Change in self-efficacy mediates the effect of a physical activity intervention in COPD

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To the Editor:

Technology-based interventions that promote physical activity (PA), defined as those that use smartphone or web-based resources, effectively increase PA in individuals with COPD [1–3]. These interventions have potential to slow disease progression [4] and reduce risk of COPD exacerbations [5]. However, mediating mechanisms that explain the observed effect of these interventions on PA are unknown. Identifying mediators is important to understand how interventions work and inform future PA interventions. Exercise self-regulatory efficacy (hereafter referred to as "exercise self-efficacy") is one's perceived capability to exercise despite barriers [6]. Given evidence that interventions can improve exercise self-efficacy among individuals with COPD, exercise self-efficacy is a plausible mediator [6, 7]. We tested the indirect effect of a technology-based PA intervention on achieving clinically meaningful improvement in daily step count through change in exercise self-efficacy among individuals with COPD. We hypothesised that, in participants who received the PA intervention, an increase in exercise self-efficacy would mediate the likelihood of achieving clinically meaningful improvement in daily step count.

The current examination analysed two study samples of US Veterans (n=212) assigned to the same 3-month technology-based PA intervention or control group. Sample 1 participants (n=104), recruited from 2012–2015, were randomised to the intervention or pedometer alone (control) [1]. Sample 2 participants (n=108), recruited from 2015–2019, were randomised to the intervention or usual care (control) [2]. In this analysis, we combined intervention groups (n=111) and control groups (n=101) from samples 1 and 2. Intervention participants received access to a website and pedometer. They received feedback on daily step count, tailored step-count goals, educational and motivational messages, and social support from an online community. Step-count goals were calculated weekly by an automated algorithm, updated on each participant's homepage, and communicated to the participant by research staff. The website provided educational and motivational content. Control participants in sample 1 received a pedometer and COPD self-management materials, uploading step-count data monthly without website access. Control participants in sample 2 received PA encouragement, the same self-management materials, and a pedometer for follow-up assessment only, with no website access. Inclusion criteria were the same for the parent randomised controlled trials and included US Veterans aged ⩾40 years-old with COPD diagnosed based on forced expiratory volume in 1 s (FEV_1) to forced vital capacity ratio of <0.70 or emphysema on chest computed tomography, and a smoking history of >10 pack-years. Exclusion criteria were an acute COPD exacerbation within 4 weeks of enrolment and inability to ambulate [1, 2]. Participants provided written informed consent approved by the VA Boston Institutional Review Board.

At baseline and follow-up, participants provided sociodemographic (baseline only) and medical history, completed questionnaires, and performed spirometry for postbronchodilator FEV_1 % predicted [1, 2]. The Exercise Self-Regulatory Efficacy scale (Ex-SRES), a 16-item scale for COPD patients, assesses confidence in persisting with exercise despite barriers, with responses from 0% (not at all confident) to 100% (highly confident) [8]. Assessed with a pedometer, average daily step count was calculated at baseline and 3-months using ⩾4 valid days across a 7- or 14-day monitoring period. A clinically meaningful improvement in daily step count was defined as 418 steps per day based on a prior study that found that this amount represented the average difference between patients with 1-point difference in Chronic Respiratory Disease Questionnaire (CRQ) mastery subscale [9]. Given our focus on exercise

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self-efficacy as a treatment mediator, the difference in average daily step count associated with the CRQ-mastery subscale was chosen, rather than differences associated with pulmonary rehabilitation or medical events [10, 11], because mastery is conceptually aligned with the construct of self-efficacy. Therefore, the clinically meaningful improvement selected provides a value that may be most sensitive to changes in self-efficacy.

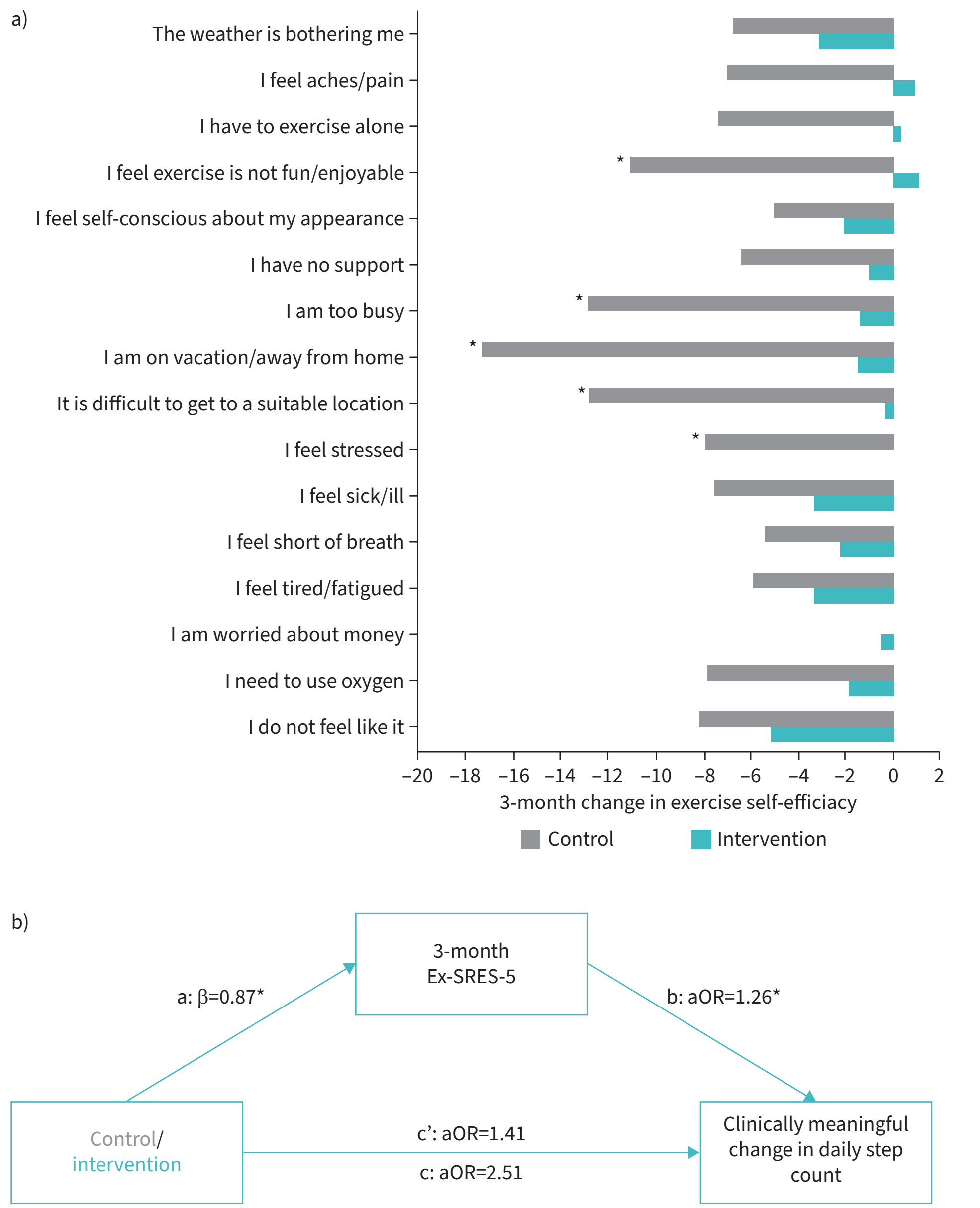

FIGURE 1 a) Change in exercise self-regulatory efficacy from baseline to 3 months by intervention exposure. A negative change reflects a decline. *: Significant between-group difference where p<0.05 and were used to generate the composite Ex-SRES-5 score. b) Mediation model of intervention exposure on achieving clinically meaningful improvement in daily step count through change in Ex-SRES-5 (exercise self-regulatory efficacy of 5 specific barriers to exercise). Path a presents the standardised effect. Paths b, c’, and c present the adjusted odds ratios (aOR). The c’ path represents the direct effect between intervention exposure and achieving clinically meaningful improvement of 418 steps per day in the presence of the mediator, 3-month exercise self-regulatory efficacy. The c path presents the total effect of the model. The indirect effect is represented by the product between the a and b paths (aOR=1.22, 95% CI (1.05, 1.64)). The mediation model adjusted for age, forced expiratory volume in 1 s % predicted, baseline Ex-SRES-5, and study sample. *: p<0.05.

Statistical significance was set at $p<0.05$, with confidence intervals not including 0.00 for standardised estimates or 1.00 for adjusted odds ratios (aOR). Independent samples t-tests assessed the impact of the intervention on the 16 Ex-SRES barriers from baseline to 3 months. A composite score was calculated (Ex-SRES-5), representing the five barriers which were significantly influenced by the intervention. Mediation analyses with Hayes' PROCESS macro [12] estimated the indirect effect of group assignment (control *versus* intervention) on the likelihood of achieving clinically meaningful improvement in daily step count through change in Ex-SRES-5. Models adjusted for baseline Ex-SRES-5, age, pre-bronchodilator FEV_1 % predicted, and study sample.

Participants with follow-up daily step counts at 3 months were included in analyses (n=179 (n=81 controls; n=98 intervention); mean age 69±8 years; 98% male; mean FEV_1 % predicted 63.83±21.01%). Mean baseline Ex-SRES-5 score was 67.52±23.45, baseline daily step count was 3437±2248, and change in daily step count was 443±1789. The percentage of participants who achieved clinically meaningful improvement in daily step count was not significantly different between groups (36% controls *versus* 47% intervention; $\chi^2=2.26$, p=0.133).

The control group experienced declines across all barriers assessed by the Ex-SRES. Compared to the intervention group, the control group had significantly more decline in exercise self-efficacy to overcome the following five barriers: feeling exercise is not fun/enjoyable (−11.07% *versus* 1.08%, p=.013), feeling too busy (−12.84% *versus* −1.37%, p=.007), being on vacation/away from home (−17.34% *versus* −1.47%, p=.001), having difficulty getting to the location for exercise (−12.80% *versus* −0.29%, p=.011), and feeling stressed (−7.92% *versus* 0.00%, p=.027) (figure 1a). The control group demonstrated significantly more decline from baseline to 3 months in the composite Ex-SRES-5 score compared to the intervention group (−12.42% *versus* −0.41%, $p<0.001$).

After adjusting for covariates, compared to the control group, exposure to the intervention was associated with a significantly higher Ex-SRES-5 score at 3 months (Figure 1b; $\beta=0.87$, 95% CI (0.21, 1.53)). For every 10-point increase in Ex-SRES-5, the odds of achieving clinically meaningful improvement in daily step count increased by 26% (aOR=1.26, 95% CI (1.07, 1.47)). The indirect effect of the intervention on achieving clinically meaningful improvement in daily step count through change in Ex-SRES-5 was significant (aOR=1.22, 95% CI (1.05, 1.64)).

Consistent with prior studies in non-COPD samples [13, 14], exercise self-efficacy mediated the relationship between the PA intervention and achieving clinically meaningful improvement in daily step count. The current intervention, which fosters self-regulatory skills for PA, maintained participants' confidence to exercise despite scheduling barriers (*e.g.*, feeling busy) and affect-based barriers (*i.e.*, stress). The control group experienced declines in exercise self-efficacy suggesting that over time, without intervention support, their confidence to exercise despite barriers waned. While not a mental health outcome, exercise self-efficacy is associated with exercise behaviour in COPD [7, 8]. Therefore, maintaining exercise self-efficacy is valuable.

Limitations include the sample being mostly white, male and US Veterans, limiting generalisability. The analysis was secondary, and exercise self-efficacy or achieving clinically meaningful improvement in PA were not primary outcomes. Only one type of self-efficacy was measured, and future research should explore other types. The study was limited to a 3-month outcome assessment, longer-term follow-up may provide additional insights. Future studies should investigate other mediators outside this study's scope to understand treatment targets for meaningful PA change. In addition, it is important for future research to explore which elements of the intervention, such as its easy accessibility, contributed to greater confidence to overcome exercise barriers. Our results suggest that future work should focus on enhancing exercise-self efficacy to optimize PA in persons with COPD.

The current analysis provides a novel examination of exercise self-efficacy as a mechanism by which technology-based PA interventions promote clinically meaningful improvements in PA among persons with COPD.

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References

1 Wan ES, Kantorowski A, Homsy D, *et al.* Promoting physical activity in COPD: insights from a randomized trial of a web-based intervention and pedometer use. *Respir Med* 2017; 130: 102–110.
2 Robinson S, Troosters T, Moy M. Technology to enhance engagement in physical activity. *In*: Moy M, Blackstock F, Nici L, eds. The Art and Science of Enhancing Patient Engagement in Pulmonary Healthcare. Cham, Springer, 2020.
3 Reilly C, Sails J, Stavropoulos-Kalinoglou A, *et al.* Physical activity promotion interventions in chronic airways disease: a systematic review and meta-analysis. *Eur Respir Rev* 2023; 32: 220109.
4 Waschki B, Kirsten AM, Holz O, *et al.* Disease progression and changes in physical activity in patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2015; 192: 295–306.
5 Wan ES, Kantorowski A, Polak M, *et al.* Long-term effects of web-based pedometer-mediated intervention on COPD exacerbations. *Respir Med* 2020; 162: 105878.
6 Selzler A-M, Rodgers WM, Berry TR, *et al.* Coping versus mastery modeling intervention to enhance self-efficacy for exercise in patients with COPD. *Behav Med* 2020; 46: 63–74.
7 Davis AT, Carrieri-Kohlman V, Janson S, *et al.* Effects of treatment on two types of self-efficacy in people with chronic obstructive pulmonary disease. *J Pain Symptom Manage* 2006; 32: 60–70.
8 Davis AH, Figueredo AJ, Fahy BF, *et al.* Reliability and validity of the Exercise Self-Regulatory Efficacy Scale for individuals with chronic obstructive pulmonary disease. *Heart Lung* 2007; 36: 205–216.
9 Driver CN, Novotny PJ, Benzo RP. Differences in sedentary time, light physical activity, and steps associated with better COPD quality of life. *Chronic Obstr Pulm Dis* 2022; 9: 34–44.
10 Demeyer H, Burtin C, Camillo CA, *et al.* The minimal important difference in physical activity in patients with COPD. *PLoS One* 2016; 11: e0154587.
11 Teylan M, Kantorowski A, Homsy D, *et al.* Physical activity in COPD: Minimal clinically important difference for medical events. *Chron Respir Dis* 2019; 16: 1–9.
12 Hayes AF. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. Guilford Publications, 2017.
13 Chang F-H, Latham NK, Ni P, *et al.* Does self-efficacy mediate functional change in older adults participating in an exercise program after hip fracture? A randomized controlled trial. *Arch Phys Med Rehabil* 2015; 96: 1014–1020.
14 Maddison R, Pfaeffli L, Stewart R, *et al.* The HEART mobile phone trial: the partial mediating effects of self-efficacy on physical activity among cardiac patients. *Front Public Health* 2014; 2: 56.