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Chapter

Comparison of Cognitive Performance between Elderly Training Practices with Weights and Sedentaria

Emily Karoline Bezerra Ribeiro,
Bianca Dayse da Silva Nascimento,
Marlon Madeiro Brasiliano,
Gabriel Barreto Fernandes de Almeida Gomes,
Danny Paollo Leite de Arruda,
Wanessa Kelly Vieira de Vasconcelos,
José Fellipe Soares Maranhão, Eric de Lucena Barbosa,
Leonardo da Silva Leandro,
Marcos Antônio Araújo Leite Filho,
Ramon Cunha Montenegro and Carlos Renato Paz

Abstract

Comparison of cognitive performance among elderly people practicing training with weights and sedentary lifestyle. Estudy descriptive, cross-sectional and comparative, composition for 24 elderly between 60 and 70 years, divided into 2 groups, (G1) submitted to weight training and sedentary (G2). The G1 was submitted to 32 training sessions with traditional weight. Both groups were submitted to CogState® computerized cognitive testing batteries. The data were not parametric, using the Kolmogorov-Smirnov test for the analysis of the dispersion curve and the Mann-Whitney test in the comparison of the cognitive performance variables. The results were performed with a significance level of 0.05 by the Statistical Package for the Social Sciences (SPSS®), version 16.0. The best cognitive performance was observed among the elderly practicing resistance exercises, as well as significant differences in the TRS and TRE variables. Elderly people who exercise with weights when compared with cognitive performance demonstrate results of the paradigms when compared to the elderly. With this, he concludes that weight training is effective in improving cognitive performance.

Keywords: weight training, CogState®, cognitive performance, aging, elderly

1. Introduction

There is great variability in cognitive aging among individuals, given the heterogeneity of biological, socioeconomic, cultural, and environmental aspects which can modulate this process. Advanced activities of daily living (AADLs) are a set of leisure activities performed on free time, independently from work, which includes volunteering, educational activities, and social participation in the community, being this dependent on personal motivation. The effects of retrogenesis are a natural process to which every individual may or may not pass, due to a number of circumstances. The effects arising from retrogenesis are cognitive and motor slowness, followed by behavioral and psychic changes, with structural and functional changes taking place, causing neural impoverishment and irreversible functional decline, which cannot be regarded as a disease but rather as a natural aging process that subsequently will induce a new process, which will form a new organization for compensating for cognitive declines [1, 2] of psychomotor function, attention, visual learning and working memory (MT). These cognitive domains are fundamental variables for a healthy life for us human beings, the psychomotor function.

In gerontological literature, AADLs may indicate good physical and mental health, and reduced engagement in these activities may suggest the onset of functional decline, cognitive impairment, and frailty. The science today aims to study the body in motion in relation to the world, with the conception of integrated and organized movements improving body movements as motor coordination, balance, and attention, which in turn is an essential skill for good adaptive and oriented functioning, are associated with the cognitive domain that enables the elderly to process all information or actions relevant to the thinking of certain tasks, leaving distracting and irrelevant stimuli aside [3], and constituting a facilitating mechanism for neural responses according with the centralization of the mental processes of a given task [4].

Rowe and Kahn [5] suggested that commitment to life is one of the essential aspects of successful aging and may delay the onset of chronic diseases and high physical and cognitive performance. Walking independently requires cognitive and motor processing whose mechanisms involved are related to attentional resources, executive functions, and the sensory and musculoskeletal systems. It is a consensus in the literature that locomotion is a factor directly related to the preservation of physical independence, performance of activities of daily living, and social interaction. The visual learning in the elderly has a key role in motor development, placing it with the external reality, providing various stimuli that help in orientation, and in their body control, enabling the ability to know, interpret, and differentiate various stimuli visually received. Vision has a direct participation in the organization and conscious and safe voluntary motor action.

Working memory enables the elderly to keep information in their mind at the moment they use it, searching for information relevant to their activities and performing other tasks, such as the relationship of different ideals, such as mental calculations, ordering and sequencing current and past events including consideration of facts or ideas that may come from different points of view. Once this decline is detected through testing, then we can organize cognitive and physical exercises to maintain a healthy life for the elderly and research on cognitive interventions indicating that cognitive training can lead to increased performance and maintenance of cognitive skills in healthy elderly [6–8].

Aging is a natural and inherent process, being associated with several physical, physiological, psychological, and social changes. Among these changes, there is a decline in cognitive performance, being negatively associated with age and cognitive degenerative diseases such as Alzheimer's disease, causing impairment in the autonomy, independence, and quality of life of the elderly, being aggravated by the sedentary lifestyle. These damages are even greater in women, which caused aging process to be more complex due to hormonal and cultural factors. However, research conducted in recent years has shown the efficacy of physical activities on the morphological, responses, and cognitive performance of the elderly of both sexes [9–11]. Successful aging goes beyond disease-free and maintenance of functional capacity. AADLs depend on the preservation of physical and cognitive functions and are influenced by gender, age and health conditions, education, marital status, and place of residence [12].

Physical activity has become a non-pharmacological and efficient approach in the prevention and treatment of elderly people suffering from degenerative diseases, besides generating benefits in balance, strength, endurance, and flexibility. Within the vast modalities of physical activity, being the training with weights (TW) or bodybuilding, as it is popularly known, the number of elderly people of this modality is increasing, providing autonomy and independence. In TW programs, when supervised by trained professionals, they have beneficial effects on memory performance and cognitive functioning and in waveform protocols of weekly bodybuilding overloads and demonstrate the effectiveness in the expansion of maximal muscle strength, proving that the active lifestyle influences the maintenance of the functional capacity of the elderly [13–16].

According to Antunes et al. [17], the stages of information processing of cognitive function or cognitive functional system are memory, learning, attention, perception, reasoning, vigilance, and problem-solving; in addition, psychomotor functioning, reaction time, and time of movement and performance have been consistently included in this concept. The practice of physical activity has shown benefits in the quality of life of the elderly as well as improvement in cognitive performance, when compared to the sedentary ones [11]. Given the assumption, the objective of the present study was to compare the performance of elderly practicing training with weights with sedentary.

Although accumulated knowledge allows us to understand that activities establish associations with cognitive performance in old age, the way these variables interact generates debate. One of the questions asked is whether there would be a cause-and-effect relationship between AADL performance and cognitive performance and predisposing factors for participation. The question is whether the elderly who engaged in cognitively complex activities would have greater cognitive or cerebral reserve or if they demonstrate gains from participation even with low cognitive reserve.

2. Methods

2.1 Detection test

The detection test uses a simple reaction time paradigm to measure processing speed in healthy volunteers in just 3 min and cognitive domain and psychomotor function. The detection test is applied with the supervision, in this case, the researcher. The test includes virtual card by computer, iPad, or tablet, universally understood, regardless of language or age; after reading, the test is started by pressing the "enter" key. In the center of the screen, a sequence of cards will appear, and the volunteer has to press the "yes" key, whenever the presented card is correct, as quickly and accurately as possible, for example, should try not to press the "yes" key. Before the card is flipped, if this happens or is not answered, this time is counted, and you will hear an error sound.

The average reaction times are transformed by the log10 unit of measurement for correct answers. The result of the detection test is the average reaction time to which the elderly responded correctly; a higher value indicates a slower response.

2.2 Identification test

The identification test (T.Id) uses a reaction time (or reaction time of choice) paradigm to measure attention, administration time in healthy and only 3-minute volunteers, and cognitive mastery and attention. In this test the objective is to identify if the card is "red" or "black." If the card is red, the elderly should press the "yes" key as soon as possible; if not red, the elderly should press the "no" key. In this test, the senior should not try to press the "yes" or "no" key before the card turns; if this happens, he will hear an error sound and so on.

There is no other way as the program measures by units. The result of the identification test is the performance speed at which the elderly responds to the test; the response performance speed time is transformed into an average of log10, where the correct answers with a lower score will indicate better performance.

2.3 One-card learning test

The visual learning test uses a standard separation paradigm to measure visual memory and administration time in healthy volunteers in just 6 minutes. In this test the objective is to identify if the card that is revealed had appeared before, so the first answer will be "no." Each time a card is revealed, the senior must decide if the card that is being presented appeared before, always answering as quickly and accurately as possible "yes" or "no"; the volunteer should not try to answer before the card is turned, and the volunteer should try to remember all the cards that are presented in this test. If an incorrect answer is given (e.g., "no" or anticipates the answer), an error noise is heard.

The outcome measure of the test is the performance accuracy when the elderly responds to the test, the square root arc transformation of the proportion to the responses, where a higher value indicates better performance.

2.4 One-back test

The one-lap test uses an n-back paradigm to measure working memory; administration time in healthy volunteers is only 4 min, and the measured cognitive domain is working memory. Learning test application is done with the supervision of the test supervisor. The instructions for the test are the same as the previous tests.

The average reaction times are transformed by log10 for correct responses, and the performance assumption is the square root arc transformation of the proportion of correct responses, where a higher value indicates worse performance.

The main body is where the author explains experiments and presents and interprets data of one's research. This research had a descriptive, cross-sectional, and comparative characteristic, which compared the cognitive performance of elderly exercising with weight and sedentary exercises [18]. The study population consisted of male seniors enrolled in the bodybuilding extension of the physical education course of UNIPÊ. The sample consisted of 40 elderly individuals, selected by non-probabilistic and random procedure, with age range between 60 and 70 years of age and with 20 training practitioners with weight and 20 sedentary.

The evaluations were carried out in the physical evaluation laboratory LAF-UNIPÊ/SANNY of the physical education course of UNIPÊ, for presenting favorable conditions and adequate material that allows the reliable application of the research. Participants received an informative report with all the procedures performed in the research. Then, an information document containing all the details regarding the date, time, and place of the research, along with the free and informed consent term, was delivered. The study included elderly between 60 and 70 years old, completed high school and has basic computer skills. The following elderly were excluded from the study: they lacked at least three weight training sessions and did not attend the morphological, neuromuscular, and cognitive tests.

After the selection, 24 elderly subjects were divided into 2 groups, being G1 submitted to weight training and G2 control group (sedentary). The G1 underwent 32 training sessions weighing 3 times a week, lasting 40 min, with weekly load progression. The program was developed with a goal of muscular strength (range of three to six repetitions—2 min intervals between the series), developed by a traditional methodology (weights, repetitions series, and fixed intervals), system located by articulation (execution of exercises for lower limbs and upper limbs on separate days), and dynamic work (execution of isotonic exercises), while G2 remained sedentary.

The present work complied with the norms for conducting research on human beings, resolution 466/12 of the National Health Council, following the recommendations of the Statute of the Elderly, Law 10741/2003. CAAE: 51751415.0.0000.5176.

One of the CogState® computerized cognitive testing batteries was used to evaluate cognitive performance, which consists of four tests: simple reaction time (SRT), reaction time of choice (CRT), working memory, and sustained attention (SA), where the four tests were applied in the study. The tests were composed of the following variables: detection test (DET) (Det_Rap = speed detection, Det_Pr = precision detection, Det_Ac = detection hits, Det_Er = error detection, and

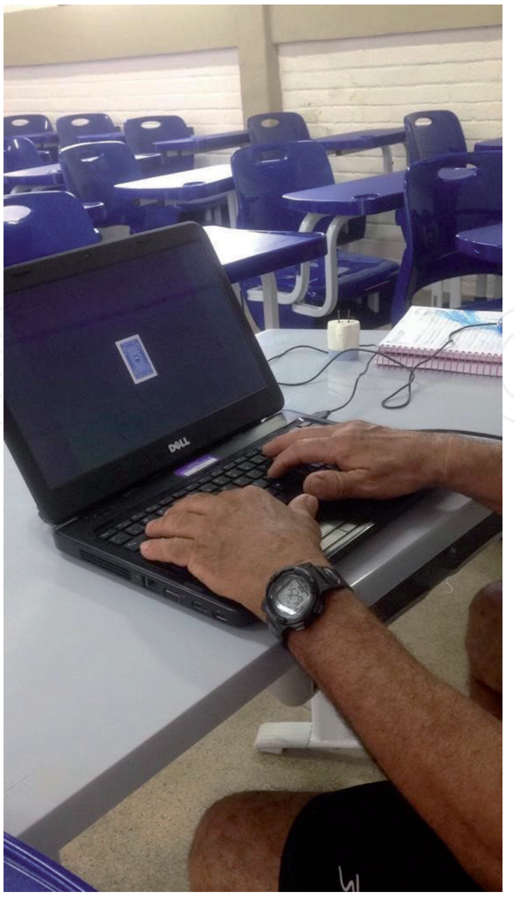

Figure 1.
Image acquired during research.

Performance cognitive tests	Variables	Elderly WT (n = 20)		Sedentary (n = 21)		Mann-Whitney	
		M ± Sd	Min_Max	M ± Sd	Min_Max	"U"	Sig.
Simple reaction time (SRT)	Det_Spee (ms)	359.8 ± 83.52	266_494	639.25 ± 330.02	238_1202	68,000	0.022
	Det_Pr (ms)	95.68 ± 5.65	84.4_100	81.00 ± 21.91	20.6_100	70,000	0.025
	Det_Hit (ms)	35.46 ± 1.13	35_39	34.25 ± 3.75	23_39	114,500	0.507
	Det_Er (ms)	0.38 ± 0.65	0_2	4.60 ± 6.12	0_20	67,500	0.014
	Det_Ant (ms)	1.50 ± 2.11	0_6	8.00 ± 18.80	0_85	86,000	0.093
Choice reaction time (CRT)	Det_Spee (ms)	534.45 ± 86.67	388_741	765.71 ± 321.21	443_1605	121,500	0.021
	Det_Pr (ms)	89.05 ± 18.35	37.3_100	72.65 ± 30.54	1.5_100	147,500	0.099
	Det_Hit (ms)	29.10 ± 3.06	17_30	27.90 ± 8.06	1_37	177,000	0.284
	Det_Er (ms)	3.45 ± 7.61	0_27	8.43 ± 11.15	0_40	153,500	0.132
	Det_Ant (ms)	1.60 ± 4.11	0_18	8.90 ± 16.99	0_57	138,000	0.043
Sustained attention (SA)	Lac. Spee (ms)	904.70 ± 125.87	756_1137	1265.10 ± 550.64	799_2225	31,000	0.151
	Lac. Pr (ms)	56.25 ± 7.80	42.9_68,2	59.92 ± 9.49	39.8_74.4	33,500	0.212
	Lac._Ac (ms)	50.70 ± 6.67	39_60	53.40 ± 8.50	35_67	37,500	0.344
	Aoc_Er (ms)	37.30 ± 6.67	28_49	34.60 ± 8.50	21_53	37,500	0.344
	Aoc_Ant (ms)	2.30 ± 3.56	0_10	1.10 ± 1.66	0_5	44,000	0.608

Performance cognitive tests	Variables	Elderly WT (n = 20)		Sedentary (n = 21)		Mann-Whitney	
		M ± Sd	Min_Max	M ± Sd	Min_Max	"U"	Sig.
Working memory (MT)	Speed_Rap (ms)	1002.65 ± 294.18	662_1732	1178.40 ± 421.6	667_2169	152,000	0.194
	Speed_Hit (ms)	28.75 ± 6.95	2_31	27.85 ± 7.40	10_36	197,000	0.924
	Speed_Er (ms)	8.30 ± 7.79	0_31	9.40 ± 8.62	0_29	192,000	0.828
	Speed_Sot An (ms)	0.55 ± 1.39	0_5	6.40 ± 13.35	0_50	112,000	0.006
	Sp_oT (ms)	77.63 ± 21.87	5.6_100	68.54 ± 25.82	23.8_100	164,500	0.336

*Legend: Elderly WT = elderly exercise practitioners with weight; M = mean; Sd = standard deviation; Min = minimum; Max = maximum; DET = detection test (Det_Speed = speed detection, Det_Pr = precision detection, Det_Hits = detection hits, Det_Er = error detection, and Det_Ant = detection of anticipation); T.Id = identification test (Id_Speed = speed identification, Id_Pr = precision identification, Id_Hit = identification of hit, Id_Er = error identification, and Id_An = identification in anticipation); LC = learning from a card (L. SC = learning speed card, L. CA = learning card accuracy, L. CS = learning card successes, and LC_Er = learning card errors; LA = learning anticipation, Speed Er = speed of errors; Sp A = speed of anticipation; Sp oT = Sig = Significance; **

Table 1.
Descriptive and comparative values of cognitive performance among elderly weightlifters and sedentary trainers.

DOI: http://dx.doi.org/10.5772/intechopen.89264

Det_Ant = detection of anticipation); identification test (Id_Rap = speed identification, Id_Pr = precision identification, Id_Ac = hit ID, Id_Er = error identification, and Id_An = Idle ID); learning from a card (AC) (AC_Cap = learning speed card, AC_Pr = learning card accuracy, AC_Ac = learning card successes, AC_Er = learning card errors, and AC_An = learning anticipation card); and one volta (UV) (Vel_Rap = Fast speed, Pr_Volta = precision velocity, Vel_Ac = speed of hits, Vel_Er = speed of errors, and Vel_An = speed of anticipation). The values obtained from the tests will be presented in milliseconds (ms).

The tests were composed of the following variables: detection test (speed detection; precision detection, detection hits, error detection, and detection of anticipation), identification test (speed identification, precision identification, identification of hit, error identification, and identification in anticipation), learning from a card (learning speed card, learning card accuracy, learning card successes, learning card errors), and learning anticipation (LA) (speed of errors and speed of anticipation). The values obtained from the tests will be presented in milliseconds (ms).

The data were collected in two stages, the first one after the selection of the elderly, who passed the battery of the four tests, taking from this result the mean, standard deviation, and maximum and minimum time reached in each test. The second stage was produced with elderly practicing resistance exercises, where they passed the same battery of the four tests, thus also generating the mean, the standard deviation, and the maximum and the minimum of time in each test. Prior to the application of the tests, it was necessary to perform a demonstration of the protocol to facilitate the understanding and learning of the test; later, it was applied in a definitive character with duration of 10 min.

The CogState® computerized cognitive evaluation battery is composed of the identification tests, with the purpose of measuring attention, using the reaction time of choice paradigm (RTC); its cognitive domain is attention and the performance measure is the speed of performance. The detection test aims to measure performance velocity using the simple reaction time paradigm, and its cognitive domain is the psychomotor function and has performance velocity as the measure of results. The learning test mediates visual memory using the pattern separation paradigm (SP); its cognitive domain is visual learning, and the measure of result is performance accuracy. The one-turn test mediates working memory. The number of laps (NV) paradigm has cognitive domain as the working memory; its performance measure is performance speed [19] as shown in **Figure 1**.

The information presented underwent quantitative analyzes, and the number of positive and negative responses was evaluated, divided by the number of attempts. The data were classified as no-parametric with the Kolmogorov-Smirnov test of the dispersion curve, and the cognitive performance variables were compared with the Mann-Whitney U test (**Table 1**). The procedures were performed with significance level of $p < 0.05$ using the Statistical Package for the Social Science, Version 25.

3. Discussion

Elderly practicing weight exercises, demonstrated better cognitive performance than the sedentary ones in the detection tests with the simple reaction time, Identification paradigm with the time paradigm of Reaction of Choice and the One Turn (UV) test that has the working memory paradigm.

In the present study, in the investigations of Dias et al. [20] with 104 elderly people, where the differences in the cognitive aspects between physical exercise practitioners (G1) and non-practitioners (G2) were evaluated, it was observed that

G1 showed better than G2, in the tests that evaluated the reaction time of choice paradigms where they obtained a reduction of 104.45 ms; in the time of simple reaction, the reduction was of 86.54 ms. However, the results differed according to the working memory paradigm, when G1 showed worse performance than G2. The study used the same battery of cognitive tests as the present study.

In a comparative study of active, intermediate, and sedentary elderly women presenting different histories of physical and intellectual activity, a trend was observed among sedentary elderly women, presenting a lower performance in the tests with SRT and SRT paradigms than the physically active elderly women. However, the study did not show statistically significant differences, differing from the present study where there were significant differences in the SRT and SRT paradigms. Luft et al. [21] point out that this may have occurred due to the aging process being more complex in the elderly.

Contrasting to the results of the present study, the Rossato et al. [22] analysis, where they investigated the correlation between the reaction time and cognitive status in 77 elderly women practicing physical activities, presented a satisfactory performance in the Mini score (MNSE), which averaged 26.56 points, and for the simple reaction time paradigm, it was unsatisfactory where the mean was 605.65, and it was found that there was a statistically significant correlation between the SRT paradigm (ms) and the cognitive state of $p = 0.023$, however, the weak relation.

It is worth mentioning that the protocol performed in the mentioned study is different from the current one, being considered gold standard. The same case occurs in the analyses of Corazza et al. [23], performed with 90 elderly, called (G1) practitioners of regular physical exercises and (G2) non-practitioners, in which the simple response time tests were compared (RTC), where there were no significant differences between groups G1 and G2; for the TRS paradigms obtained only a reduction of 0.33 ms and for ERT of 1 ms, diverging from the present study. These results can be explained by the virtue of the instrument used; in addition to that, the above study correlated reaction time with cognitive status exclusively in elderly women practicing physical activity.

Findings by Lachman et al. [24], with 210 elderly practicing resistance training, obtained an improvement in the working memory paradigm, only in the group with the greatest evolution of loads during training. The same occurs in the study of Cassilhas et al. [25]; however, 62 elderly subjects were submitted to 24 weeks of training in 2 intensities. Meanwhile, in the study by Busse et al. [15], a significant improvement was verified in the tests of mental behavior of memory and muscular strength, in addition to the occurrence of an improvement in the performance of the memory and work paradigm.

It is understood as working memory, the cognitive component connected to memory, which allows the temporary storage of information with limited capacity. According to Alloway [26], the limited capacity of working memory varies greatly between individuals and is closely related to learning skills. In addition to manipulating new information from the sensory pathways, it connects with long-term memory, that is, with the knowledge already stored.

Thus it is evident that the practice of resistance exercises can contribute significantly to improvement or at least to maintenance of some components of cognitive function, when compared to non-practicing elderly.

4. Conclusions

Physical activity represents an important non-medicinal contribution to the evolution of cognitive performance. However, it is necessarily based on literatures, the analysis of the intellectual activity of the elderly, when subjected to treatments through specific physical exercises to improve cognitive performance.

Weighing elderly individuals undergoing cognitive performance assessment demonstrates better results for the simple reaction time, choice reaction time, and working memory paradigms than the sedentary elderly. Thus, we conclude that weight training is effective for improving cognitive performance.

Acknowledgements

Own financing.

Conflict of interest

There is no conflict of interest between the authors.

Acronyms and abbreviations

DET	detection test
Det_Spee	speed detection
Det_Pr	precision detection
Det_Hits	detection hits
Det_Er	error detection
Det_Ant	detection of anticipation
T.Id	identification test
Id_Spee	speed identification
Id_Pr	precision identification
Id_Hit	identification of hit
Id_Er	error identification
Id_An	Id in anticipation
LA	learning from a card
L. SC	learning speed card
L. CA	learning card accuracy
L. CS	learning card successes
LC_Er	learning card errors
L A	learning anticipation
Speed Er	speed of errors
Speed A.	speed of anticipation
ms	the values obtained from the tests will be presented in milliseconds

Author details

Emily Karoline Bezerra Ribeiro[1,2]*, Bianca Dayse da Silva Nascimento[2], Marlon Madeiro Brasiliano[1], Gabriel Barreto Fernandes de Almeida Gomes[1], Danny Paollo Leite de Arruda[2], Wanessa Kelly Vieira de Vasconcelos[1], José Fellipe Soares Maranhão[1], Eric de Lucena Barbosa[1], Leonardo da Silva Leandro[1], Marcos Antônio Araújo Leite Filho[2], Ramon Cunha Montenegro[2] and Carlos Renato Paz[3]

1 LABOCINE-Laboratory of Cineanthropometry, Universidady Federal University of Paraiba (UFPB), João Pessoa, Brazil

2 Physical Evaluation Laboratory (LAF-UNIPÊ/SANNY), Federal Institute of Education, Science and Technology of Paraíba (IFPB), Brazil

3 Laboratório Labocine, Brazil

*Address all correspondence to: emilyribeiroef@gmail.com

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