday functionality, mobility, and have positive effects on cognitive performance of institutionalized older adults.[14,15] Therefore, if an association between physical capabilities and mental health is found for individuals in LTCFs, this would inform managers and health care providers on the need to incorporate physical exercise into routine care at these facilities to improve the general health of their residents. Furthermore, understanding how physical fitness, specific cognitive functions (e.g., short-term and working memory), and depressive symptoms are related could help us to plan specific strategies to improve mental health. The aim of this study was to examine the association among physical fitness, cognitive functions, and depressive symptoms in older adults living in LTCFs.

Methods

Participants

Seventy-six male and female elderly individuals (65 years and above) living in LTCFs were recruited. They met the following inclusion/exclusion criteria: i) independent ambulation; ii) preserved communication skills and comprehension of commands (assessed through an interview); iii) no severe cardiovascular disease; iv) no acute musculoskeletal injury; v) no delirium. These criteria were applied by a health professional. All individuals were screened for dementia by a physician. Participants with a reliable diagnosis of dementia were excluded, while individuals with probable dementia remained in the sample. Symptoms of depression were assessed between men and women for homogeneity purposes.

Sociodemographic variables of each participant such as age, comorbidities, duration of LTCF residence, and medications were retrieved from records in each LTCF. Data were collected from five separate LTCFs in two Brazilian cities (Rio de Janeiro and Montes Claros).

Cognitive assessments

Global cognition was examined using the Portuguese version of the Mini-Mental State Examination (MMSE).[16] The following cutoff points were used to determine impairment, while correcting for educational attainment: 13 if illiterate, 18 if less than 9 years of education, and 26 if 9 years of education or more.[16] Years of education were retrieved from the records in each LTCF if available.

Short-term and working memories were evaluated through Digit Span forward and backward (DSF and DSB) tasks, respectively. The DSF is composed of seven pairs of number sequences. An assessor read each pair of sequences out loud to the participant and asked them to repeat the sequence back in the exact order it was read. When the participant was not able to repeat a pair of sequences correctly, the test was terminated. Each correct response is equivalent to one point, resulting in a total possible score of 14 points. DSB is applied in the same manner as DSF. However, the number sequences should be repeated by the participant in reverse order.[17] Cutoff scores for DSF and DSB are 6 and 4, respectively, according to median values for people above 60.[16,18]

To evaluate semantic fluency and executive function, a verbal fluency (VF, animal category) test was applied.[19,20] Participants were asked to name as many animals as possible in 1 minute. A score of 13 was used as a cutoff point to determine low or high executive function, based on a previously published study.[19] Although that study showed an influence of years of education (illiterate = 11.9; up 4 years of education = 12.8; 4 to 7 years = 13.4; and 8 years or more = 15.8), we decided to determine 13 points as the cutoff because illiterate persons and those with low or intermediate education showed similar results. Moreover, having more than 8 years of schooling is unusual among residents of the study LTCFs.

All cognitive assessments were conducted in a single day in the afternoon.

Depressive symptoms

The Brazilian version of the Geriatric Depression Scale (GDS) was used to identify depressive symptoms.[21] It is composed of 30 yes/no questions. Answers indicating depression are assigned 1 point and added to yield a total score. The cutoff point to detect depressive symptoms is 10. This assessment was conducted immediately after cognitive assessments.

Physical assessments

Physical fitness was assessed using three tests from the Senior Fitness Test (SFT) protocol.[22] Upper and lower limb strength were measured using the arm curl and the sit-to-stand test, respectively. Aerobic capacity was evaluated using the 2-minute step test. These tests are scored according to the age of the participant. The SFT classifies the physical capabilities of older adults at risk of functional loss. For instance, if a woman with 60-64 years perform 11 repetitions in the arm curl, she is at functional risk in the upper limb strength because the cutoff point is at least 12 repetitions. Cutoff points vary according to age and sex, indicating functional limitation to perform a specific task.

Physical assessments were conducted in a single day in the afternoon, 48 hours apart from cognitive assessments.

Statistical analyses

Descriptive data are shown as mean (standard deviation) and median (minimum and maximum), according to data distribution. Independent T or Mann-Whitney *U* tests were used to compare cognitive functions, physical capabilities, and depressive symptoms between men and women. As these outcomes were not different ($p > 0.05$), except for lower limb strength, data were pooled, and the sample analyzed as a whole. Variables meeting parametric assumptions (global cognition, verbal fluency, short-term memory, upper limb strength, and aerobic capability) were examined using linear regression. To test the influence of physical capabilities on cognition, upper limb strength and aerobic capacity were inserted as independent variables in the linear regression (enter model), while the aforementioned cognitive functions were used as dependent variables.

Logistic regression was performed to calculate the odds ratio (OR) between physical capabilities and cognitive functions, physical capabilities, and depressive symptoms. Missing data were excluded from pairwise analyses. All statistical procedures were performed in JASP 0.13.1. Significance was accepted at the 0.05 alpha level.

Ethics statement

The study was approved by the Universidade Estadual de Montes Claros ethics committee (protocol 2.398.863/2017). All participants voluntarily provided written informed consent to take part in the study.

Results

The sample was 64% female. Participants' demographic characteristics are displayed in Table 1. None of the demographic variables was different between males and females ($p > 0.05$). Linear regression showed a relationship between aerobic capacity, upper limb strength, and cognition. However, when age was inserted as a confounding variable, only aerobic capacity predicted 32% of the variance in global cognition score (adjusted $R^2 = 0.32$, B = 0.23, t = 1.8, $p < 0.01$) and 25% of the variance in semantic fluency/executive function (verbal fluency) (adjusted $R^2 = 0.25$, B = 0.44, t = 3.5, $p < 0.01$). Physical capabilities were not related to short-term memory ($p > 0.05$).

Logistic regression indicated poor cardiorespiratory fitness was associated with semantic fluency/executive function and depressive symptoms. Full data are provided in Table 2.

Discussion

This study analyzed the associations among physical fitness, cognitive function, and depressive symptoms in a sample of institutionalized older adults. Those with better strength and aerobic capacity were found to exhibit better semantic fluency/executive function. Conversely, older individuals with poor aerobic capacity were most likely to exhibit current depressive symptoms.

Brain connectivity and mental health have been associated with cardiorespiratory fitness.[23,24] Recently, Plácido et al.[10] found a strong association among cardiorespiratory fitness measured through the 2-minute step test, Alzheimer's disease (AD), and mild cognitive impairment (MCI). The authors showed that people at risk of functional loss were most likely to be diagnosed with mild (OR = 10.7; p = 0.001) to moderate (OR = 14.7; p = 0.002) AD, whereas individuals with low aerobic fitness were 4.5 times more likely to present with MCI (p = 0.05). These findings are in line with ours, showing that poor aerobic capacity in institutionalized older adults is associated with cognitive impairments. The present study extends this literature further by demonstrating that specific cognitive functions, such as semantic fluency/executive function, are associated with strength and aerobic capacity in institutionalized elderly patients. Those at risk of functional loss were more likely to present a risk up to 38% of decreased semantic fluency/executive function. In addition, institutionalized older adults with decreased aerobic fitness were more likely to be diagnosed with depressive symptoms (OR = 1.06, 95% confidence interval = 1.02-1.10, p = 0.01). Recent literature shows that executive function (e.g., inhibitory control) is acutely improved in individuals who perform aerobic exercise.[25] In a chronic condition where the individual performs regular exercise, cardiorespiratory fitness is enhanced, which could affect hippocampal connectivity with other

Table 1 Demographic and clinical characteristics of the sample and independent statistical comparison between males and females

Characteristic	Males (n=27)	Females (n=49)	Total (n=76)
Age (years)	79±8	83±8	82±8
Weight (kg)	76±14	68±2	68±6
Height (m)	1.66±0.06	1.52±0.06	1.55±0.08
Institutionalization (months)*	15.0 (1-156)	24.0 (1-96)	20.5 (1-156)
Chronic diseases (n)*	2 (1-3)	1 (0-4)	1 (1-4)
Medications (n)*	7 (1-14)	5 (0-19)	6 (0-19)
MMSE (score)	19±7	18±6	19±7
VF (score)	10±5	9±5	9±5
DSF (score)	6±3	5±2	5±2
DSB (score)*	2 (0-7)	2 (0-7)	2 (0-7)
GDS (score)	9±5	12±7	11±7
Sit-to-stand (repetitions)	7±3	6±2	7±3
2-minute step test (repetitions)	33±15	33±17	33±16
Arm curl (repetitions)	11±4[†]	8±4	9±4

Data presented as mean ± standard deviation, unless otherwise specified.
DSF and DSB = Digit Span forward and backward; GDS = Geriatric Depression Scale; MMSE = Mini-Mental of State Examination; VF = verbal fluency.
* Outcomes described as median (minimum and maximum).
[†] $p < 0.05$ between males and females.

Table 2 Logistic regression associating physical and mental assessments

Physical and mental assessments	Odds ratio	95%CI	p-value
Sit-to-stand			
Verbal fluency	1.38	1.02-1.85	**0.03***
Digit Span backward	1.07	0.81-1.41	0.61*
Digit Span forward	1.10	0.85-1.42	0.44*
Geriatric Depression Scale	0.87	1.07-5.22	0.29†
2-minute step test			
Verbal fluency	1.07	1.01-1.14	**0.01***
Digit Span backward	1.03	0.98-1.09	0.19*
Digit Span forward	1.01	0.96-1.05	0.59*
Geriatric Depression Scale	1.06	1.02-1.10	**0.01**†
Arm curl			
Verbal fluency	1.26	1.05-1.52	**0.01***
Digit Span backward	1.15	0.96-1.38	0.12*
Digit Span forward	1.09	0.93-1.28	0.26*
Geriatric Depression Scale	0.90	0.78-1.04	0.17†

Bold types denote significance.
95%CI = 95% confidence interval.
* Adjusted by age, gender, long-term care facility, and depressive symptoms.
† Adjusted by age, gender, and long-term care facility.

brain regions, such as the medial prefrontal cortex and default mode network (DMN),[23] explaining the link between physical capacity and improved cognition and depression. The hippocampus and DMN are closely associated to cognition and depression,[23,26] reinforcing the perspective of physical fitness improving mental health. This is relevant because persons living in LTCFs have poor physical fitness and high physical dependence, which could be associated to poor mental health.[7,27]

While the neurobiological mechanisms underlying physical fitness and cognitive function have not been fully elucidated, a number of studies have shown that persons who are more physically active exhibit better mental health.[24,28] Many neurobiological processes related to physical fitness, such as improved cerebral blood flow, increased trophic factors, neurotransmitter synthesis, and synaptic branch enhancement, could be associated with brain integrity.[29,30] Recently, Kronman et al.[23] found a relationship between cardiorespiratory fitness and improved hippocampus and prefrontal cortex connectivity. The authors showed that people with high levels of cardiorespiratory fitness had more effective connections from the hippocampus to the ventromedial prefrontal cortex, posterior cingulate cortex, lateral temporal cortex, and dorsomedial prefrontal cortex. Interestingly, these brain regions are directly related to episodic memory, short-term and working memory, executive functions, and emotional processing,[8,31,32] which provides a possible mechanism underlying our findings. Since institutionalized older adults have poor physical fitness, impaired semantic fluency/executive function, and often experience depressive symptoms, they are likely to present with brain atrophy and weak neuronal connections. However, the current study was cross-sectional in nature; longitudinal studies are needed to examine changes in brain structure over time.

These findings may be used to encourage health professionals and LTCF managers to offer physical activities in these institutions, since physical capabilities are directly associated with mental health. Physical activity and supervised exercise have been strongly recommended by the World Health Organization to prevent cognitive decline and reduce the risk of dementia.[9] Moreover, a position statement published by the Task-force Group suggests physical activity and exercise to improve the health of people living in LTCFs.[7]

The current study has a few limitations. First, the cross-sectional design does not allow us to establish causal relationships, although many studies in the literature support a causal link between physical fitness and mood/cognitive outcomes. Second, data with non-normal distribution were not inserted in the linear regression model. For instance, we could verify whether depression influences cognition and physical capabilities, but depressive symptoms did not meet parametric assumptions. Third, participants with probable dementia (uncertain diagnosis) were retained in the sample, which increased the variability of the data. Finally, full data on some variables, such as years of education, institutionalization period, diagnosis of dementia, and type of medications, were not available from all LTCFs or were missing from our records, and therefore were not inserted as covariates in our analysis. Conducting research in LTCFs is not easy, especially in Brazil, since the majority of these institutions are philanthropic in nature, are not usually supported by the government, and have limited resources (including limited access to specialized health professionals).

In conclusion, physical fitness is associated with cognition and depressive symptoms in institutionalized older adults. In these individuals, poor strength and aerobic fitness increase the odds of presenting with impaired semantic fluency/executive function, which may be associated with prodromal dementia. In addition, poor aerobic fitness was slightly associated with depressive symptoms, showing that sedentary institutionalized older adults could be at particular risk for depression.

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Disclosure

The authors report no conflicts of interest.

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