
Cognitive performance and physical fitness in the health of Brazilian elderly women

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Abstract

This study investigated the association between cognitive performance and cardiorespiratory capacity, strength, body mass and body composition of Brazilian elderly women. The sample was composed by 44 Brazilian elderly women, 31 cognitively healthy and 13 with cognitive decline. In the cognitively healthy group, dominant hand grip strength was correlated with Stroop condition 3 performance, ACE-R Total and in verbal fluency and language subdomains. In cognitive decline group, correlations were observed between non-dominant hand grip strength and Stroop condition 3 and; VO2 cardiorespiratory capacity with the RAVLT learning curve in ACE-R Total and attention, language and visuospatial subdomains. These findings indicate that the relationship between cognitive and physiological measures in Brazilian elderly women is also moderated by cognitive health. On neuropsychological field physical and cognitive measures could be combined for successful aging.

KEYWORDS: Aging, Body Composition, Cognition, Neuropsychology, Physical Fitness.

Desempenho cognitivo e aptidão física na saúde de idosas brasileiras

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Resumo

Este estudo investigou a associação entre desempenho cognitivo e capacidade cardiorrespiratória, força, massa corporal e composição corporal de idosas brasileiras. A amostra foi composta por 44 idosas brasileiras, 31 cognitivamente saudáveis e 13 com declínio cognitivo. No grupo cognitivamente saudável, a força de preensão dominante foi correlacionada com o desempenho da condição 3 de Stroop, ACE-R Total e em subdomínios de fluência verbal e linguagem. No grupo de declínio cognitivo, foram observadas correlações entre a força de preensão palmar não dominante e a condição 3 de Stroop e; Capacidade cardiorrespiratória do VO2 com a curva de aprendizado do RAVLT no ACE-R Total e subdomínios de atenção, linguagem e visuoespacial. Esses achados indicam que a relação entre medidas cognitivas e fisiológicas em idosas brasileiras também é moderada pela saúde cognitiva. No campo neuropsicológico, medidas físicas e cognitivas podem ser combinadas para um envelhecimento bem-sucedido.

Palavras-chave: Envelhecimento, Composição Corporal, Cognição, Neuropsicologia, Aptidão Física

Desempeño cognitivo y aptitud física en la salud de ancianas brasileñas

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Resumen

Este estudio investigó la asociación entre desempeño cognitivo y capacidad cardiorrespiratoria, fuerza, masa corporal y composición corporal de ancianas brasileñas. La muestra fue compuesta por 44 ancianas brasileñas, 31 cognitivamente sanos y 13 con declinación cognitiva. En el grupo cognitivamente sano, la fuerza de asimiento dominante fue correlacionada con el desempeño de la condición 3 de Stroop, ACE-R Total y en subdominios de fluencia verbal y lenguaje. En el grupo de declinación cognitiva, se observaron correlaciones entre la fuerza de asimiento palmar no dominante y la condición 3 de Stroop y; Capacidad cardiorrespiratoria del VO2 con la curva de aprendizaje del RAVLT en el ACE-R Total y subdominios de atención, lenguaje y visuoespacial. Estos hallazgos indican que la relación entre medidas cognitivas y fisiológicas en ancianas brasileñas también es moderada por la salud cognitiva. En el campo neuropsicológico, las medidas físicas y cognitivas se pueden combinar para un envejecimiento exitoso.

Palabras-clave: Envejecimiento, Composición Corporal, cognición, neuropsicología, Aptitud Física

Introduction

Healthy aging and the maintenance of physical and cognitive abilities in old age is the aim of studies in the field of Gerontology (Baltes & Baltes, 1990; Hammer et al., 2018; Kirk-Sanchez & McGough, 2014; Lima et al., 2018; Rowe & Kahn, 1998; Smolarek, 2016). Cognition is one of the most promising areas and has been increasingly investigated by experimental and observational studies (Belleville, 2017; Schaie, 2005). Part of these studies try to understand the factors that are associated with healthy cognitive aging, indicating that lifestyle, social relations, leisure, occupational profile, nutritional status and physical fitness have been associated with cognitive performance (Berkman, Seeman, Albert, Kahn & Mohs, 1993; Hertzog, Kramer, Wilson & Lindenberger, 2009; Silva et al., 2014; Yaffe et al., 2010).

An association between cognition and physical function has been shown to exist but the roles of muscle and brain structure in this relationship are not fully understood (Kilgour, Todd & Starr, 2014). The Brazilian population has cultural, economic, educational and lifestyle differences that must be considered and that interfere with cognition. Although the relation between physical and cognitive performance has already been extensively studied, the relation of these variables in a Brazilian elderly population was still little explored. In addition, the pattern between cognition and physical performance may vary between cognitively healthy and cognitive decline elderly, which may contribute to the neuropsychology of aging.

Of these variables, more recent studies have proposed an integration between measures of physical performance and cognitive performance in old age (Baker et al., 2017; Zammit et al., 2018). Physical fitness related to health status was defined as "a dynamic state of energy and vitality that allows not only the accomplishment of daily tasks, active occupations of leisure hours and to face unforeseen emergencies without excessive fatigue, but also to avoid the appearance of hypokinetic functions, functioning at peak intellectual capacity and feeling a joy of living "(Guedes, 1996, p.46).

Physical fitness encompasses physiological dimensions such as maximal aerobic power, strength, flexibility and components of body composition (Araújo & Araújo, 2000). These skills tend to decline with the aging process due to decreased cardiac capacity, loss of muscle mass, increased blood pressure and visceral body fat (Fechini & Trompieri, Silva, Souza, & Crepaldi-Alves, 2015; Kennedy, Hardman, Macpherson, Scholey, & Pipingas, 2016; Lima & Duarte, 2014).

The practice of regular exercise can slow the decline of these functions and improve others, such cognitive abilities. (Colcombe et al, 2004; Kennedy, Hardman, Macpherson, Scholey, & Pipingas., 2016; Kelly et al, 2014; Maki et al, 2012). Some studies suggested physical and cognitive performance are related by several ways: cardiorespiratory fitness was associated with 11% of improvement on visual attentional tasks (Colcombe et al. al., 2004; Liu-Ambrose et al, 2010); better cardiorespiratory and greater muscle strength capacity were associated with a reduction of 43% risk of dementias (Barnes et al, 2013; Gates, Singh, Sachdev, & Valenzuela, 2013; Kennedy et al., 2016).and resistance and aerobic exercise practitioners had improvement of 21% in memory functions (Antunes, De Mello, Santos-Galduróz, Galduróz, Lemos, Tufik, & Bueno, 2015).

Despite the several studies that examined these relationships, few studies have investigated Brazilian older adults. Educational, cultural and lifestyle characteristics of Brazilian older adults populations could explain different relationships between physical and cognitive abilities, especially less educational level and health care when they are compared with USA and European populations (Szwarcwald et al, 2017) To this, it is important to identify how physical and cognitive domains are related into a Brazilian population of cognitively healthy older adults and a population of older adults individuals with global cognitive decline.

Considering these questions, the present study integrates the research project "Evaluation of Two Interventions of Memory in Physiological, Cognitive and Mood Measures in the Elderly in the Distrito Federal, Brazil", whose objective are to intervene, evaluate and accompany the older adults among two years to measure the impact of physical and cognitive interventions. Therefore, the purpose of this specific study was to investigate, regarding pre-intervention, the relationship between physical and cognitive performance variables in Brazilian women elderly with or without cognitive decline. For this, we analyzed the association between measures of global cognitive performance, attention, memory and language with tasks associated with cardiorespiratory capacity, strength, body mass and body composition.

Method

Participants

The participants originates from a population of 85 older adults enrolled in a cognitive training program developed in Distrito Federal, Brasília. Of the total number of enrollees, 58 older adults were evaluated. However, to homogenize the sample and compare the participants in physical performance measures, were excluded males ($n = 10$) because we cannot compare men and women in physical measures, were excluded who had incomplete physical evaluation ($n=4$), summed 14 participants. Therefore, the final sample analyzed was 44 elderly women with and without cognitive decline (Scores below of cut-off MMSE according to Neri et al., 2013 criteria), mean age 67.77 ± 6.34 years (60-87).

Procedure

The procedures followed five steps. The first stage invited older adults through electronic media, social networks, and by disclosures in social groups, health services and social assistance services for older adults in Distrito Federal. The second stage consisted of an introductory lecture on memory and aging developed by the researchers of the Research Group (NeuroCog-Idoso) which participants had information about the objectives of our project. In the third stage, participants were assessed by cognitive evaluation tests after signing the Informed Consent Form (approved by Ethical Committee Research, nº CAAE: 67653517.4.0000.0029). In the fourth stage the psychological evaluations were performed and in the fifth stage the physical evaluation. The evaluations were carried out on three separate days, individually and with an average duration of one hour (each evaluation). The cognitive assessment was conducted by Gerontology

postgraduate students and Psychology undergraduate students, psychological assessment was conducted by Psychology students and physical assessment by a postgraduate student in Gerontology and physical educator under the supervision of a cardiologist. All participants were advised on the preparatory procedures prior to the physical evaluation, such as adequate food intake and wearing comfortable clothing for testing.

Instruments

The instruments applied were grouped into three types: sociodemographic, cognitive and physical tests. The sociodemographic evaluation was composed by age, sex, schooling, marital status and socioeconomic status (SES). SES was evaluated by the CCEB questionnaire (Critério de Classificação Econômica do Brasil) developed by the Brazilian Association of Survey Companies (Associação Brasileira de Empresas de Pesquisa, 2014) that classifies individuals into seven classes (in decrescent order of socioeconomic status): A1 (scores ranging between 42 and 46), A2 (35–41), B1 (29–34), B2 (23–28), C (18–22), D (14–17) and E (0–7).

The cognitive evaluation was composed by several tests of pencil and paper adapted and validated for Brazil, as shown below:

- Stroop (Stroop Color and Word Test) - to evaluate inhibitory control and selective attention (Stroop, 1935). In this study we chose the Execution Time in seconds in the condition of inhibition of semantically related words to the colors.
- RAVLT (Rey Auditory-Verbal Learning Test) - to evaluate the processes of learning, evocation and recognition of episodic memory (Salgado et al., 2011). Among the measures RAVLT chose to use as memory as episodic the sum of the five lists of words (A1 to A5) for gathering an indicator of the learning curve.
- Addenbrooke's Cognitive Examination- Revised (ACE-R) adapted and validated for Brazil (Carvalho & Caramelli, 2007) to assess global cognition functions. The ACE-R has a maximum score of 100 points and allows for a brief characterization of the following cognitive domains: attention and temporal and spatial orientation (ACE-A); visuospatial function (AVE-V); episodic memory (ACE-M); language (ACE-L) and fluency (ACE-F).
- MMSE (Mini Mental State Examination) - to assess the global cognitive status (Brucki et al., 2003). The dependent variable in the study used the sum of correct responses on the MMSE.

The classification of the older adults with cognitive decline was based on the cut notes used in the MMSE, being: 17 for the illiterate; 22 for the elderly with education between 1 and 4 years; 24 for those with schooling between 5 and 8 years and 26 for those with schooling equal to or greater than 9 years. These cutoff points were based on the criteria suggested by the Brazilian Academy of Neurology, based on the medians presented by Brucki et al. (2003), minus one standard deviation. The option for such cutting notes, also adopted in other Brazilian studies such as the FIBRA - Fragilidade em Idosos Brasileiros (Neri et al., 2013).

The physical evaluation was composed of several tests and physical measures, but for this analysis the following variables were collected:

- **Body composition** - Measurements of body composition (fat percentage, fat mass and lean mass) method were measured by dual energy X-ray absorptiometry (DXA). Measurements by DXA (DPX-L model, LUNAR Radiation, Madison, WI) were performed in a full-body scan. All scans were analyzed by a specialized investigator using the LUNAR Radiation version 1.2i DPX-L program for body composition analysis.
- **handgrip strength test** - After familiarization with the equipment, the participants were seated, with the shoulder in a neutral position, elbows flexed at 90° and wrist in the neutral position. The subjects were instructed to perform the maximum isometric contraction at the verbal command of the examiner. Three attempts were made alternating the limbs, with interval of 60 seconds. The procedure was performed respecting the criteria described by SHIRATORI (2014).
- **Ergospirometry test** - For the evaluation of the maximum cardiopulmonary capacity, the ergospirometry test was used, which can determine, with relative precision, the maximum VO₂ with the following data: a) presence of QR (VCO_2 / VO_2) > 1.1; b) existence of an anaerobic threshold (lactate threshold); (c) VE > 60% of the maximum forecast; e) possible presence of a plateau in the VO₂ before an increase in the load of effort. This test was performed with a ramp protocol, with an initial velocity of 3.0 km and a final velocity of 6.0 km, with an initial slope of 4% and a final slope of 14%, in a maximum time of 10 minutes

Data analysis

Initially, the descriptive data of the sample were analyzed through means, deviations and frequencies. For the inferential analyzes, the normality of all physical and cognitive variables by groups (with and without cognitive deficit and practitioners and non-practitioners of self-reported physical activity) by the Shapiro-Wilks test was first evaluated. In a second moment t tests were performed for independent samples (deficit group and physical activity group) for the comparisons of physical fitness variables. And at the end, we analyzed the correlation between physical and cognitive fitness variables. For all tests the level of significance was $p < 0.05$.

Results

Of the 44 women investigated, the majority were married and widowed, living with relatives and companions. Approximately 50% had education equal to or greater than 11 years of study, ¼ mentioned still working and approximately ⅓ of the sample that has not yet have retired, as shown in Table 1.

Table 1 - Sociodemographic Characterization of Older Women Enrolled in a Follow-Up Study of Training and Cognitive Stimulation

Variables		n (n=44)	%
marital status	single	4	9.1
	married	16	36.4
	live with partner	1	2.3
	widow	13	29.5
	divorced	10	22.7
	total	44	100%
schooling	elementary school incomplete	14	31.8
	complete primary education	6	13.6
	incomplete high school	2	4.5
	complete high school	14	31.8
	incomplete higher education	1	2.3
	complete higher education	7	15.9
	total	44	100%
job	yes	10	22.7
	no	34	77.3
	total	44	100%
retired	yes	27	61.4
	no	17	38.6
	total	44	100%
habitation	alone	6	13.6
	with partner	5	11.4
	with son	13	29.5
	with partner and son	7	15.9
	other people	13	29.6
	total	44	100%

We found that the group of women who reported regular practice of physical activity presented better performance in the variable cardiorespiratory capacity ($p = 0.01$) (Table 02).

Table 2 - Comparison of The Physical Fitness of Physical Activity Practicing and Non-Practicing Older Womens

Physical fitness variables	Physical activity	Mean	Deviations	P
dominant hand grip strength	yes (23)	44.97	13.23	0.16
	no (21)	50.25	10.85	
non-dominant hand grip strength	yes (23)	43.72	9.35	0.64
	no (21)	45.05	9.46	
fat percentage (%)	yes (23)	38.05	8.21	0.07
	no (21)	42.14	4.92	
fat mass (g)	yes (23)	25644.18	8547.20	0.06
	no (21)	30913.32	8515.65	
lean mass (g)	yes (23)	40272.45	4432.37	0.43
	no (21)	41602.68	6299.23	
cardiorespiratory capacity (vo2)	yes (23)	20.38	4.00	0.01
	no (21)	17.08	4.09	

Group that reported doing physical activity performed 2 to 3 times a week (91.3%), with weak to moderate intensity. When physical fitness was compared among elderly women with or without decline in the MMSE, no statistically significant differences were identified between the groups (Table 3).

Table 3 - Comparison of Physical Fitness Among Elderly Women With and Without Cognitive Decline

physical fitness variables	cognitive decline	mean	deviations	p
dominant hand grip strength	with (31)	47.24	12.21	0.83
	without (13)	48.10	13.03	
non-dominant hand grip strength	with (31)	43.32	9.51	0.26
	without (13)	46.82	8.68	
fat percentage (%)	with (31)	41.23	6.37	0.22
	without (13)	38.46	5.02	
fat mass (g)	with (31)	28812.37	8609.75	0.39
	without (13)	26104.91	9559.24	
lean mass (g)	with (31)	39989.10	5160.42	0.08
	without (13)	43342.91	5310.82	
cardiorespiratory capacity (vo2)	with (31)	18.60	4.57	0.58
	without (13)	19.40	3.81	

As shown in Table 4, the dominant hand grip strength in older women without cognitive decline was associated with Stroop performance, ACE-F, ACE-L and Total ACE-R (Table 4). In the group of elderly women with cognitive decline (not shown in Table 4), statistically significant correlations were observed only between Non-dominant Hand grip strength and Stroop ($r = 0.65$; $p = 0.015$); ACE-A ($r = 0.77$, $p = 0.002$), ACE-L ($r = 0.56$, $p = 0.043$), ACE-V ($r = 0.65$, $p = 0.014$); and finally between cardiorespiratory capacity VO₂ with the sum of RAVLT = 0.57, $p = 0.039$) and ACE-R Total ($r = 0.69$, $p = 0.009$).

Table 4 - Correlations Between of Cognitive and Physical Variables among Healthy Older Women (n = 31)

physical fitness/ cognition	values	stroop	ravlt	ace-a	ace- m	ace-f	ace-l	ace-v	ace-r total
dominant hand grip strength (Joules/Force)	r	-0.41	0.25	-0.79	0.53	0.42	0.48	0.33	0.41
	p	<u>0.024</u>	0.17	0.67	0.77	<u>0.018</u>	<u>0.005</u>	0.066	<u>0.022</u>
non-dominant hand grip strength (Joules/Force)	r	-0.42	0.14	-0.79	0.53	0.29	0.30	0.31	0.24
	p	<u>0.017</u>	0.45	0.67	0.77	0.10	0.09	0.08	0.18
fat percentage (%)	r	0.046	0.06	0.14	0.02	-0.046	0.034	0.10	0.056
	p	0.809	0.734	0.44	0.89	0.80	0.86	0.56	0.76
fat mass (g)	r	-0.085	0.259	0.17	0.13	0.04	0.21	0.15	0.19
	p	0.65	0.16	0.34	0.49	0.82	0.24	0.43	0.30
lean mass (g)	r	-0.22	0.29	0.15	0.13	0.19	0.29	0.06	0.23
	p	0.22	0.11	0.40	0.46	0.30	0.11	0.73	0.20
cardiorespiratory capacity (vo2)	r	-0.04	0.03	0.02	0.11	0.11	0.11	-0.044	0.10
	p	0.79	0.84	0.88	0.53	0.53	0.53	0.81	0.56

Legend: ace-a - attention and orientation domain; ace-m - memory domain; ace-f - fluency domain; ace-l - language domain; ace-v - visuospatial domain;

Discussion

In the present study the dominant hand grip strength in Brazilian older women without cognitive decline was associated with attention and inhibitory control performance of Stroop, global cognitive performance and verbal fluency and language subdomains of ACE-R. In the sample of women with cognitive decline, we observed correlations between Stroop and non-dominant hand strength, and between VO2 cardiorespiratory capacity with the learning curve in RAVLT, global cognitive performance and attention, language and visuospatial subdomains of ACE-R. It is important to emphasize that physical fitness was similar between the groups (with and without cognitive decline) and that although approximately 50% of the total sample reported having self-reported some physical activity practice 2 to 3 times a week (91.3%) of low to moderate intensity, the cardiorespiratory capacity in our sample was weak.

Recent research corroborates our data, associating strength how an indicator of better cognitive performance in old age and also as an indicator of better health and functional performance (Santos et al, 2017; Smolarek et al, 2016; Taekema, Gussekloo, Maier, Westendorp, & Craen, 2010). In a study with older Korean women Kang et al. (2016) found that higher strength was associated with better global cognitive performance. Blankevoort et al. (2013) found a relationship between strength, global cognition and executive functions measured by the Stroop test and tests of planning, visuomotor attention and alternation; after adjusting the analyzes by gender.

Based on this, the relationship between strength and cognitive variables may be related to functionality and to physiological, hormonal and systemic pathways. From the functional point of view, strength can subsidize better functional performance in activities related to self-care and the

maintenance of an independent life, and these activities, in turn, are related to social interaction, communication and the continuous stimulation of mental abilities ('Use it or Lose it' hypothesis - Hertzog, Kramer, Wilson & Lindenberger, 2009; Barnes et al., 2007; Willis & Schaie, 1986).

From the physiological point of view, insulin, growth hormone; cortisol; and inflammatory markers could have bidirectional associations with indicators of cerebral reserve and muscle function, such as interleukins and TNF; and by neuronal protection markers such as the Brain-derived neurotrophic factor (BDNF) and related to angiogenesis and neurogenesis (Morley & Malmstrom, 2013). All these factors can be modulated by the sustained practice of physical activity and allow the regulation of homeostasis and consequently the better cognitive performance in old age (Morley & Malmstrom, 2013).

Relative to muscle mass and body fat mass there was no direct association between body composition, muscle mass and cognitive performance, different of Tyrovolas et al. (2016) that found a skeletal muscle mass correlated with successful aging scores (as better cognition, physical performance, absence of disease and increased engagement with life) even after adjusting for sex, home arrangement, alcohol consumption, smoking, and tea. It can be seen that body fat may play a protective role in relation to aging-related metabolic changes, especially at later ages (after 75 years) when conferring a metabolic reserve capacity (Rissanen et al., 1988). In addition, as the age increases, body fat increases and the percentage of water and muscle decreases (Rissanen et al., 1988). The homogeneity of the sample investigated in relation to fat and body mass may explain why they were not associated with cognitive performance.

Other fitness variables such as VO₂ have already been highlighted in longitudinal studies with healthy adults and older adults (Wendell et al, 2014). In an 18-year follow-up study, Wendell et al. (2014) found that lower the VO₂ the more accelerated the trajectory of cognitive decline (verbal memory, visual memory and global cognition) over time. Others studies suggested that cardiorespiratory fitness are related to hippocampal volume (Dougherty et al., 2017), better memory performance in the older adults (Hayes, Hayes, Williams, & Verfaelle, 2017) and lower inflammatory levels (C-reactive protein, CRP) and a higher level of BDNF, which influence higher working memory performance in adults from 18 to 29 years of age, regardless of schooling and IQ (Hwang, Castelli & Gonzalez-Lima, 2017). These data are in line with our study that found association between VO₂, RAVLT learning curve - verbal memory test and ACE-R subdomains, although these correlations were only found in the population of elderly women with cognitive decline.

In summary, our findings have implications for the neuropsychology of aging considering that the assessment of cognitive abilities can be allied by physiological markers that integrate healthy aging. Our findings also indicate that physical fitness indicators are also associated with cognitive performance in older adults with cognitive decline, indicating that it is also possible to remedy impairment in this group through multimodal

interventions focused on physical activity (Eggermont, Swaab, Luiten, & Scherder, 2006; Kennedy et al., 2016; Martelli, 2013).

Although these findings promote an important discussion, the correlations presented do not allow us to establish a cause-effect relationship, which does not allow us to conclude that having a good cognitive performance leads to better physical performance, or vice versa. In addition, the limitations of this study include not having controlled the analyzes for clinical measures that could affect the level of physical performance; the small sample number and the low scores in different values of physical fitness, even considering that approximately 50% of the sample has reported doing some type of activity. Conclusions that are consistent with the results of this initial exploratory study and the perspectives of the future studies of the NeuroCog-Idoso group includes the longitudinal assessments of cognitive and physical training.

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