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SIX MONTHS OF EXERCISE PROGRAME TWICE A WEEK SEEMS TO BE NOT ENOUGHT TO IMPROVE COGNITIVE FUNCTION IN OLDER PEOPLE

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ABSTRACT

Aging is a natural process that implies a physical and cognitive decline. In the last two decades, physical exercise has emerged as a powerful modulator of this process, and an important lifestyle to reduce frailty and dependence. This study measure physical and cognitive performance of sixteen old people who participated in a six-month physical exercise program, twice a week. Our results show an improvement in strength and agility with the exercise program, and a tendency to improve cognitive outcomes depending of assistance. The variable assistance or maybe the exercise program leads to not find significant improvements in endurance, neither in cognitive responses, when all group is taken in care, and these two variables maybe are related.

Key words: aging, exercise, stroop, strength

UN PROGRAMA DE EJERCICIO FÍSICO, DOS VECES POR SEMANA, DURANTE SEIS MESES, PARECE NO SER SUFICIENTE PARA PRODUCIR MEJORAS COGNITIVAS EN PERSONAS MAYORES

RESUMEN

El envejecimiento es un proceso natural que implica un declive físico y cognitivo. En las últimas dos décadas, el ejercicio físico ha emergido como un poderoso modulador de este proceso, y un elemento fundamental del estilo de vida para reducir la fragilidad y la dependencia. Este estudio evalúa el rendimiento físico y cognitivo de dieciséis personas mayores de sesenta años que participaron durante seis meses en un programa de actividad física, dos veces por semana. Nuestros resultados muestran una mejora en la fuerza y la agilidad con el programa de ejercicio, y una tendencia a la mejora cognitiva en función del grado de asistencia de los usuarios. El efecto de la asistencia, o quizá el propio programa propuesto, no ha producido mejoras significativas ni en la resistencia aeróbica, ni en la función cognitiva medida mediante el test Stroop. La eficacia del programa podría estar limitada por la asistencia.

Palabras clave: envejecimiento , ejercicio físico, stroop, fuerza

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INTRODUCTION

Aging is a natural process that takes place inexorably in all living beings (Jones et al., 2014). Unfortunately, this process implies in humans, a downregulation of biological functions (Park & Yeo, 2013). This decline affects all different systems of the human body, like heart (Celik et al., 2015), the vascular system (Mendonca, Pezarat-Correia, Vaz, Silva, & Heffernan, 2017), the fiber muscle (Miljkovic, Lim, Miljkovic, & Frontera, 2015) or the motor junction (Gonzalez-Freire, de Cabo, Studenski, & Ferrucci, 2014). This inevitable decline in the biological system has an impact in human functionality and can lead to dangerous conditions like frailty (Fried et al., 2001).

Fortunately, this process can be regulated, at least partially, by physical activity and healthy lifestyle. There is an important amount of science articles showing the improvements obtained by physical exercise, improvements in strength (Peterson, Rhea, Sen, & Gordon, 2010), endurance (Vigorito & Giallauria, 2014), or reducing the fallen risk (Greenwood-Hickman, Rosenberg, Phelan, & Fitzpatrick, 2015).

Evidently, the nervous system is not exempt of this process. With aging, there is a loss in nervous tissue, with a loss in grey matter (Erickson, Leckie, & Weinstein, 2014; Fletcher et al., 2016; Tian, Studenski, Resnick, Davatzikos, & Ferrucci, 2016) and also in a white matter (Hayes, Salat, Forman, Sperling, & Verfaellie, 2015). And this morphological decline come together with a capacity decline, that implies a poor plasticity of the system (Mahncke, Bronstone, & Merzenich, 2006).

This neural decline comes, unavoidably, with a loss in cognitive function during aging. And, as in the other systems, physical exercise has been able to modulate this decline, maintaining or improving cognitive function and nervous system during aging (Bherer, Erickson, & Liu-Ambrose, 2013; Colcombe & Kramer, 2003; Diamond, 2015). This cognitive improvement has been explained by different biological process observed during aging and physical activity, like for example, the increasing of neurogenesis (Curlik & Shors, 2013; Urban & Guillemot, 2014; Yau et al., 2014), the improvement in blood flow (Nishijima, Torres-Aleman, & Soya, 2016) or simply an increase in brain volume (Erickson et al., 2014; Fletcher et al., 2016; Tian et al., 2016). It has been also explained by the increased of neurotrophic factors (Phillips, Baktir, Srivatsan, & Salehi, 2014), with special mention to Brain Derived Neurotrophic Factor (Kowianski et al., 2017)

These cognitive improvements associated with physical exercise and physical activity has been explained commonly by improvements in cardiovascular function and aerobic endurance (Colcombe & Kramer, 2003; Erickson & Kramer, 2009; Erickson et al., 2014; Roig, Nordbrandt, Geertsen, & Nielsen, 2013; Schmolesky, Webb, & Hansen, 2013; ten Brinke et al., 2015), but

also has been explained with strength improvements with resistance training (Liu-Ambrose & Donaldson, 2009; Liu-Ambrose et al., 2010; Nagamatsu, Handy, Hsu, Voss, & Liu-Ambrose, 2012).

But these studies have been usually elaborated in laboratory conditions, far from an ecological environment. The impact of physical exercise over cognitive function can be modulated by different variables, like intensity, and it can be modulated by the activity and the environment (Peruyero, Zapata, Pastor, & Cervello, 2017). Furthermore, in a real environment, we know it is possible to implement with success physical exercise programs (Falck, Davis, Milosevic, & Liu-Ambrose, 2017), but adherence is not guaranteed (Picorelli et al., 2014), and the reduction in assistance can leads to a reduction in effectiveness of the program.

The objective of this study was to evaluate the physical and cognitive improvements of six months of physical activity program in older people. With the hypothesis that, not only physical, but also cognitive improvements, will be achieved in six months of aerobic and strength training.

MATERIAL AND METHOD

Participants

Sixteen old people of sixty years or older (68.25 ± 5.69 years) participate during six months, twice a week, in a physical exercise program. There were a total of forty-three sessions, but the real assistance was 30.06 ± 6.7 sessions, with a maximum of 39 and a minimum of 20 sessions.

All participants were informed by the program and signed an informed consent. The study was designed in accord with Helsinki Declaration, and approved by the Ethics Committee of the university.

Experimental Design.

The participants were introduced in the exercise program during two weeks with social and low intensity activities. In the third week they were evaluated. First they did a Stroop Test for a cognitive evaluation. Then, they were evaluated with the Senior Fitness Test (Rikli & Jones, 2013) for a physical evaluation.

During the next six months, the subjects assist twice a week for a sixty minutes exercise sessions. The first week session consisted in three cyclic activities of ten minutes each one, with small rest between them, to improve aerobic endurance. The second week session included a strength circuit using elastic bands and low weights. During these circuit eight global exercises were implemented during approximately ten minutes. The circuit was repeated twice in the session, with a 10 minutes cyclic activity in the middle. Both sessions starts with the same 10 minutes warm-up and end with 10 minutes cool down.

Assistance was registered. At the end of six months, both evaluation test were repeated.

Measures

Senior Fitness Test. To measure physical performance, the battery Senior Fitness Test was used *(*Rikli & Jones, 2013*)*, which is an easy and well known field battery test for older people. The battery implies seven tests, two to measure strength, one for arms (Curl Test) and other for legs (Stand Up Test). One endurance test, using the well-known 6 minutes' walk test. Two test to measure range of movement, one for arms (Back-Scratch Test) and the other for legs (Sit & Reach Test). And one agility test, were is used the *Time Up and Go Test.* Finally, the Body Mass Index (BMI) is measured using height and weight. All the subjects realized all the test in the same order explained by the Senior Fitness Test manual.

Stroop Test. The *Stroop test* is a famous cognitive test used to measure the cognitive inhibition capacity of the participants (Golden, 1994; Martin et al., 2012; Rodríguez Barreto, Pineda Roa, & Pulido, 2016). The cognitive inhibition is a task to take part of the executive function, and implies the capacity to avoid irrelevant information and block a natural response tendency (Peruyero et al., 2017).

Informatics software was used for this test, in 8 inches tablets devices. This software test a fixed fifty words, and answer must be digitally introduced in the program. Software registered the correct answers and mistakes, and also the time spent to complete the fifty words.

The Stroop test have three phases, one congruent phase, where word is presented in the same color. One neutral phase, were XXX is presented with the color ink. And an incongruent phase, where the word written is different than the color ink, and subjects must to avoid the word, matching the ink.

The first time the subjects was measured, they realize 3 previous test to learn the test and use the tablet. At the end of six month program, subjects were measured again, and one training trial was realized before the measured trial, to remember the test and the device.

Data Analysis.

Data are showed as mean and standard error. The different variables were evaluated by paired T-Test to know the pre-post changes. To know the "assistance effect", the group was divided in two respect their assistance, and analysis were did again using T-Tests. As the number of subjects were small after assistance division, the Effect Size of the results was analyzed using de d of Cohen (Cohen, 1988, 1992). The magnitudes of standardized effects were consider as small (< 0.2), moderate (< 0.6), large (< 1.2) very large (< 2.0) and

extremely large (> 2.0). Correlations were analyzed using r of Pearson. All statistical analysis were carried with a $p < 0.05$ signification level.

RESULTS

Physical Improvements

After six months physical exercise program, subjects significantly improve their strength, in arms and also in legs. And they reduce its time in the Time Up & Go test (Table 1). However, the other physical variables did not change at the end of the program. The endurance did not improve, neither the range of movement, and its BMI was maintained during all period. One of the subjects was not evaluated at the end of the program, so there is only n = 15.

TABLE 1
Physical Tests results analyzed by paired T-Test.

		Before		After training		
Variable	**n**	**Mean**	**SE**	**Mean**	**SE**	**P Value**
IMC	15	28.723	1.264	28.689	4.087	0.925
Curl Test	15	16.25	0.873	17.8	0.987	0.007
Stand Up Test	15	12.333	0.433	15	0.683	0.003
Back-Scratch Test	15	-1.633	1.558	-2.571	1.017	0.468
Sit & Reach Test	15	-0.713	1.147	-1.82	1.453	0.223
Time Up&Go	15	5.614	0.314	4.746	0.243	<0.001
6 minutes´ Walk	15	595	25.735	588.333	23.833	0.974

Cognitive Improvements

At the end of six month program, none cognitive variables changed significantly. There were no changes in correct answers in any phase, neither in times dedicated to complete these phases, as we can see with the paired T-Tests (Table 2).

TABLE 2
Stroop test performance analyzed by paired T-Test.

		Before		After training		
Variable	**n**	**Mean**	**SE**	**Mean**	**SE**	**P Value**
Correct answers in Congruent Phase	16	49.688	0.176	49.063	0.636	0.258
Correct answers in Neutral Phase	16	49.313	0.27	49.375	0.287	0.817
Correct answers in Incongruent phase	16	47.063	1.433	49.063	0.382	0.188
Time in congruent phase	16	70.625	2.852	69.75	3.206	0.785
Time in neutral phase	16	75.875	3.361	73.375	2.825	0.449
Time in incongruent phase	16	85.313	3.319	85.938	3.479	0.755

However, it seems to be some differences related to assistance. So, group was divided in relation with assistance. There were a high assistance group (n =

9) with more than 30 sessions assisted. And a low assistance group (n = 7) with less than 30 sessions assisted of a total of 43 sessions. The differences between pre and post in all variables were calculated and analyzed, there were no differences between groups in physical variables, neither in correct answers, but it was shown a tendency in time to complete each phase. As n was small, d of Cohen (Cohen, 1988, 1992) was used to study de Effect Size. We can observe a ≈-0.5 (moderate effect) value for the three phases, but confidence interval was too wide to implies significant results, but seems that the high assistances subjects reduce its time in all phases, and the low assistance subjects increase it (Table 3).

TABLE 3
Increments in time during different Stroop phases depending of assistance.

	High assistance			Low assistance				Confidence Interval	
Variable	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**d Cohen**	**Low**	**High**
Δ Time in Congruent	9	-4	3.064	7	3.143	5.998	-0.54	-1.55	0.46
Δ Time in Neutral	9	-5.56	3.516	7	1.429	5.781	-0.52	-1.52	0.49
Δ Time in Incongruent	9	-1.33	2.034	7	3.143	3.628	-0.54	-1.55	0.46

Correlations between age, assistance, physical and cognitive variables.

All physical and cognitive variables were correlated, by Pearson correlations, with assistance and age of the subjects. And all of these correlations was did at the beginning and at the end of the six-month exercise program. And also were correlated the change in the variables with the exercise program, calculated as the difference between the performance at the end of the program, less the performance at the beginning.

Results show that assistance did not have any correlation with any of the variables, and when it occurs, like for example in Correct answers in neutral phase of the Stroop test, it seems anecdotic, because it does not occur in any other strop variable (Table 4).

TABLE 4
Correlations between cognitive and physical performance and age.

				CC = Correlation Coefficient		n = 16
				Study variable: Assistance		
	Difference		Before		After Training	
Variables	CC	P Value	CC	P Value	CC	P Value
Correct answers in Congruent Phase	0.073	0.788	-0.208	0.440	0.004	0.989
Correct answers in Neutral Phase	0.486	0.056	0.182	0.501	0.621	0.010
Correct answers in Incongruent phase	0.297	0.264	-0.295	0.267	0.019	0.944
Time in congruent phase	-0.261	0.328	0.167	0.536	-0.108	0.689
Time in neutral phase	-0.228	0.396	0.195	0.470	-0.028	0.919
Time in incongruent phase	-0.259	0.333	0.252	0.346	0.095	0.728
Curl Test	0.221	0.411	0.130	0.630	0.240	0.389
Stand Up Test	0.179	0.506	0.241	0.368	0.237	0.396
Back-Scratch Test	0.270	0.330	-0.428	0.098	-0.262	0.365
Sit & Reach Test	0.178	0.509	0.024	0.931	0.150	0.593
Time Up and Go	0.315	0.234	-0.258	0.335	-0.308	0.265
6 minutes´ Walk	0.206	0.444	0.275	0.303	0.342	0.212

By other side, age, at the beginning of the study, only correlates with Up & Go and 6 minutes' walk tests. However, at the end of the exercise program, age also correlates with the rest of physical variables, except range of motions of the arm (*Back-Scratch Test*), and also in correct answers in all phases of the Stroop Test (Table 5). In contrast, there are not correlations with the differences of the variables during the training period.

TABLE 5
Correlations between cognitive and physical performance and age.

				CC = Correlation Coefficient		n = 16
				Study variable: Age		
	Difference		Before		After Training	
Variables	CC	P Value	CC	P Value	CC	P Value
Correct answers in Congruent Phase	-0.825	<0.001	-0.162	0.548	-0.734	0.001
Correct answers in Neutral Phase	-0.179	0.506	-0.579	0.019	-0.710	0.002
Correct answers in Incongruent phase	-0.146	0.590	-0.041	0.879	-0.709	0.002
Time in congruent phase	0.143	0.598	0.251	0.348	0.364	0.166
Time in neutral phase	0.493	0.053	0.008	0.976	0.571	0.021
Time in incongruent phase	-0.254	0.343	0.358	0.173	0.198	0.462
Curl Test	-0.064	0.813	-0.346	0.190	-0.515	0.049
Stand Up Test	-0.010	0.971	-0.461	0.072	-0.469	0.078
Back-Scratch Test	-0.245	0.380	0.389	0.137	0.278	0.336
Sit & Reach Test	-0.331	0.211	-0.464	0.070	-0.565	0.028
Time Up and Go	0.031	0.909	0.510	0.043	0.665	0.007
6 minutes´ Walk	0.108	0.691	-0.556	0.025	-0.522	0.046

DISCUSSION AND CONCLUSIONS

Other studies has relate physical exercise, fitness and cognitive function (Bherer et al., 2013; Colcombe & Kramer, 2003; Diamond, 2015; Erickson & Kramer, 2009). Reading scientific bibliography, it seems clear that physical exercise must improve cognitive performance in older adults. However, our results has not been able to show this improvement in a significantly manner after six month intervention.

Is truth that many reasons can explain our fail improving cognitive responses. For example, our training program fail improving cardiovascular outputs, as we can´t improve 6 minutes' walk performance. Some authors explain the cognitive improvement in relation with aerobic fitness improvements, and we did not achieve this improvement. (Colcombe & Kramer, 2003; Erickson & Kramer, 2009; Griffin et al., 2011; Hayes et al., 2015). However, our six month physical exercise program improve significantly the subjects strength, but we did not find the cognitive improvements associated with this fitness dimensions as other authors propose (Liu-Ambrose & Donaldson, 2009).

The variability in assistance maybe has influence our negative results, because it was some variability in subject's assistance, and this can be the reason of an increased standard deviations and the reduction of significant results probabilities. On the other hand, this is a real environment where nowadays physical programs are done with old people in Spain. And we must to be able to translate the scientific results to real environments. Other authors show low adherence to this practice in older people (Picorelli et al., 2014), and we must to know if the physical exercise programs improvement can achieve its objective in this low adherence reality, or which are the limits for its success.

By other side, age is another relevant variable to take in care. In our study, age did not correlate with physical or cognitive variables at the beginning of the study, but at the end of the exercise program, it correlates with many of them. Maybe the improvements of the program make clear the age differences, which are not so evident in sedentary subjects.

In conclusion, twice a week training program for six months, with only one session of strength training, seems to be enough to improve whole body strength, no matter the participant's assistance, but it is not enough to improve aerobic fitness, neither to improve cognitive outcomes. So, it seems that a more intense, or more frequency exercise program must to be implemented to improve endurance and cognitive function, or maybe is enough to improve adherence and assistance to the exercise program.

This study present two principal limitations that must be taken in care, one is the small number of subjects, and the other de absence of control group, that can misunderstanding the results.

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