EFFECT OF SIX MONTHS EX ERCISE TRAINING IN OLDER ADULTS. THE RESULTS OF THE ERASMUS PLUS PACE PROJECT.

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Abstract
The PACE (Physical Activity Enhancement) Project is a European Erasmus + KA2 project, funding by European Commission, who keeps in contact five organizations from five different European countries to create a manual about physical exercise programs for older adults. 132 adults from four different countries participate in a six-month pilot program, with different activities in the four different countries. Participants were divided into two groups, one of younger elders, from 50 to 65 years, and another of old elders, 65-75 years old. All the activities were designed to include aerobic and strength exercises. Physical fitness and well-being vitality were measured before and after six months of practice, all aggregated or divided in two blocks of three months separated by 3 months holiday period. Both groups improve leg strength and vitality well-being, and the older elders also improve aerobic resistance and arm strength. There were no differences between countries in the improvements, neither were differences between the six months continuum training or divided into two blocks of three months. All the activities described in de PACE document seems to have the same efficiency to improve physical fitness in older adults and offers different ways to achieve it.

Keywords: Exercise, Aging, Fitness, Well-being, Vitality

Introduction

Aging is a natural process in life, a consequence of time in systems designing for a limited life span. In humans, aging is a process with a loss of function, loss of adaptability, and finally death. During life span are inevitable some physiological changes in human body [1]. A great increase in the human life span has been achieved in the last century, as a consequence of some behavioral and environmental changes [2]. As a consequence, there is a great increase in physiological changes produced by aging in our actual societies.

The most evident changes with aging are physical changes. During aging, there are a great number of physiological changes that will lead our bodies to a loss of physical performance and fitness [1]. This impairment on physical fitness leads to common mobility limitations in elderly, and frequent dependent states [3]. We can group the different changes in three great areas: the loss of strength, the loss of endurance, and the loss of mobility.

Regarding strength, there are many physiological processes that underlies this loose, the most evident is sarcopenia that means, the loose of muscle mass. The European consensus on definition and diagnosis of sarcopenia include three criteria to identify sarcopenia: low muscle strength, low muscle quantity or quality, and low physical performance [4]. Some physiological processes are the cause for these loose quantity and quality in muscle mass.

With aging, there is a fast-to-slow fiber type shift associated with changes in motor neurons [3]. In muscle fiber, there is a reduction in excitation-contraction coupling, reducing the calcium flow, and affecting the muscle quality [3]. The reduction in mitochondrial content of muscle fiber with aging is another cause for a lesser functionality in muscle, impairing the muscle energy intake [3]. Looking at the whole muscle, there is an increase in intermuscular adipose tissue-related to a reduction in strength and functionality in older people [5].

Many molecular changes explain the reduction on muscle quality and quantity, as aging has an impact in fundamental molecules related to muscle health. The reduction in testosterone and growth hormone reduces the possibility of hypertrophy and muscular regeneration [6]. In addition, there is also a reduction in insulin-like growth factors related to proliferation, differentiation, and fusion of muscle satellite cells, the stem cells precursors of muscle mass [6]. Moreover, myogenic regulatory factors (MRF), involved in the growth and development of muscle cells, do not respond to exercise in older people as they do in young people [6].

All this tissue and molecular changes in muscle go with a group of neural changes also related to muscle functionality [7]. For example, there is a reduction in axon diameter of motor neurons with age. That implies a reduction in firing speed and a reduction in excitability of muscle fibers [7]. This axonal reduction is accompanied by a significant reduction in motor neurons, and its consequent reduction of motor units, producing the atrophy of muscle denervated fibers [7].

Related to endurance lose with aging, it is evident the reduction in oxygen uptake with aging [8]. There are a number of physiological causes for this reduction in performance, like the reduction of maximal heart rate with aging [9], changes in right ventricular diastolic function during exercise [10], lesser number of capillaries perfusing the lungs [11]. The increased stiffness of the vascular system increase systolic and diastolic pressure during exercise, increasing heart afterload and, reducing volume stroke during exercise [11]. The already mentioned reduction in mitochondria with aging implies the reduction in muscle fibers to use oxygen to produce ATP [12], with the consequent reduction in arteriovenous difference O_2, and the reduction in oxygen consumption.

Finally, aging has an impact on neuromotor response, with coordination difficult, increased variability of movements respect young, slow movements, and problems with balance and gait [13]. As a consequence, older people present a high number of falls than young people [13].

To compensate for this entire decline, physical exercise has proven to be the most efficient treatment [14]. Many studies have shown that resistance training can reduce strength decline, with improvements in muscle mass [15,16], and also improvements in motor unit recruitment, and motor unit firing rates [15]. These improvements are related to intensity, with grater improvements with higher intensities [15], and with contraction velocity, where power exercise shows great improvements in strength and health-related conditions [17]. Strength training has also a positive impact on functionality and other health variables [14].

Besides, aerobic exercise training, based on cycling, walking, or similar repetitive endurance activities improves oxidative capacity and redox status [18], improving heart conditions [19], reducing metabolic syndrome, and high arterial pressure [14]. Moreover, exercise can reduce the risk of falls, reducing disability risk, improving gait and walking speed, and functionality [14].

Also, exercise shows the potential to improve psychological variables like quality of life, cognitive function and well-being [14,20]. Self-efficacy and self-esteem also are affected by exercise training [21]. It seems that aerobic training and moderate intensity is the most beneficial combination to improve well-being [22].

The PACE project pilot intervention aimed was to prove the different exercise programs proposed by the different European groups. As an efficiency measure, some physical and well-being variables were measured during the pilot study. This article presents the results of the program respect the improvements in physical and well-being measures.

Material and Methods.

Participants:

Participants were distributed in two groups in each country, one younger group selected by the rank age 50-65 years (YG; n = 79, 30 males and 49 females; Age = 58.39 ± 5.89 years), and the older group, selected by the rank age 65-75 years (OG; n = 53, 24 males and 29 females; Age = 69.34 ± 3.44). All participants were selected in each country. There were participants from four countries for the YG, and participants from three countries for the OG. The participants signed informed consent to participate in the project. They were selected with two criteria, aged more than 50 years old, and do not present a medical inconvenient to do physical exercise. The experiment was approved by the Ethics Committee of the authors' university.

Exercise programs:

All the participants, in each country, complete a six months program based on two days of physical exercise. Three of the four different countries distribute these six months in two periods of three months of training, with a period of two months of holidays in the middle of the program. One country organizes the six months program as a continuous program. These differences have been taken into account in the statistical analysis.

All the programs have the objective to improve the endurance of participants, and also their strength. All the information about the programs is in the PACE Project Memory. As a synopsis, younger participants (50-65 years) complete endurance activities, like running, Nordic walking or Zumba. The older group, complete activities of less intensity, like adapted gymnastics, fitness exercises, and stretching and walking activities.

Fitness and Well-being measurements

Different fitness measurements were used to measure physical fitness in both groups (YG and OG). Both groups used a Strength Grip test for arm strength, and one stand up test to measure leg strength. To measure endurance, the YG group used the Rockport walking test, a mile walking test to estimate oxygen consumption. Old group use the Six minutes' walk test, more adapted for their capacities. Finally, the OG also did Time Up and Go test, as a measure of agility and gait. Weight was also registered, and participants complete one Vitality test to measure well-being.

All evaluators of each country were trained together in one of the project meetings. And all the evaluators had videos and documentations about the protocols.

1. Strength Grip Test

Each country used its own strength grip dynamometer for the test. Subjects were placed stand, with 90 degrees of elbow flexion, and with the strength grip dynamometer adapted to their hand. They did their maximum strength during 3 seconds with right and left hand, and repeat three times with each hand alternatively. The medium of all six tests was used as a result.

2. Stand Up Test

The participant was placed in a chair without arms. Both hands crossed over their shoulders. They were asked to stand up and sit down in the chair as many times as they could in 30 seconds. The evaluator counts how many repetitions they did. This test was presented exactly equal to in Senior Fitness Test [23].

3. Rockport Walking Test

Rockport Walking Test is a demonstrated indirect test to measure oxygen consumption. Subjects must walk one mile in a constant speed, and must register their heart rate and time spent to complete the distance. With this information, the age, sex, and weight of the participant, we can estimate the VO_2 [24]. Oxygen consumption is presented related to body weight, in ml/kg·min.

4. Six minutes' walk test.

In the Six minutes' walk test, participants must walk for six minutes, as fast as they can, and they can stop to rest during the test. The test is developed around a rectangular field of 50 yards. The total distance done in the six minutes is registered. The test was done with the exact specifications of the Senior Fitness Test [23].

5. Timed Up and Go test

The participants are seated in a chair. In front of them, separated eight feet distance, there is a mark. When the evaluator speaks the start signal, the participant must stand up, walk around the mark, and come back to sit down again in the chair. The time placed to complete the test is registered. The test is done twice, and the best time is used as a result. The test has been done following the instructions of the Senior Fitness Test [23].

6. Subjective Vitality

To measure well-being, it was used the Subjective Vitality Questionnaire [25]. The questionnaire has 7 items about personal feelings related to vitality. Is rated on a Likert-type scale (1 to 7).

7. Weight

All participants were weighed at the beginning and at the end of the program. In each country was used a different weight, but each participant was weighted in the same instrument both times.

Statistical Analysis.

All data are presented as median and standard deviation. Paired T-Test was used for each test to analyze the impact of the exercise program on the different dimensions of fitness and well-being. Statistical significance was marked as $p < 0.05$. The effect size of the treatment was calculated by d of Cohen [26,27]. 95% Confidence Interval of the Difference (CI) is presented Effect sizes are reported as small (≤ 0.20), medium (≤ 0.50), or large (≤ 0.80) [27].

To analyze the possible interaction in results of different country groups, or analyze possible differences between six months of continuous training against two blocks of three months training with a middle rest. Two 2x2 ANOVA was done, first of them, with the variables MOMENT (Pre vs Post) and Program (Continuous vs. Blocks). The other compared MOMENT and. Country (4 different countries)

Results

In the YG, we can observe a significative improvement in leg strength (Stand Up Test), Well-being (Subjective Vitality), and a small but significant loose of weight (Table 1). No changes were observed in arm strength, neither in oxygen consumption (Table 1).

Table 1: Results for Young Group

	PRE	POST	Sig.	n	d	CI
Weight	71.79 ± 15.19	71.57 ± 14.97	0.004	56	0.01	0.07 – 0.36
Stand Up Test	17.66 ± 5.62	18.48 ± 5.59	0.005	79	0.15	-1.38 - -0.26
Strength Grip	27.33 ± 8.71	27.36 ± 8.28	0.872	79		-0.54 – 0.46
VO_2 (ml/Kg·min)	34.21 ± 15.89	34.34 ± 15.72	0.793	56		-01.14 – 0.87

Subjective Vitality	4.93 ± 1.53	5.99 ± 0.65	< 0.001	79	0.90	-1.39 – -0.75

There were no interactions between these changes and the Program or the Country, as we can see in the results of the 2x2 ANOVA (Tables 2 and 3)

Table 2: Interactions between MOMENT x Program for the Young Group

	Sig.	F	ηp^2
Weight	.777	.080	.001
Stand Up Test	.648	.210	.002
Strength Grip	.848	.037	.000
VO_2 (ml/Kg·min)	.863	.030	.000
Subjective Vitality	.090	2.922	.022

Table 3: Interactions between MOMENT x Country for the Young Group

	Sig.	F	ηp^2
Weight	.995	.005	.000
Stand Up Test	.844	.170	.003
Strength Grip	.994	.006	.000
VO_2 (ml/Kg·min)	.986	.014	.000
Subjective Vitality	.417	.880	.014

For the Old Group, there were improvements in Strength (arms and legs, measured as Strength Grip and Stand Up Test respectively), agility and gait (measured as Up and Go test), endurance (using Six Minutes' Walk Test) and well-being (measured as Subjective Vitality). In contrast, there were no changes in weight (Table 4).

Table 4: Results for Old Group

	PRE	POST	Sig.	n	d	CI
Weight	72.789 ± 13.11	72.726 ± 12.98	.261	53		-0.04 – 0.16
Stand Up Test	14.83 ± 4.16	15.81 ± 4.25	.000	52	0.23	-1.48 – -0.47
Strength Grip	24.98 ± 7.37	25.15 ± 7.39	.000	53	0.02	-0.27 – -0.08
Up and Go Test	5.48 ± 1.43	5.26 ± 1.32	.000	53	0.16	0.11 – 0.33
6 minutes´ walk	508.58 ± 114.09	512.25 ± 114.99	.031	53	0.03	-6.98 – -0.34
Subjective Vitality	4.68 ± 1.77	5.24 ± 0.99	.000	53	0.39	-0.80 – -0.33

Again, there are no interactions depending on Program (Table 5)

Table 5: Interactions between MOMENT x Program for the Old Group

	Sig.	F	ηp^2
Weight	.986	.000	.000
Stand Up Test	.708	.141	.001
Strength Grip	.977	.001	.000
Up and Go Test	.701	.149	.001
6 minutes´ walk	.841	.041	.000
Subjective Vitality	.757	.096	.001

In contrast, in the analysis for MOMENT x Countries, there were differences in Subjective Vitality (Table 6). And as we can see, these differences are explained because, in one of the countries, the starting values of Vitality were so high, that it was impossible to improve (Table 7). So, the participants of this country did not improve their Subjective Vitality.

Table 6: Interactions between MOMENT x Country for the Old Group

	Sig.	F	ηp^2
Weight	.999	.001	.000
Stand Up Test	.743	.298	.006
Strength Grip	.999	.001	.000
Up and Go Test	.840	.174	.004
6 minutes walk test	.910	.095	.002
VItality	.000	19.658	.284

Table 7: Results Pre and Post from each country.

	PRE	POST	n
Country 1	2.12 ± 0.35	3.97 ± 0.36	12
Country 2	4.71 ± 0.96	5.16 ± 0.73	20
Country 3	6.30 ± 0.59	6.15 ± 0.34	20

Discussion

This study shows a positive impact of the different programs used in old people, with an interesting difference that must be discussed. First of all, it can be seen that exercise programs proposed produce better improvements in the older group. The older group, aged 69.34 ± 3.44 years old, presents significant improvements in all the fitness and well-being variables. There is only a lack of improvement in weight, but weight is dependent on more variables than only physical exercise, for example, caloric consumption.

However, the amount of improvement in the physical variables of the older group is not too big. The effect sizes of the change show small changes for all the variables, excepting vitality, which presents a medium effect size. That means the programs produced an improvement in fitness, but a small improvement. The small changes in strength are probably due to the small amount of resistance training and small intensity because resistance training usually has bigger improvements in strength in old people [16]. And as we know, the intensity is relevant variable respects the strength improvements [15].

Regarding endurance, other studies have shown important improvements in oxygen consumption for 6 months and one-year exercise training [28,29]. We used an adapted endurance test (six minute walk test) to measure this fitness dimension in the older group, to be sure they could do it despite their functional limitations, this test correlates with oxygen consumption [30]. Anyway, the improvements are small and maybe are related with a small intensity of exercise program.

However, despite the small improvements in fitness, subjective vitality, as a measure of well-being, increased to a moderate degree. We are already knew that well-being is improved with physical exercise [31,32], and is not only related to fitness, but also with a social activity, self-esteem…

Respect the younger group, aged 58.39 ± 5.89 years, this group is larger, and more heterogeneous, as we can see in the larger standard deviations for the strength grip and stand up tests. In this younger group, the exercise program shows lesser improvements in physical fitness, with only changes in leg strength and with a small effect size. The strength improvements are clearly lower than usual improvements with recommended resistance training [15-17]. Moreover, oxygen consumption neither improves as usual it can change with aerobic training [28,29]. It is clear that exercise programs were designed with a lack of intensity and/or volume for the younger and more fitness participants.

At least, subjective vitality of this group increases with large effect size, probably not as a response of fitness changes, and maybe more related to social and personal aspects of well-being, related to the social activity and self-esteem.

Conclusion

In conclusion, the PACE program seems to present different alternatives to do exercise with older people, which can show the professionals new practice possibilities, in a safe manner. These programs seem enough to produce some improvements in the fitness of the older elders, and probably need more individualized intensities and volumes for the younger elders. In both cases, these programs present the capacity to improve well-being in older adults, and this is really good because all the starting programs have the most important aim to increase adherence and prevalence to practice and adherence is strongly related to well-being.

Future Projects will need to study how to increase volume and intensity, and how to individualize the training stimulus, to obtain the greatest improvements in fitness.

Limitations of the study

The principal limitation of the study is its multi-centric, multi-country design. Because different evaluators have done the tests, and despite the training, that can produce some bias which reduces the validity of the study. Another limitation is the lack of control group, as this study was designed to measure the implementation of the programs, and the project has not scientific objectives, not founds for control groups were solicited, and not control groups were measured.

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