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ORIGINAL

MUSCLE STRENGTH, GAIT SPEED, AND REACTION TIME IN ACTIVE ELDERLY PEOPLE

FUERZA MUSCULAR, VELOCIDAD DE LA MARCHA Y TIEMPO DE REACCIÓN EN PERSONAS MAYORES ACTIVAS

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ABSTRACT

This study aimed to assess physical and perceptual abilities such as muscle strength, gait speed, and reaction time in older people. The sample was 170 over 50 years old (93 women), who participated in the physical activity program of the University of Jaén. Muscle strength was measured using the bench press test, the chair test, and the manual grip test. The walking speed of 0-30 m using photoelectric cells. Reaction time is used using an infrared platform. The results show a good level of physical condition of the participants, although the older ones are slower and take longer to respond to a stimulus. Variable muscle strength parallel to aging. Men have a better level of muscle strength and walking speed than women.

KEY WORD: Physical activity, fitness level, perceptive abilities, program, aging.

RESUMEN

Este estudio tuvo como objetivo evaluar las capacidades físicas y perceptivas como la fuerza muscular, la velocidad de la marcha y el tiempo de reacción en personas mayores. La muestra fue de 170 mayores de 50 años (93 mujeres), que participaban en el programa de actividad física de la Universidad de Jaén. La fuerza muscular se midió mediante la prueba de press de banca, el test de la silla y la prueba de prensión manual. La velocidad de la marcha de 0-30 m usando células fotoeléctricas. El tiempo de reacción se obtuvo usando una plataforma infrarroja. Los resultados muestran un buen nivel de condición física de los participantes, aunque los de más edad son más lentos y tardan más en responder a un estímulo. La fuerza muscular disminuye paralelo al envejecimiento. Los hombres tienen un mejor nivel de fuerza muscular y velocidad de marcha que las mujeres.

PALABRAS CLAVE: Actividad física. Nivel de condición física. Habilidades perceptivas. Programa. Envejecimiento.

1. INTRODUCTION

Nowadays it is widely proven that there is a significant association between the level of physical abilities of elderly people and their health, quality of life and longevity. The countless benefits of an active life are recognised (Neufer et al., 2015; Romero, Carrasco, Sañudo, & Chacón, 2010). The increase of sedentary habits is common in most countries of the European Union, being insufficiently active around two thirds of its population, mainly in the elderly. The number of people with a low level of physical activity (FA) has increased, with a higher prevalence in women (Munera et al., 2016).

Aging implies loss of functionality in many systems and organs, which worsens if the physiological stimuli, which is aggravated if the necessary physiological stimuli are not given to have good physical fitness (Izquierdo, Santos, Martínez, & Ayestarán, 2008). This situation may worsen if physical activity is not practised (PA) regularly since it is considered an important health factor by the scientific community (Ruiz-Juan & Zarauz, 2011). In fact, the PA practice has a positive impact on the health of people, from various levels such as physical, psychological and social-affective. Focusing on the first, USDHHS (2008) has verified the existence of an improvement in muscle strength and muscle mass as well as in the maintenance of functional capabilities and an improvement of balance, which translates into better physical condition of the elderly with active lifestyle habits.

The benefits may be more optimal if PA is done following the guidelines recommended by organizations such as (USDHHS, 2008), which recommends doing moderate to vigorous PA, with a duration of between 150 to 75 minutes daily, and between 5 to 3 weekly days. Recommendation that has subsequently been endorsed by different international organizations (Thompson, Arena, Riebe, & Pescatello, 2013; World Health Organization, 2010) and that has reinforced the importance of increasing the practice of FA as a strategy to improve the quality of life of the elderly (Lera-López et al., 2017).

What is important about working on one's strength, understood as the tension exerted by a muscle or muscle group during a muscle contraction, is to find improvements in the physical abilities of people as a result of the increase of the muscle mass and of a greater functionality associated with a correct coordination of the central nervous system and the different components of the muscle. This produces thus a greater protection for the organism, reducing the risk of numerous diseases and/or allowing a more effective treatment to these (Cornelissen & Fagard, 2005; Enns & Tiidus, 2010; Tanasescu et al., 2002; USDHHS, 2008).

Numerous studies confirm that the strength is the physical ability with greater association to a good health condition, producing a loss of muscle mass associated with the aging process over the years (Reid et al., 2014) The age of 50 years old has been considered as the moment where more pronounced is the decline, losing 1-2% of lean mass per year (Keller & Engelhardt, 2013), as well as it has also been significantly influenced by the important effects of the sarcopenia with advancing age (Evans, 2015). The combination of sarcopenia, loss of muscle mass and ability to transmit nerve impulses, contributes to decrease the functionality of the person, making difficult tasks such as standing up from a chair, going upstairs, recovering the position after a disturbance of balance and even walking at a normal speed (Lang et al., 2010).

The direct result of the decrease in strength capacity translates into a functional loss that limits the ability to move and favors falls (Shahudin et al., 2016). Proof thereof is the fact that, (Ruiz et al., 2008) found evidence that a low level of strength is related to every cause of morbidity and mortality. This implies the need to prevent or act against physical deterioration, being the PA an important protector with greater relevance when aging and an essential tool to fight against this deficiency (Keller & Engelhardt, 2013). It has been proved that even in elderly people, if practiced regularly, the strength can be significantly improved (Ferreira et al., 2012).

The gait speed (GS) is an important predictor of the fall risk and of the health condition of the elderly (Ojagbemi, D'Este, Verdes, Chatterji, & Gureje, 2015). This ability decreases with age, being usually around 20% lower in the elderly, and this reduction is many times lead by the need to prolong the support time in order to seek greater safety and stability when walking (Sorenson & Flanagan, 2015).

Falls and morbidity are two factors associated with the gait speed, which often results in elderly people practicing less PA for fear of suffering some kind of injury (Studenski et al., 2011). In fact, a low level of mobility, defined (Blain et al., 2010) as a GS lower than 8m/s or a stride length inferior to 0.5 m is indicative of a bad health condition and of risk of dependence, and even of death (Cheung, Lam, & Cheung, 2016). A precarious mobility may be often associated with concomitant circumstances such as problems in motion control, stability, or malfunction of organs and systems such as the heart, the respiratory, circulatory and musculoskeletal systems (Studenski et al., 2011).

The reaction time (RT) is a good indicator of the performance of the nervous system in the elderly people (Mercer, Hankins, Spinks, & Tedder, 2009), this being understood as the time interval between the presentation of a stimulus and the beginning of the response (Leon, Ureña, Bilbao, & Bolanos, 2011). This is seriously affected in old age (Aley et al., 2007; Woods, Wyma, Yund, Herron, & Reed, 2015), mainly due to the deterioration and changes which occur in the central nervous system caused by age (Hagger-Johnson, Deary, Davies, Weiss, & Batty, 2014). This aspect is evident, especially in the RT needed by the elderly when choosing a foothold during the gait (Pijnappels, Delbaere, Sturnieks, & Lord, 2010). According to Mirelman et al. (2012), this deficit limits the ability to respond to a loss of balance, being considered this variable as an important indicator of the ability of an elderly person when developing daily tasks (Burton, Strauss, Hultsch, & Hunter, 2009).

However, as it happens with variables such as strength, the role of physical activity is vital to halt the decline of cognitive variables, especially if we talk about elderly people (Kamijo et al., 2009). Thus, the RT appears to have more similarities with the strength and speed of the gait, since men tend to show better results than women (Kamijo et al., 2009). In fact, Tun & Lachman (2008) demonstrated in their study that men, from 45 and up to 85 years old, react faster than women. This difference seems to be typical of the nature of each gender, where the hormonal component becomes relevant, since even with training, the difference remains (Lipps, Eckner, Richardson, Galecky, & Ashton-Miller, 2009). This data takes on great importance having into account that the RT is also considered as an indicator of mortality risk (Batty et al., 2009; Hagger-Johnson et al., 2014; Metter, Schrager, Ferrucci, & Talbot, 2005).
As it has been proven, there are numerous factors which can be included in what is generically called physical abilities of people, which suggest that there are multiple elements which influence health from this perspective and in the association that exists between all of them. When there is a deficit in one of them, the others are affected.

Based on this background, the main purpose of this study was to analyse the level of physical and perceptive abilities of the participants in the PA program organized by the University of Jaén. Four secondary objectives were also proposed in order to verify the level of strength, the RT and the GS; taking into account the age and sex of the participants.

2. METHOD

2.1. Design and participants

This is a descriptive cross-sectional study in which the sampling was intentional and non-probabilistic, since the aim was to choose people with a similar age and level of PA.

The sample under study was composed of a total of 170 people (77 mens y 93 women), over 50 years of age (65 ± 6.8 years), who participated in a PA program managed by the University of Jaén. This program was carried out throughout the academic year with a weekly frequency of 3 sessions, in which the main purpose was to work the overall fitness of the participants.

2.2. Instruments

Several materials were employed for measuring different suggested physical abilities, commonly used in this type of research:

- T-Force: To register the variable of upper body strength, it was used the linear position measuring device T-Force (Ergotech Consulting, SL, Murcia, Spain), which has a coupler that was placed on the weightlifting bar (Adam Sport, Granada, Spain). The linear position measuring device measures with a space measurement resolution of 2mm and the sampling rate at which data are acquired is set at 1000 Hz, therefore, a velocity data is obtained every millisecond.

- Handgrip test: For the measurement of the arm isometric strength, an adaptive handgrip test, the "Grip Strength Dynamometer TKK.5101. Grip-D with an accuracy of 1 Kg has been used.

- Infrared Platform: The different reaction times were measured with an OptoGait infrared platform (Microgate, Bolzano, Italy).

- Photocells: For the variable of GS, the materials used to measure were 3 photocells of Microgate kit racetime2 light radio (Microgate, Bolzano, Italy).

- Chair and stopwatch: To carry out the chair test, a firm chair with a backrest, whose seat was at a height of 43 centimetres was used along with a stopwatch to measure the 30s duration of the test.

2.3. Procedure

Authorizations from the University of Jaén where the working sessions were held were obtained, as well as the informed consent of all the study participants. Brief instructions were given and participants were assured of the confidentiality of their responses. Participation was completely voluntary, knowing that the abandonment of the study could be unilateral and without any need of justifying their resignation. The people interviewed received no monetary compensation for their contribution. No participant refused to cooperate. The research was conducted following the ethical guidelines of the Declaration of Helsinki in force, complying at all times with the highest safety standards and professional ethics for this type of work.

As inclusion criteria, they had to meet the following requirements: they must have participated in the physical activity program for seniors at the University of Jaén for the past three years. For this, the attendance list was consulted and those who had long periods of absences or a high level of absences were rejected. Not having a prescription which prevents them from performing PA and/or any of the evidence suggested in the research.

Data collection was conducted under the supervision of the main researcher, who was also responsible for the training, specifically for these tests, of 3 collaborators who helped in data collection. These collaborators had previous experience in the assessment of the physical abilities of elderly people, in addition to a training related to the field of physical-sportive activity (two Graduate in Physical Activity and Sports Sciences and one Graduate in Physical Education).

2.4. Data analysis

A descriptive study was performed using frequency analysis, which allowed to extract information as accurate as possible about the characteristics of the sample. Subsequently, the Levene test was used for the analysis of variances between the genders. The statistic Student's t-test for equality of means was applied. The existing relationships between variables were analysed using Pearson correlation coefficient. Analyses were performed using SPSS (v.20.0 of SPSS Inc., Chicago, IL, USA).

3. RESULTS

3.1. Descriptive analysis of variables

For the description of the different variables analysed, descriptive indexes such as the mean, median, standard deviation, asymmetry and kurtosis, were calculated (Table 1).

Reaction Time. The variable of Acustic Reaction Time (ART) is the one showing a shorter reaction time (0.63510 s.) followed by the Acoustic-Visual Reaction Time (A-VRT) (0.64369 s.) and the VRT (0.66976 s.). In percentage terms, 70% of the individuals analysed in the ART have reaction times between 0.45 and 0.7 s. Visual Reaction Time (VRT) indicates that 80% of the participants have a response time which is between 0.5 and 0.8 s. Regarding the A-VRT, 67% of the participants react within a time between 0.5 and 0.75 s.

Gait speed. In the test of 0-8 m. the 85% walked at a rate between 1.5 and 2.25 m/s, being the overall average speed of 1.9 ± speed 33 m/s. In the distance of

8-30 m., a slight decrease is observed in the GS, since the 93% of the participants developed a speed of between 1 and 1.75 m/s, being in this case the average speed of 1.38 ± 25 m/s. In the distance of 0-30 m., the 83% obtained a speed of between 1.25 and 1.75 m/s, an average speed of 1.49 ± 0.27 m/s.

Strength. The handgrip strength measured with the handgrip test (HT) reflects an average score of 24.61 ± 8.56 kg., placing the 58% of the participants between 15 and 25 kg. In the chair test, the average of repetitions was 21.06 ± 4.61, managing to make 68% of the individuals between 16 and 23 repetitions. In the flat barbell bench press test, the average Maximum Repetition (MR) was of 22.28 ± 15.02 kg., placing the 82% of the sample between 10 and 24 kg. on the MR.

Table 1. Descriptive statistics of the 3 types of reaction time, gait speed and strength.

		REACTION TIME			**GAIT SPEED**			**STRENGTH**		
		ART (s)	**VRT (s)**	**A-VRT (s)**	**0-8 m. (m/s)**	**8-30 m. (m/s)**	**0-30 m. (m/s)**	**HT** (kg.)	**Chair test (**repetitions)	**MR** (kg.)
Median		0.63510	0.66976	0.64369	1.9042	1.3864	1.4941	24.61	21.06	22.28
Standard de.		0.124733	0.124439	0.135734	0.33153	0.25636	0.27106	8.568	4.614	15.029
Asymmetry		1.013	0.586	0.500	1.363	1.716	1.677	0.988	0.403	1.717
Kurtosis		1.742	0.566	0.618	3.979	0.283	0.283	0.299	-0.201	1.938
Percentages	10	0.48190	0.50880	0.48600	1.6149	1.1748	1.2635	15.48	16.00	10.00
	20	0.53200	0.56560	0.52880	1.6701	1.2228	1.3280	17.66	17.00	13.00
	25	0.54825	0.57925	0.55825	1.7149	1.2354	1.3390	19.23	18.00	13.25
	50	0.62250	0.65300	0.63200	1.8562	1.3269	1.4218	22.65	21.00	16.50
	75	0.70400	0.76500	0.72400	2.0385	1.4997	1.6311	27.25	23.00	22.75
	80	0.73440	0.77860	0.73620	2.1153	1.5559	1.6598	30.26	25.00	27.80
	90	0.78780	0.82800	0.82950	2.2386	1.5991	1.7306	42.25	28.00	51.00

There are several modes, the minor is chosen.
ATR: acoustic reaction time; VTR: visual reaction time; A-VTR: visual-acoustic reaction time; GS 0-8m: walking speed distance 0-8m; GS 8-30 m: walking speed distance 8-30 m; GS 0-30 m: walking speed distance 0-30 m; HT (kg): a maximum repetition of the chest.

3.2. Study of the variance and the equality of means

A comparative analysis between men and women for the study of variance (Levene's test) and of equality of means (Student's t statistic) (Table 2) was performed.

Levene's test. For comparative analysis of variances between men and women, the Levene's test was used. The results obtained show statistically significant differences ($p \leq 0.05$) in all the variables analysed except in the ART.

Student's t test. The equality of means between men and women was studied through the statistic Student's t test. The results show different means in all tests of strength as well as in the different sections of GS, finding also statistically significant differences ($p \leq 0.05$). By contrast, in the data found, there is no remarkable differences by sex in the variable of TR. Reason why it could be concluded that in terms of strength and GS, the means found are different, and in relation to the SR, the means tend to equality.

Table 2. Comparative analysis of variances (Levene's test) and of means (Student's t test) between gender

VARIABLE	VARIANCES ANALYSIS (Levene's test for the equality of variances)			MEANS ANALYSIS (95% Confidence interval for the difference)					
	F	Sig.	Report	t	Sig. (bilateral)	Differences of means (M-H)	Inferior	Superior	Report
ART (s)	2.433	0.123	EVA	0.311	0.757	0.010831	-0.058646	0.080309	EM
VRT (s)	10.969	0.001	No EVA	0.476	0.639	0.022253	-0.075540	0.120047	EM
A-VRT (s)	5.035	0.028	No EVA	0.314	0.756	0.014000	-0.078449	0.106449	EM
GS 0-8 (m/s)	12.220	0.001	No EVA	-4.011	0.001	-0.43946	-0.66946	-0.20947	DM
GS 8-30 (m/s)	13.329	0.000	No EVA	-3.419	0.003	-0.31472	-0.50842	-0.12102	DM
GS 0-30 (m/s)	13.879	0.000	No EVA	-3.545	0.002	-0.34074	-0.54295	-0.13853	DM
HT (kg)	10.916	0.002	No EVA	-10.315	0.000	-16.792	-20.183	-13.400	DM
Chair test	9.603	0.003	No EVA	-2.410	0.026	-3.701	-6.904	-0.497	DM
MR (kg)	60.940	0.000	No EVA	-7.808	0.000	-29.514	-37.500	-21.529	DM

ATR: acoustic reaction time; VTR: visual reaction time; A-VTR: visual-acoustic reaction time; GS 0-8m: walking speed distance 0-8m; GS 8-30 m: walking speed distance 8-30 m; GS 0-30 m: walking speed distance 0-30 m; HT (kg): a maximum repetition of the chest.
F: Size of the effect; Sig.: Significance; EVA: Equal Variances are assumed; No EVA: No equal variances are assumed; W: Woman; M: Man; EM: Equal Means; DM: Different Means

3.3. Correlations analysis

The correlation analysis of all physical variables among them and with age was obtained by the Pearson correlation coefficient (Table 3).

Physiological variables and age. The results showed a high positive relationship between all types of RT and age (ART: 0.346 ** VRT: 0.323 ** and A-VRT: 0.367 **). However, the relationship was negative in the GS variable, in the three variables evaluated (0-8m .: -0.271 * -0.286 * m .: 8-30 and 0-30 m .: -0.285 *). Although to a minor extent, it was also negative, in the chair test (-0.232).

Physiological variables. From the analysis of the obtained results, it can be stated that there is, in general, a high correlation in all the tests of the same physiological category (for example, between the three measures of time reaction). From the mix between different variables, it particularly stands out the positive correlation found between the GS measured at 0.8m. with the HT (0.619 **) and the MR (0.628**).

Table 3. Correlation analysis of all the physical variables among them and with age.

		ART	VRT	A-VRT	GS 0-8	GS 8-30	GS 0-30	HT	Chair	MR	Age
ART (s)	Pearson	1	0.709(**)	0.676(**)	-0.235(*)	-0.247(*)	-0.246(*)	-0.270(*)	-0.289(*)	-0.206	0.346(**)

	Sig.	0.000	0.000	0.047	0.037	0.037	0.022	0.014	0.083	0.003
VRT (s)	Pearson	1	0.695(**)	-0.264(*)	-0.272(*)	-0.272(*)	-0.285(*)	-0.267(*)	-0.274(*)	0.323(**)
	Sig.		0.000	0.025	0.021	0.021	0.015	0.023	0.020	0.006
A-VRT (s)	Pearson		1	-0.348(**)	-0.379(**)	-0.376(**)	-0.310(**)	-0.303(**)	-0.282(*)	0.367(**)
	Sig.			0.003	0.001	0.001	0.008	0.010	0.016	0.002
GS 0-8 (m/s)	Pearson			1	0.955(**)	0.972(**)	0.619(**)	0.573(**)	0.628(**)	-0.271(*)
	Sig.				0.000	0.000	0.000	0.000	0.000	0.021
GS 8-3 (m/s)0	Pearson				1	0.998(**)	0.595(**)	0.608(**)	0.600(**)	-0.286(*)
	Sig.					0.000	0.000	0.000	0.000	0.015
GS 0-30 (m/s)	Pearson					1	0.605(**)	0.606(**)	0.610(**)	-0.285(*)
	Sig.						0.000	0.000	0.000	0.015
HT (kg)	Pearson						1	0.430(**)	0.831(**)	-0.159
	Sig.							0.000	0.000	0.183
Chair test	Pearson							1	0.524(**)	-0.232
	Sig.								0.000	0.050
MR (kg)	Pearson								1	-0.054
	Sig.									.0652
Age										1

** The correlation is significant at level 0.01 (bilateral); * The correlation is significant at level 0.05 (bilateral).
ATR: acoustic reaction time; VTR: visual reaction time; A-VTR: visual-acoustic reaction time; GS 0-8m: walking speed distance 0-8m; GS 8-30 m: walking speed distance 8-30 m; GS 0-30 m: walking speed distance 0-30 m; HT (kg): a maximum repetition of the chest.

4. DISCUSSION

The aim of this research is to assess the level of strength, RT and GS, and determine whether there are differences by sex and age in the parameters analysed. The results suggest that regular PA improves the physical condition of the elderly. The older age individuals show less speed and reaction. Males have higher levels of strength and speed than women.

Of all the variables analysed, the GS in the elderly people over 50 years old analysed has always been greater than 1 m/s. These data show a good physical condition, since as collected by different studies (Dodson et al., 2016; Purser et al., 2005; Woo, Ho, & Yu, 1999) the health problems and the risk of disease are intensified with a lower GS than 8 m/s. These values also provide a predictive value in detecting people with a risk of suffering from disability or of having daily life accidents.

The highest levels of GS are located in the distance of 0-8m, experiencing a gradual decrease as the distance increases. Decreased performance that can be associated with the appearance of fatigue and / or inability to maintain high speed over longer distances (Lindsay, Obrosielski, & Knuth, 2015).

Age is another variable to take into consideration, since a negative correlation between age and GS (-0.285) was obtained, fact that indicates that people who get older are losing GS. These data match with those obtained by Bonhannon

(1997) where the correlation was -0.210. Bonhannon studied the GS in 0-7.62m and in the current investigation, where the distance is similar, of 0-8m, similar data were obtained (1.75 m/s vs. 1,75-2m/s).

The assessment of muscle strength reflects a trend similar to that found with MV in relation to age. More specifically, in the chair test, a slight negative correlation (-0.232) is evidenced, as in the handrip test and the MR but to a lesser extent, which means that young people are the ones who obtain better indicators. In line with other studies (Srinivas-Shankar et al., 2010), in which a notable decrease in strength due to age is confirmed. Although this situation can be mitigated in part by increasing the practice of AF, since an improvement in explosive strength has been demonstrated and even benefiting the body composition of older people (Jiménez, Pardo, Quintero, & Muñoz, 2019).

The RT established that from the three tests made, the ART is the one presenting a shorter RT (0.63510 s.), followed by the A-VRT (0.64369 s.) and the VRT (0.66976 s.). When comparing these three variables with the age of the individuals, it is stated the significant positive correlation in both the ART (0.346**), VRT (0.323 **) and A-VRT (0.367**). These results were similar to those obtained by Hunter et al. (2001) whose correlation between these variables was 0.360**. Coinciding also with the positions of other authors, when they affirm that there is an increase in the TRs parallel to the increase in the age of the subjects (Aley et al., 2007; Tun & Lachman, 2008).

In the comparative analysis of the RT in both genders, we appreciate that in the ART, the equal variances are assumed, however this does not happen in the VRT and the A-VRT. Despite this, according to the statistical analysis, the average values of both sexes are not very different between them in all the RT. Regarding the difference in means, Saar, Paz, & Rosental (1995) obtained different results, in this case, the average TR men presented significantly lower than the women. Like another study (Tun & Lachman, 2008), which found similar results in people between 45 and 85 years old. Other researchers (Lipps et al., 2009) rate this difference around 20-30 milliseconds. Furthermore, they affirm that this difference persists in subjects with different levels of physical condition. Therefore, the increase in the practice of FA becomes more important (Moral-García, Al Nayf Mantas, López-García, Maneiro, & Amatria, 2019).

The interpretation of these results must be done cautiously, being aware of the existence of possible contaminating variables. Different characteristics of samples, the membership or non-membership to a program of physical exercise, as well as the practice or non-practice of regular PA may cause that the physical condition of people fluctuate as much in the levels of strength and in speed and RT (Ferreira et al., 2012). Although it is necessary to highlight the importance of physical condition with the practice of FA and with the quality of life and emotional well-being of older people (Lera-López et al., 2017). Furthermore, physically active older people have a better positive self-esteem and a lower risk of dependency than sedentary people (Moral-García, García, García, Jiménez, & Dios, 2018).

5. CONCLUSIONS

The practice of regular PA benefits people over 50 years old, placing their physical abilities inside the optimal levels according to the RT, GS and strength. Age is a determining factor which conditions the gait speed and the reaction times, decreasing the speed and increasing the reaction time when aging. In terms of sex, there are no differences in reaction times, however, both in the gait speed as in the strength, men present higher values than women.

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