

**Daily physical activity changes the brain activity, functional autonomy and frailty of elderly**

**Atividade física habitual altera a atividade cerebral, autonomia funcional e fragilidade de idosos**

**La actividad física diaria cambia la actividad cerebral, la autonomía funcional y la fragilidad de los mayores**

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## **Abstract**

**Introduction:** In Brazil, 13% of the population is composed of people with upper than 60 years, and is estimated that this number will be 29,3% in 2050. **Objective:** The goal of the study was to determine the profile and correlation between the variables: brain activity, functional autonomy, and frailty of the elderly with different daily physical activity. **Methodology:** Were selected 60 elderly inserted on an active and healthy aging program, with different levels of daily physical activity, of both sex, age upper than 60 years, and physical and cognitive functions preserved. Were evaluated frailty, functional autonomy, and daily physical activities, besides brain activity through an electroencephalogram, using as reference the international system 10/20. **Results:** The results showed that the more active participants got better results in functional autonomy and frailty tests, and also had recorded more brain activity in areas related to executive functions. **Conclusion:** The more active participants got better punctuations in functional autonomy and frailty tests, besides also got a higher brain activity. However, although the relationship found to have a background in the scientific literature, only the correlation between the frailty and functional autonomy scores was statistically significant.

**Keywords:** Aging; Frailty; Motor activity; Electroencephalography.

## **Resumo**

**Introdução:** No Brasil, os dados indicam que 13% da população é formada por pessoas com mais de 60 anos, e estima-se que esse número possa subir para 29,3% em 2050. **Objetivo:** O estudo teve como objetivo determinar o perfil e a correlação entre as variáveis: atividade cerebral, autonomia funcional e fragilidade de idosos com diferentes demandas de atividade física habitual. **Metodologia:** Foram selecionados 60 idosos de um programa de desenvolvimento do envelhecimento ativo e saudável, com diferentes atividades físicas diárias, de ambos os gêneros, com idade superior a 60 anos e capacidade física e cognitiva preservadas. Foram aplicados testes de fragilidade, autonomia funcional e atividades físicas habituais. Além disso, foi medida a atividade cerebral através de um eletroencefalograma utilizando-se como referências os pontos do sistema internacional 10/20. **Resultados:** Os resultados mostraram que os participantes mais ativos tiveram melhor pontuação tanto no teste de autonomia funcional quanto no teste de fragilidade, além de apresentarem maior atividade cerebral nas áreas relacionadas às funções executivas. **Conclusão:** Os participantes

mais ativos obtiveram melhores pontuações nos testes de autonomia funcional e fragilidade e também apresentaram maior atividade cerebral em áreas relacionadas às funções executivas. Contudo apesar de se encontrar respaldo na literatura científica, apenas a correlação entre os escores da fragilidade e da autonomia funcional se mostraram estatisticamente significativas.

**Palavras-chave:** Envelhecimento; Síndrome da fragilidade; Atividade motora; Eletroencefalografia.

## Resumen

**Introducción:** En Brasil, el 13% de la población está compuesta por personas mayores de 60 años, y se estima que este número será del 29,3% en 2050. **Objetivo:** El objetivo del estudio fue determinar el perfil y correlación entre las variables: actividad cerebral, autonomía funcional y fragilidad del anciano con diferente actividad física diaria. **Metodología:** Se seleccionaron 60 ancianos insertados en un programa de envejecimiento activo y saludable, con diferentes niveles de actividad física diaria, de ambos sexos, edad superior a 60 años, y funciones físicas y cognitivas conservadas. Se evaluó la fragilidad, la autonomía funcional y la actividad física diaria, además de la actividad cerebral mediante un electroencefalograma, utilizando como referencia el sistema internacional 10/20. **Resultados:** Los resultados mostraron que los participantes más activos obtuvieron mejores resultados en las pruebas de autonomía funcional y de fragilidad, y también registraron más actividad cerebral en áreas relacionadas con las funciones ejecutivas. **Conclusión:** Los participantes más activos obtuvieron mejores puntuaciones en las pruebas de autonomía funcional y de fragilidad, además también obtuvieron una mayor actividad cerebral. Sin embargo, aunque la relación se encontró con antecedentes en la literatura científica, solo la correlación entre los puntajes de fragilidad y autonomía funcional fue estadísticamente significativa.

**Palabras clave:** Envejecimiento; Fragilidad; Actividad motora; Electroencefalografía.

## 1. Introduction

The current times are characterized by a chain of previous historical, philosophical, economic, political, and social changes that have promoted humankind's essential legacy. One of the most remarkable characteristics of this process is the continuous increase of the elderly population contingent all over the entire world (United Nations, 2017).

As the population grows older, it's expected the increase of frailty cases. It promotes the increase of older people's dependence to perform their daily life activities and

vulnerability to diseases due to the impairment of homeostasis mechanisms, the onset of chronic incapacitating disorders, decreased muscle strength, mobility, and balance (Felippe & Campos, 2017).

Besides that, another factor impacted by aging is how different brain functional areas intercommunicate efficiently (Varela, Lachaux, Rodriguez, & Martinerie, 2001). Such intercommunication has been denominated as functional brain connectivity, and recent evidence has shown a correlation between this functional connectivity and a variety of cognitive and motor functions (Solcà, Mottaz, & Guggisberg, 2016).

Thus, it is considered that the practice of any physical activity, and not just systematic physical exercises, is a way to maintain and/or increase the functionality of people during the aging process. However, it does not mean that specific planning of physical exercises is not essential for promoting health and maintaining the functional capacity of the elderly (Ferreira, Maciel, Costa, Silva, & Moreira, 2012).

Thus, the objective of this study was to determine the variables profile: brain activity, functional activity, and the elderly's cognitive performance according to different daily physical activity demands.

## **2. Methodology**

The methodology employed in this study was evaluated and approved by ISECENSA's Ethics Committee for Human Research, receiving number 2.779.749. The study's universe was 2000 individuals, both genders, inserted in a program of active and healthy aging promoted by the town government.

For inclusion, the participants had to be at least 60 years old, they are inserted in some of the services offered by program of active and healthy aging and must exhibit the minimal conditions required for the practice of physical exercises, besides voluntarily sign the term of free and informed consent.

Were ineligible for the study all individuals who had diagnoses of chronic diseases that prevent them from practicing physical exercises and/or performing the proposed dynamics at the methodology, or even if they had a hearing or visual problems that would not be compensated by the use of an external device.

Of the total universe of elderly attended by the active and healthy aging program, 60 individuals were selected because they were present at the cohabitation houses when the data were recorded. So, the study sample comprised the elderly, with an age average of  $72 \pm 8$

years, being 18% male and 82% female participants. Analysis of participants' records provided by the cohabitation houses management indicated they were all from the same socioeconomic background.

Evaluation of participants' daily physical activity was made by the Baecke questionnaire modified version specifically developed by Voorrips, Ravelli, Dongelmans, Deurenberg, & Van Staveren (1991) for the elderly. This tool ranks individuals according to a score in numbers. From the test score, it is possible to classify the individuals as sedentary (score < 9), active (score between 9 and 16), or very active (score > 16) (Guedes, P. D.; Guedes, C. L. C.; Pinto, 2009).

An electroencephalogram device (Neurotec, Neuromap EQSA260 model, made in Brazil) was used to assess in real-time the brain activity of Alpha and Beta brain waves frequencies at the specific points of the cerebral cortex. The points chosen for this study were F7 – related to visual and auditory working memory, selective and divided attention; F8 – related to visual and spatial working memory, emotional processing and keeping of attention; C3 and C4 – related to sensory-motor functions, attention, mental processing, calm, emotion, and empathy; P3 and P4 – related to problem-solving, attention and association, visual processing and nonverbal association (Soutar & Longo, 2011). Besides those, points A1 and A2 were used as references and two more points as ground. All these points are by the international 10-20 system, and the adopted cares to eliminate any possible cause of interference on data collection was made according to described by Branco et al. (2020).

Verification of functional autonomy was made according to the Latin American Development Group for Maturity (LADG) protocol for functional autonomy evaluation (Dantas & Vale, 2004). Times spent to perform the tasks planned in the LADG protocol were recorded in seconds.

Participants' fragility was measured using the Edmonton Frail Scale (EFS), which evaluates nine dominions: cognition, general health state, functional independence, social support, use of medicine, nutrition, mood, continence, and functional performance. According to test punctuation, individuals are classified as follows: non-frailty – if they score between 0 and 4; seemingly frailty – when they score between 5 and 6; light frailty – if their score is 7 or 8; moderate frailty – when they score 9 or 10; and finally, severe frailty – if their punctuation is 11 or higher (Felippe & Campos, 2017).

All participants underwent a stage of tests aiming to evaluate the participants' profiles for the study, thus establishing the possible relationships between the amount of habitual physical activities and the functional autonomy of the elderly.

Evaluations were performed in a large room adequately prepared to minimize distracting events, such as excessive noise and high temperatures, which could compromise data reliability. Participants were then individually invited to enter the room to apply the tests by each protocol's specifications.

The first data taken were of fragility and the level of habitual physical activity. The elderly participants were invited to sit comfortably to answer all questions of each questionnaire. After that, the brain activity level was determined through an electroencephalogram (EEG) by positioning the electrodes on the participants' heads. After following all procedures to position and test the electrodes proposed by Branco et al. (2020), data recording was started and had 3 minutes. Data from the first minute was then excluded; data from the second and third minutes were used to determine a baseline of each participant's brain activity. When this test stage ended, participants were asked to perform the tasks predicted by the LADG protocol.

All recorded data were firstly treated through the Shapiro Wilk test to determine the normality and define the parametric or non-parametric nature of all data, for descriptive analysis was found the data's central tendency, extremes, and dispersion. The relationship between variables was calculated by the Spearman correlation coefficient ( $r$ ), with intervals of confidence of 95%; in other words:  $p < 0.05$ .

### **3. Results**

The first data to be showed are of all participants together and have the goal of present the participants' profile on the variables: habitual physical activity level (Baecke-Modified); Fragility (EFS); and Functional Autonomy (LADG) tests. These data were exposed in Table 1 together with the normality test results.

**Table 1.** Scores of normality, extremes, central tendency, and standard deviation recorded through the tests Baecke, Edmonton Frailty Scale, and LADG applied to study participants.

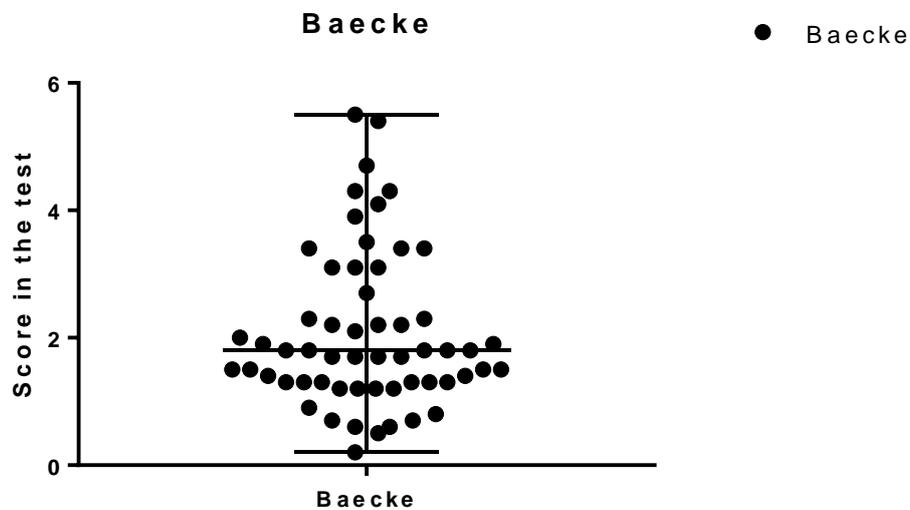
	Baecke Modified	EFS	LADG
Shapiro-Wilk normality test			
W	0.9	0.94	0.92
P value	0.0002	0.0104	0.0016
Passed normality test (alpha=0.05)?	No	No	No
Descriptive Analysis			
Minimum	0.2	2	41
Median	1.8	5	47
Maximum	5.5	10	59
Std. Deviation	1.2	2.3	4.2

Fonte: autores.

Taking the Baecke-Modified scores for central tendency and extremes alone, we can notice that, in the whole sample, no participant punctuated high enough to be considered active concerning their habitual physical activity level. Regarding frailty, Table 1 shows that the central tendency of the group pointed to a seemingly vulnerable classification, varying between non-frailty and moderate frailty participants. Finally, Table 1 also indicates that, as far as functional autonomy is concerned, results followed the same central tendency of the ones recorded by the Baecke-Modified tests. In other words, by analyzing the central tendency and extremes of the group, we can notice that no participant scored differently than "weak" in functional autonomy.

However, the aim of this study is to determine the variables profile: brain activity, functional activity, and cognitive performance of the elderly according to different daily physical activity demands. So, to divide the sample between participants more and less physically active in accordance with their performance in the Baecke questionnaire was established the central tendency number as the limit point to classify the participants as more or less physically active like is showing in Figure 1. Also, at Figure 1, we can notice how individuals were distributed regarding the central tendency baseline

**Figure 1.** Dispersion of Baecke-Modified questionnaire scores around the baseline determined by the central tendency of all scores.



Source: Authors.

As is observed in Figure 1 makes it possible to systematically determine which participants exhibit a higher or a lower activity level according to their position either above or below the central tendency baseline. And now, it is possible to make relationships between the physical activity level and the performance at all other evaluated variables in this study. In Table 2 we can analyze the data performance according to the level of daily physical activity performed by the participants. Due to the greater number of data to be shown, Table 2 will be displayed the EEG data of Alpha frequency only.

**Table 2.** Scores to descriptive analysis of Baecke, Edmonton Frailty Scale and LADG tests, and, brain frequency Alpha of the more or less physically active participants.

Less Active Participants									
				Electroencephalogram					
	Baecke	EFS	LADG	F7	F8	C3	C4	P3	P4
	Final score	Final score	IG	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha
Minimum	0.2	2	42	6.4	6.3	6.1	6.2	6.3	5.8
Mean	1.5	5.6	47.9	12.0	10.3	15.9	12.8	14.8	17.3
Median	1.5	5.5	47.	10.3	10.2	13.3	11	11	11.5
Maximum	2.3	10	58.9	21.8	17.9	33	24.6	37.5	41.6
Std. Deviation	0.52	2.2	4.27	6.12	3.87	8.75	7.26	9.75	11.92
More Active Participants									
	Baecke	EFS	LADG	F7	F8	C3	C4	P3	P4
	Final score	Final score	IG	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha
	Final score	Final score	IG	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha
Minimum	2.7	2	41.4	11.5	9.2	8.7	12	11.5	11.7
Mean	3.8	5.1	44.72	14.85	12.95	17.1	16.7	24.2	24.5
Median	3.5	4	43.7	14.85	12.95	17.1	16.7	24.2	24.5
Maximum	5.5	10	49.8	18.2	16.7	25.6	21.4	36.9	37.4
Std. Deviation	0.84	2.74	2.9	4.74	5.30	11.9	6.65	17.96	18.1

Highlight given for central tendency scores. Source: Authors.

Table 2 shows that the most active participants exhibited the best functional autonomy and frailty results. Being the most remarkable differences were found at the points P3 and P4, whose wave activity was on average 115% higher in the more active individuals than in the less active ones.

Finally, we need to know if such differences between more or less active participants could also be registered in Beta brain frequencies. The results are exhibited in Table 3.

**Table 3.** Scores to descriptive analysis of Baecke, Edmonton Frailty Scale and LADG tests, and, brain frequency Beta 1 of the more or less physically active participants.

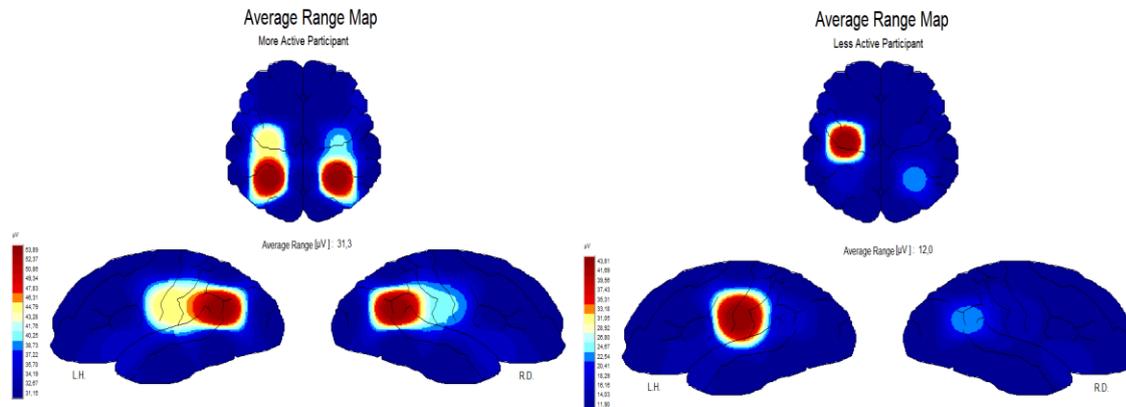
Less Active Participants									
	Electroencephalogram								
	Baecke	EFS	LADG	F7	F8	C3	C4	P3	P4
	Total Score	Total Score	IG	Beta	Beta	Beta	Beta	Beta	Beta
Minimum	0.2	2	42	13.3	8.5	11.2	9.9	12.1	10.6
Mean	1.5	5.6	47.9	22.6	20.6	25.1	18.6	19.9	25.7
Median	1.5	5.5	47.5	19.7	18.4	22.5	18.6	19.4	24.1
Maximum	2.3	10	58.9	44.8	44	45.1	38	29.1	47.3
Std. Deviation	0.52	2.2	4.27	10.51	10.96	12.46	8.18	5.95	10.08
More Active Participants									
	Baecke	EFS	LADG	F7	F8	C3	C4	P3	P4
	Total Score	Total Score	IG	Beta	Beta	Beta	Beta	Beta	Beta
Minimum	2.7	2	41.4	21.3	3.9	28.7	25.9	21.8	23.1
Mean	3.8	5.1	44.72	27.75	19.3	34.55	32.35	33.5	33.45
Median	3.5	4	43.7	27.75	19.3	34.55	32.35	33.5	33.45
Maximum	5.5	10	49.8	34.2	34.7	40.4	38.8	45.2	43.8
Std. Deviation	0.84	2.74	2.9	9.12	21.78	8.27	9.12	16.55	14.64

Highlights to the central tendency in accordance with the recalculated normality. Source: Authors.

Table 3 shows that, only at the point F8, less active participants exhibited Beta activity 16,7% higher than the more active individuals. In all other points, the brain activity of the more active participants was higher than the less active participants' one, reaching 74% higher at point C4 and 68% at point P3.

In Figure 2 is possible to note clearly that the average range map of the brain activity was higher in the physically more active participants, which proves that a more active life-style promotes higher patterns of brain activity at the observed points.

**Figure 2.** Maps of average brain activity amplitude at the analyzed points for the more and less active participant. Images from the software used by the EEG device used to record brain activity.



Source: Authors.

Finally, to try to establish a cause-and-effect relationship between habitual physical activity and the existence of frailty and functional autonomy impairment is necessary to determine the correlation coefficients of the variables, and it can be seen in Table 4.

**Table 4.** Scores of correlation coefficient (rs) and significance level (p) between the results of Baecke, Edmonton Frailty Scale, and LADG tests.

	EFS		LADG	
	Spearman (rs)	p value	Spearman (rs)	p value
Baecke	-0.11	0.42	-----	-----
EFS	-----	-----	-0.35	0.007*
LADG	0.13	0.31	-----	

\*  $p < 0.05$ . Source: Authors.

Table 4 demonstrates the existence of a negative correlation between habitual physical activity and frailty and also between frailty and functional autonomy. In both situation that is the higher the score in the first test, the lower the score in the second. In other words, the higher is the habitual physical activity, the lower will be the participant's frailty;

and the higher is the functional autonomy test classification, the lower will be the frailty test classification.

The last possible correlation showed in Table 4 is the one between the LADG and EFS test scores. This was a positive correlation, which indicates that as better is the functional autonomy classification, the better will also be the frailty classification because, in both tests, lower scores indicate better functional classifications.

#### **4. Discussion**

The study sample was composed of elderly with functional autonomy relatively preserved because they could make their daily activity as self-care and move themselves to participate in proposed activities in the active and healthy aging program. This program offers regular physical activity programs, workshops of theater and singing, and medical services. Thus, every participant joined some of the services provided by the program autonomously.

The data pointed out that the sample, in a general way, got levels of daily physical activities not sufficiently to be considered actives, and it can be associated with the lower results in the frailty and functional autonomy tests. This correlation between physical activity and functional autonomy has already been pointed out by other researches (Baptista, 2018; Costa, Rodrigues, Prudente, & Souza, 2018; Pereira de Llano et al., 2017), and here it seems was proved.

Brain functionality is a crucial component to structure cognitive and motor functions, and it can be measured through the frequency of brain activity (Guggisberg et al., 2014). We can note that more Alpha brain activity is associated with functional improvement. The Alpha rhythms are related to vigilance, inhibitory process, attention, working memory, perception skills, and information processing (Braboszcz & Delorme, 2011) in cognitive processing (Cruceanu & Rotarescu, 2013). Thus, it can be stated that the more active participants will probably be more skillful in cognitive processes related to the points evaluated in this study - with a particular highlight for resolution of problems, attention, association, visual processing, and non-verbal association, which are associated to points P3 and P4 (Soutar & Longo, 2011).

Finally, about Beta brainwaves, it is known that they occurring specifically in the motor cortex area, indicate that the body is ready to execute a movement (Carvalho, 2014); in other brain areas, they relate to readiness for work and to dedicate full attention (Rios & Glanzmann, 2016). From the data showed, in functional terms, both groups had a similar performance at the point F8, which can indicate a similar performance in tasks that involve

visual and spatial working memory, emotional processing, and maintenance to attention. On the other hand, the more active participants will probably be better in tasks that require greater demand for auditory and visual working memory, selective and divided attention (point F7). Also, more active participants can be better in tasks which mainly relate to sensory-motor functions, attention, mental processing, calm, motion, and empathy (point C4), and also tasks related to problem-solving, attention and association, visual processing, and non-verbal association (point P3) (Soutar & Longo, 2011).

## 5. Final Considerations

Although we didn't find the elderly with upper levels of daily activity, the data profile was enough to establish marked differences between the elderly with more or less daily physical activity levels.

In general lines, the profiles of the elderly included in the sample demonstrate that the activities they used to engage at the time of the study had not been relevant for them to be classified as active according to the Baecke-Modified – and it might be reflected in their functional autonomy scores and frailty results, once the majority of the participants exhibited some frailty.

It could also be noticed that the more active participants scored better in both functional autonomy and frailty tests, and also displayed higher brain activity in areas related to executive functions. It indicates that the elderly's adoption of a lifestyle in which includes the practice of physical activities, produces a positive impact in variables related to a better quality of life and functional autonomy.

Only one of the verified correlations was statistically significant, which didn't allow established to this sample a definitive cause-effect relationship between daily physical activity and lower levels of frailty and functional autonomy. However, our results pointed to how it is essential to motivate an active lifestyle for older people. We can suggest that other studies could be developed to verify if more significant levels of daily physical activity will promote better results in brain activity and functional variables with more significant correlations.

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