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## ORIGINAL

# EFFECTS OF A PHYSICAL ACTIVITY PROGRAMME ON THE MUSCLE FUNCTION IN PATIENTS WITH COPD

# EFECTOS DE REALIZAR ACTIVIDAD FÍSICA EN LA FUNCIÓN MUSCULAR EN EPOC

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## ABSTRACT

The purpose of this study was to examine the effects of a 12-month physical activity (PA) programme consisting in walking on muscle function in patients with COPD (Chronic Obstructive Pulmonary Disease). Forty-four men (70.3 ± 6.7 years old) diagnosed with moderate-severe COPD were recruited. The intervention group (PAG) completed a physical activity programme and the control group (COG) followed their standard treatment. Upper- and lower-limb maximum strength (1RM), lower-limb muscle power (50% and 70% 1RM) and physical activity were measured before and after 12 months. After 12 months, lower-limb maximum strength increased by 8% in the PAG (P<0.01), while it did not change in the COG. Lower-limb muscle power at 50% 1RM increased by 12% in the PAG, while it decreased by 9% in the COG (P<0.05). A physical activity programme increased muscle strength and preserved muscle power of the lower limb.

**KEY WORDS**: chronic obstructive pulmonary disease, physical activity, muscle strength, muscle power, skeletal muscle dysfunction.

## RESUMEN

El objetivo de este estudio fue examinar los efectos de un programa de actividad física (AF) de andar en la función muscular en pacientes con EPOC (Enfermedad Pulmonar Obstructiva Crónica), con un seguimiento de 12 meses. Se reclutaron 44 hombres (70,3 ± 6,7 años) diagnosticados de EPOC moderado-severo. El grupo intervención realizó un programa de actividad física (GAF) y el grupo control (GCO) siguió su tratamiento estándar. Se midió la fuerza máxima (1RM) del miembro inferior y superior, la potencia muscular del miembro inferior (50% y 70% 1RM) y la actividad física, antes y después de 12 meses. A los 12 meses, incremento un 8% (P<0,01) la 1RM del miembro inferior en GAF, sin cambios en GCO. La potencia muscular al 50%1RM incrementó un 12% en GAF, disminuyendo un 9% in GCO (P<0,05). Un programa de AF incrementa la fuerza y preserva la potencia muscular del miembro inferior.

**PALABRAS CLAVE**: Enfermedad Pulmonar Obstructiva Crónica, actividad física, fuerza muscular, potencia muscular, disfunción muscular periférica.

## INTRODUCTION

Skeletal muscle dysfunction is a systemic consequence of chronic respiratory diseases, among which we find Chronic Obstructive Pulmonary Disease (COPD), its prevalence increasing with disease severity (Seymor et al., 2010). Skeletal muscle dysfunction in individuals with COPD is characterised by functional, metabolic and morphological disorder of the upper- and lower-limb skeletal muscle (Nyberg et al., 2015; Maltais et al., 2014). At the functional level, a decrease in muscle maximum strength and endurance, as well as greater muscle fatigability have been observed in patients with COPD compared to healthy subjects (Bernard et al., 1998; Coronell et al., 2004). Muscle mass (Marquis et al., 2002) and muscle strength (Swallow et al., 2007) reduction are predictors of mortality in these patients. Clinically, the skeletal muscle dysfunction is associated with the pulmonary function (Cebollero et al., 2017), physical exercise intolerance (Seymor et al., 2010; Gosselink et al., 1996), higher dyspnoea (Seymor et al., 2010), poorer quality of life (Seymor et al., 2010) and greater utilisation of health care resources (Decramer et al., 1997).

The ageing process is associated with the reduction of limb muscle mass, maximum strength and muscle power (Izquierdo et al., 1999). Maximum strength decreases after 50 years old (12-15%/decade) (Hurley, 1995; Hunter et al., 2004). Ageing has been observed to be associated with greater difficulty to walk, climb stairs and bend down in the Spanish population (Leirós-Rodríguez et al., 2018). In elderly people, lower-limb muscle power (strength times velocity) at high speed could be more important than maximum strength to perform daily-life activities such as walking and climbing stairs (Bassey et al., 19992; Bean et al., 2002; Bean et al., 2003). In elderly patients with COPD, lower-limb muscle power has been observed to be related with the respiratory function (Cebollero et al., 2017) and physical exercise tolerance, and muscle power has been found to be associated with physical activity (Hernández et al., 2017).

This muscle dysfunction is mainly a consequence of physical inactivity secondary to dyspnoea, which produces physical deconditioning in patients with COPD (Hernández et al., 2017; Waschki et al., 2015). It has been proved that muscle strength training, a fundamental element of respiratory rehabilitation programmes, improves exercise tolerance, muscle strength, dyspnoea, fatigue and quality of life (Zambom-Ferraresi et al., 2015). Therefore, it is an essential therapeutic intervention for muscle dysfunction treatment in patients with COPD. In individuals above 50 years old, physical activity is associated with perceived health status (Lera-López et al., 2017), as well as with improved physical fitness (Moral-García et al., 2019) and health status (Salinas Martínez et al., 2010). Nevertheless, there is lack of knowledge on whether a physical activity programme could prevent or improve the skeletal muscle function in patients with COPD.

This, the aim of this study was to examine the effects of a physical activity programme consisting in walking on muscle maximum strength and power in patients with COPD monitored during 12 months. It was hypothesised that a physical activity programme consisting in walking would preserve the level of lower-limb maximum strength and muscle power in patients with COPD.

## MATERIAL AND METHOD

### Participants

This is a non-randomised study. Two groups were compared: an intervention group and a reference or control group. A total of 44 patients from a respiratory medicine unit were included, according to the following criteria: 1) males diagnosed with moderate-severe COPD, with post-bronchodilator $FEV_1$/FVC ratio <0.70 and $FEV_1$ of 30%-80% compared to reference males (GOLD grades II-III, Vestbo et al., 2013), 2) grade 2-3 dyspnoea measured with the modified Medical Research Council (mMRC) dyspnoea scale, and 3) older than 50 years old. The exclusion criteria were: 2) active smokers, 2) exacerbation in the past 3 months, 3) unstable heart disease, and 4) neoplasia or any neuromuscular condition, either skeletal or arthritic, that could restrict physical exercise tolerance. All patients performed spirometry, plethysmography, the 6-minute walk test (6MWT) and the COPD assessment test (CAT), which measures the impact of the disease. The requirements established by the Declaration of Helsinki were followed and the Committee for Ethics, Animal Testing and

Biosecurity of the Public University of Navarra approved the study (Approval number: PI-002/11). Personal details were coded for data analysis. All participants provided informed consent.

## Intervention programme

The participants were measured at the beginning (basal) and after 12 months of monitoring. The intervention group (N = 32; PAG) completed a physical activity programme consisting in walking during 12 months. They were requested to complete one walk of at least 30 minutes, at least 3 days a week. All patients filled in a daily record of symptoms and exacerbations. Once a month they received a phone call and were asked for the monthly average fulfilling rate of the guidelines provided.

The standard care or control group (N = 12; COG) followed the general recommendations on physical activity received in the respiratory medicine unit. This group was not composed of patients who had refused to participate in the physical activity programme.

## Muscle function measurements

**Lower-limb maximum strength assessment.** Maximum strength on the bilateral knee extension exercise was measured through a one-repetition maximum test (1RM) on a commercial exercise machine (Technogym, Gambettola, Italy) and was defined as the maximum weight lifted on bilateral knee extension exercise. On the testing day, the participants performed a warm up consisting of a 5-min walk and stretching exercises. Moreover, they performed several contractions in preparation for the knee extension exercise. Subsequently, four to five attempts were used to determine the 1RM. There was a break of 2 minutes between consecutive attempts. The 1RM was defined as the maximum weight lifted in one single attempt.

**Lower-limb muscle power assessment.** After measuring the 1RM, muscle power on the leg press exercise was assessed. Leg and hip extensor muscle power (W) was measured during the concentric phase of the bilateral leg press exercise using the weight (kg) corresponding to 50% and 70% 1RM. The participants were requested to move the weight as fast as possible. Two attempts were performed with each weight, with 2-min rest between consecutive attempts. The best attempt for each weight was used for analysis.

**Upper-limb maximum strength assessment.** Upper-limb maximum strength (1RM) was measured on seated chest press and seated row exercise machines. The maximum load was determined after four to five attempts, with 2-min rest between them. The 1RM was defined as the last valid attempt completed with the maximum load.

## Statistical analysis

The variables were expressed as mean ± standard deviation (SPSS version 20.0, IBM Corporation, Armonk, NY, USA). The variables' normal distribution was verified using Shapiro-Wilk's test. Basal values were compared between groups through Student's t or Mann-Whitney's U test. The treatment comparison (time effect) within groups was conducted through Student's t for parametric variables or Wilcoxon test. Significance level was set at P <0.05.

## RESULTS

The population's basal characteristics are displayed in Table 1. No significant differences were observed between groups in any variable at the beginning of the study. A total of 44 patients from a respiratory medicine unit were recruited: 32 in the physical activity group (PAG) and 12 in the control group (COG). The sample loss in the PAG was due to 5 withdrawals and 1 deceased, while there were 3 withdrawals in the COG. The values of dyspnoea, CAT and 6MWT and the number of steps per day (physical activity) have been previously published (Cebollero et al., 2018).

**Table 1.** Basal characteristics

| **Variable** | **PAG** N = 32 | | | **COG** N = 12 | | | ***P* Value** |
|---|---|---|---|---|---|---|---|
| Age (years) | 69.9 | ± | 7.2 | 71.0 | ± | 5.2 | 0.8 |
| BMI (kg/m$^2$) | 28.4 | ± | 4.5 | 28.5 | ± | 7.1 | 0.8 |
| FVC (%) | 77.0 | ± | 12.2 | 75.7 | ± | 21 | 0.6 |
| $FEV_1$ (%) | 51.5 | ± | 14.2 | 50.2 | ± | 12.5 | 0.9 |
| $FEV_1$/FVC (%) | 47.5 | ± | 11.5 | 48.3 | ± | 9.1 | 0.8 |
| 6MWT (m) | 478.3 | ± | 66.5 | 473.5 | ± | 79.5 | 0.8 |
| Dyspnoea (mMRC, score) | 2.1 | ± | 0.3 | 2.0 | ± | 0 | 0.1 |
| 50% 1RM Muscle power (W) | 573.7 | ± | 264.9 | 585.7 | ± | 205.4 | 0.7 |
| 70% 1RM Muscle power (W) | 568.0 | ± | 259.9 | 582.5 | ± | 203.4 | 0.7 |
| Knee extension 1RM (kg) | 73.0 | ± | 20.8 | 69.4 | ± | 17.6 | 0.6 |
| Seated chest press 1RM (kg) | 55.5 | ± | 15.7 | 55.1 | ± | 12.3 | 0.9 |
| Seated row 1RM (kg) | 53.4 | ± | 12.2 | 52.8 | ± | 13.9 | 0.9 |

PAG: physical activity group; COG: control group; BMI: body mass index; FVC: forced vital capacity; $FEV_1$: forced expiratory volume in the first second; 6MWT: 6-minute walk test; mMRC: modified Medical Research Council dyspnoea scale; 1RM: one-repetition maximum. Data are expressed as mean ± standard deviation.

Lower-limb maximum strength on the knee extension exercise increased by 8.5 ± 9.9% in the PAG (from 78 ± 18 to 84.5 ± 19.5kg; P=0.004), while no improvement was detected in the COG (from 68.1 ± 11.3 to 67.1 ± 9.5kg; P=0.6) after 12-month monitoring (Figure 1A).
The improvement in upper-limb maximum strength on the seated chest press exercise of 10.8 ± 16.3% in the PAG (from 58.7 ± 14.6 to 64.5 ± 15.9kg; P=0.003) was significantly larger (P= 0.027) than the -3.4 ± 11.4% (from 56.9 ± 8.1 to 54.6 ± 8.7kg; P=0.4) observed in the COG (Figure 1B). The upper-limb

maximum strength on the seated row exercise increased in the PAG (from 55.2 ± 12.8 to 58.1 ± 11.8kg; P=0.004), while no improvement was observed in the COG (from 55 ± 11.2 a 55 ± 10kg; P=1.0) after 12-month monitoring.

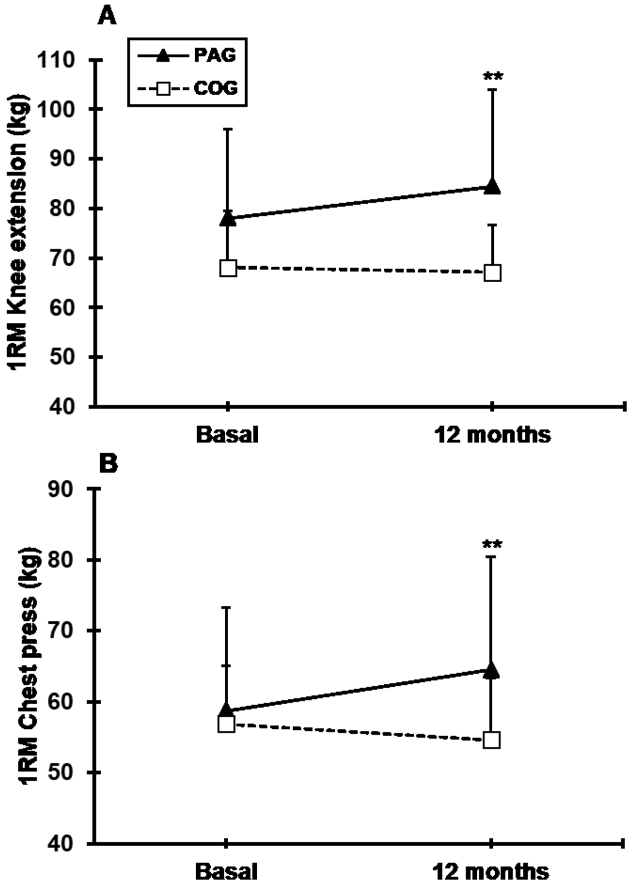


**Figure 1.** Lower-limb (A) and upper-limb (B) maximum strength (1RM) before and after a 12-month monitoring period in the physical activity group (PAG) and the control group (COG). N = 20 completed the test in the PAG and N = 7 completed the test in the COG. Significance level: **P<0.01 basal-12 months within groups.

After a 12-month monitoring period, the improvement in lower-limb muscle power at 50% 1RM of 12 ± 49.6% in the PAG (from 659.1 ± 287.1 to 684.7 ± 247.3W; P=0.8) was significantly larger (P=0.014) than the -9.2 ± 6.1% observed in the COG (from 568 ± 79.7 to 513.3 ± 57.6W; P=0.026) (Figure 2A). Neither the PAG nor the COG experienced changes in muscle power at 70% 1RM after 12 months of monitoring. No significant differences were observed between groups in lower-limb muscle power at 70% 1RM after that monitoring period (Figure 2B).

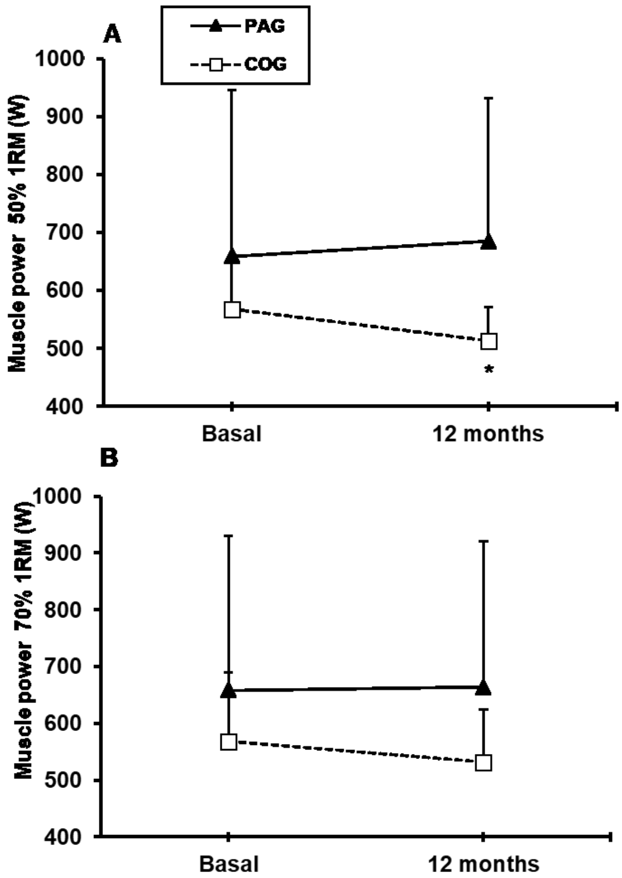


**Figure 2.** Lower-limb muscle power at 50% 1RM (A) and 70% 1RM (B) before and after a 12-month monitoring period in the physical activity group (PAG) and the control group (COG). N = 18 completed the test in the PAG and N = 6 completed the test in the COG. Significance level: **P<0.05 basal-12 months within groups.

## DISCUSSION

The most relevant results of this study were that a 12-month physical activity programme consisting in walking for at least 30 minutes, 3 days a week increased lower- and upper-limb maximum strength and it preserved lower-limb muscle power values in patients with COPD, in contrast to the muscle power decrease observed in the control group after 12-month monitoring.

Skeletal muscle dysfunction in individuals with COPD has been recognised as one of the most important extrapulmonary systemic effects, since it is associated with mortality, quality of life and daily-life activity tolerance (Marquis et al., 2002; Decramer et al., 1997). This skeletal muscle dysfunction is characterised by a decrease in lower-limb maximum strength and muscle mass (Bernard et al., 1998; Gosker et al., 2003). Previous studies in patients with COPD (Beijers et al., 2017, van de Bool et al., 2017) have observed increased lower-limb maximum strength after an aerobic endurance and muscle strength physical exercise programme. Nevertheless, physical exercise and physical activity are not synonyms. Physical exercise is a subset of physical activity that is planned, structured and repetitive and has as objective the improvement or maintenance of physical fitness, while physical activity is defined as any movement produced by skeletal muscles that results in energy expenditure

(Caspersen et al., 1985). In the present study, lower-limb maximum strength on the knee-extension exercise increased by 8% after the completion of the physical activity programme, while it did not improve in the control group. Cebollero et al. (2018) observed that, after 12 months of monitoring, the number of steps per day was maintained in the group who followed a physical activity programme, suggesting that the physical activity level had been upheld during 12 months (Cebollero et al., 2018). The fact that the physical activity level was maintained for 12 months in the group who completed the physical activity programme could be the explanation for the improvement in maximum strength.

Additionally, one of the major findings of the present study was that upper-limb maximum strength increased by 10% in the group who followed the physical activity programme. Based on our results, it is not possible to identify the physiological mechanisms that are responsible for the improvement in upper-limb maximum strength after completing a walking programme. Nonetheless, these findings could be explained due to the maintenance of the physical activity level during the 12 months, what could have allowed the participants to perform a higher number of daily-life activities and, consequently, to achieve an increase in upper-limb strength. In agreement with the results of the present study, Garcia-Aymerich et al. (2009) observed that the patients with COPD who showed the highest physical activity levels also presented the highest values of espiratory muscle maximum strength. Therefore, it could be concluded that a physical activity programme consisting in walking for at least 30 minutes, 3 days a week is a simple strategy to improve upper- and lower-limb skeletal muscle dysfunction in patients with COPD.

The reduction in muscle strength and power that occurs during the ageing process has been attributed to the loss of muscle mass, mediated by the decrease in number and size of muscle fibres, as well as the reduction in physical activity observed with ageing (Hunter et al., 2004). The loss of lower-limb muscle power has emerged as an even more significant variable than lower-limb maximum strength for the maintenance of functional capacity in individuals with COPD (Hernández et al., 2017). In elder adults, lower-limb muscle power at high speed is a more important factor than maximum strength for the performance of daily-life activities (Bassey et al., 1992; Cadore et al., 2014; Casas-Herrero et al., 2013). However, to our knowledge, very few studies have examined the effects of a 12-month physical activity programme on lower-limb muscle power in patients with COPD. The findings of the present study revealed that lower-limb muscle power was maintained in the group who completed a physical activity programme, while it decreased significantly in the control group after 12 months of monitoring. Therefore, the results of the present study suggest that a physical activity programme consisting in walking for at least 30 minutes, 3 days a week can preserve lower-limb muscle power in patients with COPD. A practical recommendation derived from the results of this study is to include a lower-limb muscle power programme for individuals with COPD in the physical activity programme. The lower-limb muscle power programme would consist of lower-limb strength exercises performed twice a week at moderate intensity (40-60% 1RM) (Izquierdo et al., 1999), 2-3 sets of 8-10 repetitions, starting at 40% 1RM and progressing until 60% 1RM. During exercise execution, the patient would be requested to perform at maximum velocity. These recommendations for healthy elder adults should be examined in future research studies with patients with COPD.

The present study has several methodological limitations. Firstly, it is a study where a treatment group was compared to a reference group, it was not randomised. The control group was selected afterwards, they followed the standard recommendations on physical activity received during the visit to the respiratory medicine unit and no patient who had refused to participate in the programme was included. In spite of the non-randomisation, both groups were equivalent as regards the basal measurements. The second limitation is the small sample size. Thirdly, all participants were male and, therefore, the results cannot be extrapolated to women. In Spain, COPD prevalence is higher among men (15.1%) than women (5.6%) (Miravitlles et al., 2009). Lastly, muscle mass was not measured in this study, which could have explained the changes observed in muscle strength and power after the intervention. One strength of this study was the patient adherence to the study, despite of the 12-month monitoring duration.

## CONCLUSIONS

In conclusion, a 12-month physical activity programme consisting in walking for at least 30 minutes, 3 days a week was effective to increase upper-and lower-limb maximum strength. Besides, it preserved lower-limb muscle power levels. This type of initiative, simple and easy to implement, such as a walking programme, should be included in the regular clinical practice for prevention and/or improvement of skeletal muscle dysfunction in patients with chronic obstructive pulmonary disease.

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