

Title	Behaviour change interventions for physical activity in adults with chronic obstructive pulmonary disease; a systematic review and meta-analysis
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Publication date	2023-11-14
Original Citation	Hanrahan, C., Broderick, J., O'Connor, T. M. and McVeigh, J. G. (2023) 'Behaviour change interventions for physical activity in adults with chronic obstructive pulmonary disease; a systematic review and meta-analysis', Respiratory Medicine and Research, 85, 101068 (12pp). doi: 10.1016/j.resmer.2023.101068
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.1016/j.resmer.2023.101068
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Download date	2026-10-29 09:11:05
Item downloaded from	https://hdl.handle.net/10468/15237



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Behaviour change interventions for physical activity in adults with chronic obstructive pulmonary disease; a systematic review and meta-analysis

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23 Abstract

24 Background: Physical activity in adults with COPD is poor, but behaviour change
25 interventions could help improve activity. This systematic review aims to examine
26 behaviour change interventions to promote physical activity and health outcomes for
27 adults with COPD.

28 Methods:

29 Eight databases were searched from inception until February 2022: Web of Science,
30 CENTRAL, MEDLINE, EMBASE, APA PsychINFO, CINAHL, PROSPERO,
31 Cochrane Airways Trials Register. Relevant studies were appraised to determine the
32 impact of behaviour change interventions on physical activity outcomes.

33 Interventions were mapped to Michie's Theoretical Domains Framework (TDF) and a
34 meta-analysis and narrative synthesis conducted. The Cochrane risk of bias tool
35 and the GRADE criteria evaluated bias and the quality and certainty of the evidence.

36 Results: Twelve randomized controlled trials (RCTs) were included in the review (n=
37 1211). The most frequently utilized behaviour change interventions included
38 counselling, stepcount monitoring, social support and goal setting. The most
39 commonly measured outcomes across studies were steps-per-day, physical activity
40 levels, exercise capacity and quality of life. A meta-analysis of comparable studies
41 demonstrated there was no difference in stepcount in favour of behaviour change
42 interventions with respect to steps-per-day (SMD 0.16, 95% CI -0.03, 0.36; p=0.10).
43 There was some evidence of short-term improvement in physical activity and quality
44 of life, with behaviour change interventions related to goals, behaviour regulation and
45 social influences.

Conclusions: People with COPD may benefit from behaviour change interventions to increase physical activity and quality of life in the short-term. The overall certainty and quality of the evidence is low however.

Keywords

Chronic obstructive pulmonary disease, behaviour change techniques, physical activity, systematic review

1. Introduction

Chronic obstructive pulmonary disease (COPD) is a complex chronic disease that slowly develops and is often undiagnosed until relatively late in the disease trajectory. The World Health Organization (WHO), state approximately 65 million people globally currently live with moderate to severe COPD [1, 2]. COPD is a preventable and manageable heterogenous disease, defined by persistent, irreversible obstructive airflow limitation and characterized by recurrent exacerbations [3]. People with COPD are less active than people without COPD, with physical inactivity leading to higher morbidity and mortality rates, and poorer quality of life (QoL) [4, 5]. Troosters *et al.* [6] report an approximate decline of 450 steps-per-day-per-year in this population, the cause of this decline being multifactorial. The World Health Assembly recommends inclusion of interventions by healthcare providers in primary care to reduce physical inactivity [7], however, the optimal approach to improve activity, and thus QoL in COPD, remains unknown.

In order to elicit change in physical activity (PA), effective behaviour change strategies must form part of interventions [6, 8]. Michie *et al.*'s behaviour change taxonomy, theoretical domains framework and COM-B model of behaviour change

are well-recognized in health literature and set out to contextualize an individual's behaviour from the perspective of capability, opportunity and motivation [9, 10] .

"Active ingredients" from the behaviour change taxonomy such as feedback, monitoring, reinforcement are considered to regulate, re-direct or alter behaviour [9, 10]. Mapping interventions to the theoretical domains framework (TDF) , and subsequently to the COM-B model can provide a lens through which analysis of an individual's key behavioural determinants can take place [11]. This model has been used successfully to support behaviour change in a number of chronic conditions, for example in PA and counselling in obesity [12, 13], timely symptom presentation in cancer [14] and behaviour change techniques in diabetes [15]. However, to date the COM-B behaviour change model has rarely been applied to PA and COPD and so the most effective behaviour change interventions for PA in COPD remain unclear.

In one of the few studies to examine behaviours of people with COPD using the TDF, Wshah *et al.* [16] qualitatively explored and reported on the determinants of sedentary behaviour of 14 participants with COPD. When mapped to the TDF, participants' sedentary behaviour was influenced by lack of knowledge, beliefs pertaining to capabilities, environment, resources and society. Some studies in COPD have reported tele-coaching, self-management and counselling as effective behaviour change mechanisms to increase PA [17, 18], however, sample sizes were small and attrition rates were high. It remains unclear, therefore, which are the most effective behaviour change interventions to improve engagement with PA in people with COPD. The aim of this systematic review therefore, was to evaluate behaviour change interventions which were aimed at improving PA and health related outcomes for adults with COPD. The objectives were to identify, analyze and synthesize available evidence exploring behaviour change interventions targeted at

increasing PA and health-related outcomes delivered to people with COPD. Interventions were subsequently mapped against Michie *et al.*'s theoretical domains framework [11].

2. Materials and Methods

This review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [19]. The review was registered at PROSPERO (CRD42021264965) on the 29th June 2021. The protocol was reported in line with the PRISMA-P guidelines and the full protocol for this review has been published [20]: <https://doi.org/10.12688/hrbopenres.13399.2>

2.1 Eligibility criteria

Inclusion criteria:

(1) Randomized controlled trials (RCTs) including adults with COPD as defined by the GOLD guidelines [21]. (2) Studies in English only. (3) Studies were included if data from participants with COPD was presented separately or participants with COPD comprised >80% of mixed diagnostic groups. (4) RCTs that investigated any behavioural change intervention in relation to its effect on PA engagement or sedentary time. (5) The intervention had to have a PA focus and could be out-patient pulmonary rehabilitation (PR), community or home-based interventions, supervised or non-supervised by a healthcare professional. Interventions targeting caregivers, healthcare professionals or organisations, studies that did not focus on PA levels or sedentary time as a therapeutic target were excluded.

2.2 Information sources

Searches were carried out in February 2022 in conjunction with a health sciences librarian and updated in April 2023. The following databases were searched from inception to April 2023:

[Web of Science](#), [CENTRAL](#), [MEDLINE](#) (via EBSCO), [EMBASE](#), [PsychINFO](#), [CINAHL](#) (via EBSCO), [PROSPERO](#), [Cochrane Airways Trials Register](#).

Reference lists of the relevant studies and grey literature were searched using [Grey Literature Report](#), [Open Grey](#) and [Google Scholar](#) search engines. The search strategy was adapted for each database.

Relevant studies were systematically reviewed in order to evaluate behaviour change interventions for adults with COPD. Interventions were mapped to Michie's TDF and a narrative synthesis with respect to nature, effectiveness on target population and setting/environment is provided. Findings are reported in relation to the generalizability of the primary results and the primary research question, and include secondary findings on health-related outcomes such as QoL, dyspnea, and adverse events.

2.3 Search strategy

Search strings consisted of free terms and controlled vocabulary (MeSH headings). To ensure inclusion of suitable search terms and potential studies, multiple key words from previous systematic reviews were considered for inclusion as key words including PA, and filters for health-related outcomes (e.g. dyspnea, quality of life) were applied. Using a concept table, key words were combined using the Boolean operators AND / OR.

2.4 Study records

2.4.1 Data management

References were imported from Endnote Reference Manager X9 [22] to Covidence systematic review software 2021 for review [23].

2.4.2 Selection process

Screening of studies was initially based on title and abstract information and conducted by two independent investigators (CH and JMcV). Full text papers were screened for inclusion by CH, and a 10% sample reviewed by (JMcV and JB). In the case of uncertainty regarding a papers' suitability for inclusion, a third investigator (either JB, TOC) was available to consult.

Where studies did not easily fit with the inclusion/exclusion criteria but where relevant subgroup data was provided, results of the group that met the inclusion criteria were included. Otherwise, the study was excluded. Study authors were contacted where full details of interventions had not been reported or clarity was required. Studies were excluded if details of reported interventions were not made available.

2.4.3 Data collection process

Data was extracted from the included studies by two reviewers independently, and details entered onto a standardized abstraction form including; publication demographics, study design, participant demographics and baseline characteristics, components and characteristics of interventions, study duration and setting, retention rates, comparator and outcomes.

2.5 Risk of bias

Version 2 of the [Cochrane risk of bias tool](#) (RoB2) [24] for RCTs was applied to primary outcomes to assess bias within and across studies. Studies were assessed using five fixed domains assessing for randomization bias, deviations from the intended interventions, missing data on the outcomes of the trial, outcome measurement bias and/or selection bias of the results reported. The RoB2 algorithm was used to generate judgements on the study's risk of bias as 'low', 'high', or 'some concerns'.

2.6 Data

2.6.1 Synthesis

A four-step approach was undertaken for analysis and synthesis of the included studies. Behaviour change interventions were identified, extracted and summarized as reflected in Michie's behaviour change taxonomy (BCT) [9] and subsequently mapped to the TDF [11]. For example, if an intervention group received telephone calls to support PA every two weeks for one year (where the control group did not) this intervention was interpreted as an active ingredient within the taxonomy, as "social support", "instruction on how to perform the behaviour" and "credible source" [9], with subsequent mapping to relevant TDF domains of "knowledge", "skills", "reinforcement" and "social influences" [11]. In order to confirm and clarify our interpretation, authors of all included studies were contacted in relation to the interventions in their studies, as mapped to the BCT [9] and the TDF [11]. Finally, intervention data were extracted into a standardised template independently by two reviewers and results compared and discussed by two reviewers (CH and JMcV) to ensure standardisation of the process.

A narrative synthesis of interventions with respect to nature, effectiveness on target population and setting/environment is provided. Findings are reported in relation to the generalizability of the primary and secondary results.

A meta-analysis was performed (using Review Manager (RevMan) version 5.4 [25] for the outcome of steps-per-day using a random effects model. The Cochrane Excel tool was used to convert median interquartile ranges (IQR) to mean and standard deviations where necessary [26]. Results were pooled (standardized mean difference (SMD)), with 95% confidence intervals and two-sided P values used for every outcome, and to assess heterogeneity, the Chi square and I-squared statistic were used.

2.7 Confidence in cumulative evidence

The GRADE working group criteria (Grading of Recommendations, Assessment, Development and Evaluations) [27] was used to rate the quality and certainty of the evidence in the included studies, from very low GRADE certainty ratings to high, and reported in a summary of findings table. GRADE considerations included limitations of studies, inconsistencies, lack of precision, indirectness and publication bias. Two investigators (CH and JMcV) scored all studies using the GRADE criteria and GRADEpro GDT software [28], and justified their decisions. Where discrepancies existed, a third investigator (JB or TOC) was available discussion to resolve any discrepancy.

3.Results

3.1 Literature review and selection

Initial identification of studies via database and register search yielded 3476 papers, as outlined in Figure 1. Following duplicate removal, 2664 papers were screened by

210 title and abstract and a further 2590 papers were excluded. The remaining 74 papers
211 were assessed for eligibility, with 62 deemed ineligible according to pre-determined
212 inclusion criteria.

213 Figure 1 PRISMA Flow **ABOUT HERE**

214

215 Twelve papers were eligible for inclusion in the systematic review, including 1211
216 participants. All studies were RCTs where the intervention groups received
217 behaviour change interventions to improve PA levels. Characteristics of the included
218 studies (participants, interventions, outcome measures and primary results) are
219 presented in the supplementary materials (Table 1).

220 Table 1 Behaviour change interventions mapped to the behaviour change taxonomy and the theoretical domains framework

221 **ABOUT HERE**

222

3.2 Participants

Participants across all included studies had COPD as defined by the Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD) [3]. Baseline characteristics varied within and between studies, with participant ages ranging from 53 [29] to 88 years [30] and forced expiratory volume in one second (FEV₁ predicted) ranging from severe 21% [31] to mild 87% [32] disease. Of the ten studies that measured steps-per-day, three did not report on significant difference between groups at baseline [29, 30, 33]. Three studies reported comparable baseline stepcounts between groups within each study [32, 34, 35], ranging from M(SD) 4634±2697 [34] to 7161.5±1708.1 [32] steps-per-day. One study reported significant differences in baseline exercise capacity (six minute walk distance)(6MWD) between groups (M(IQR) 452(360-515)) [36] and one reported clinically relevant, but not statistically significant, higher mean repetitions in one minute sit-to-stand (1MSTS) in the intervention group when compared to the control group at baseline (M(SD) CG 16.06(8.72), IG 20.97(7.04) (p value not reported) [37].

3.3 Behaviour Change Interventions

While behaviour change interventions may have been inherently present in treatments received by the control groups, for the purpose of this review and in order to align with Michie's behaviour change model, "active ingredients" (added to and separate from the control group intervention) such as additional follow-up phone-calls, pedometer feedback, goal setting were considered in order to establish the effect, if any, of these additional interventions. Across the included studies, various behaviour change interventions were utilized, with some studies using more than one intervention, including counselling [31, 35-38] stepcount monitoring/feedback [29, 31-35, 37-40], social support (e.g. home visits, phone-calls) [30-34, 37, 40] goal

setting [29, 31-38] motivational interviewing [35, 36] and tele-coaching [34]. Interventions were predominantly delivered in the community and primary care settings by physiotherapists, with the aim of increasing participants PA. Duration of interventions varied across studies from eight weeks [31, 33, 38, 40] to one year [30, 37, 39], the most common intervention duration reported was 12 weeks [29, 32, 34-36]. Frequency of the interventions varied from daily messaging via smart-phone application [34], to twice and three times weekly contact via classes or telephone [30-33, 38, 40] to weekly or monthly contact only [35, 39]. Six studies included interventions within PR programmes [31, 32, 35, 36, 38, 39], three studies included interventions in general exercise programmes [30, 33, 40] and one study included interventions post PR [29].

3.4 Interpretation of behaviour change techniques and mapping to behaviour change taxonomy and theoretical domains framework:

All 12 authors were contacted and asked to comment on our identification, interpretation and mapping of the behaviour change techniques reported in their studies, to the BCT [9] and TDF [11]. Seven authors responded [30, 32, 34, 35, 37, 38, 40] and Table 1 was amended to reflect their comments. When mapped to the BCT the groupings of "goals and planning", "feedback and monitoring" and "social support" were used in more than 80% of studies (Figure 2 in supplementary material). Only two studies did not include "goals and planning" in their interventions [30, 39], one study did not include "feedback and monitoring" [30], and two did not include "social support" [29, 34].

Of the six studies that demonstrated improvements in various PA outcomes post-intervention (Table 1 in supplementary materials) [31-34, 36, 39] only one did not

272 use goals and planning techniques as part of an intervention [39]. All but one study
273 [31] included feedback and monitoring in their intervention, and all but one [34]
274 included social support. When mapped to the TDF two domains were common to
275 these six studies: behavioural regulation and social influences. The domain of goals
276 was also common across five of these studies [31-34, 36]. The frequency of
277 interventions across all studies varied between daily, weekly and monthly
278 participation, with settings also varying between primary, secondary, tertiary care, in
279 participants homes, community or PR centres. Interventions were delivered mostly
280 by physiotherapists, but also trained exercise counsellors, investigators, PR staff
281 and/or semi-automated application.

3.5 Objective measurements of physical activity

Numerous methods of objectively measuring PA engagement or sedentary time as an outcome were utilised across all studies. Ten studies reported changes in steps-per-day (stepcount) [29, 30, 32-38, 40] while PA levels were variously measured across studies using moderate or moderate to vigorous PA (MPA/ MVPA) (MPA n=2) [34, 38], (MVPA n= 1) [32], change in sedentary time (n=4) [30, 32, 35, 40], metabolic equivalent of task (MET) (n= 3) [29, 30, 35], PA levels (n=3) [32, 35, 36], change in walking time (n= 2) [34, 39], time spent in PA (n=1) [40], or total energy expenditure (TEE) (n=1) [35].

3.5.1 Steps-per-day

Of the ten studies reporting steps per day as an outcome, five used pedometers [32, 33, 36, 37, 40] and five used accelerometers [29, 30, 34, 35, 38]. Measurement timepoints for all outcomes varied between studies, from two months [38] to 15 months [36]. Statistically significant improvements between groups in steps-per-day were reported in five studies in favour of intervention groups at the final measurement timepoints ($p=0.001$ [36], $p=0.001$ [32], $p=0.009$ [38], $p=0.009$ [33], $p<0.05$ [40]) and one within group improvement $p \leq 0.00$ [34]. Three of these studies were assessed as displaying overall high risk of bias [32, 34, 36] and three displaying some concerns [29, 33, 40]. Six studies reported clinically significant outcomes between groups at final timepoints [29, 33-35, 37, 38], with results exceeding the minimal clinically important difference (MCID) for COPD in intervention groups, as defined by Demeyer *et al* to be 600-1100 steps-per-day [41]. Only three of these studies, however, despite achieving MCID for steps-per-day, reached statistical significance at final timepoints ($p=0.001$, $p=0.009$, $p<0.05$) [32, 33,

40], with one of these studies displaying overall high risk of bias [32] and two showing some concerns [33, 40]. (Detailed characteristics and results of studies reporting steps-per-day are included in Table 1 of supplementary materials).

Meta-analysis

A meta-analysis of the ten studies that reported steps-per-day as an outcome was performed (Figure 2). There was moderate heterogeneity between studies (Chi^2 20.26; $\text{df} = 9$; $P = 0.02$; $I^2 = 56\%$) and we found little evidence of a difference in stepcount between intervention and control groups (10 RCTs, $n = 1094$, SMD 0.16, 95% CI -0.03, 0.36).

Figure 2 Meta-analysis of all studies that reported steps-per-day as an outcome

ABOUT HERE

In six studies, PA monitoring devices were worn, as per recommendations [42, 43], for a minimum of four consecutive days, over seven days for more than eight hours per day [29, 30, 32, 33, 37, 39]. Pedometers were used in four of these studies [32, 33, 37, 39], and accelerometers were used in two studies [29, 30]. The remaining studies were either unclear in their reporting or did not meet the recommended criterion of a valid measurement. Following a sensitivity analysis, there was sufficient consistency to perform a meta-analysis on the five papers that met the valid measurement of PA and reported steps-per-day (Figure 3). There was considerable heterogeneity in the outcome (Chi^2 18.72; $\text{df} = 4$; $P = 0.0009$; $I^2 = 79\%$) and no clear difference was found in stepcount between groups (5 RCTs, $n = 363$, SMD 0.41, 95% CI -0.08, 0.90).

Figure 3 Meta-analysis of studies that measured steps-per-day as an outcome and met the valid measurement criteria for physical activity **ABOUT HERE**

3.5.2 Sedentary time

Sedentary time (minutes) was recorded objectively in four studies [30, 32, 35, 40]. Two studies reported statistically significant between group improvements post intervention in relation to sedentary time, the first study at three months ($p=0.024$) but not at 12 months ($p=0.986$) [30] and the second study at six months only ($p=0.031$) [32]. Both studies were assessed as demonstrating overall high risk of bias. There were no significant differences between control and intervention groups in the two remaining studies [35, 40]. The MCID for sedentary time in COPD has not yet been established, and could provide a useful guide for use of interventions in this population [44].

3.5.3 Exercise capacity

All studies measured exercise capacity. The most commonly utilized measurements of change in exercise capacity across studies were 6MWD [29-32, 34-36, 39], 1MSTS [35, 37], endurance shuttle test (EST) and incremental shuttle walk test (ISWT) [38]. Four studies reported statistically significant improvements post-intervention in 6MWD at final measurement timepoints following PA counselling ($p=0.049$) [36], behaviour change support ($p<0.001$) [32], low intensity exercise with pedometer feedback ($p<0.01$) [39], and counselling with problem solving ($p=0.023$) [31] respectively. Varas *et al* [33] however, reported not only statistically significant changes in exercise capacity in the EST ($p=0.001$ at ten weeks, $p=0.00$ at one year) following a community-based exercise programme including feedback, but results

were also above the minimal clinically important difference for EST in COPD (174-279 seconds) [45].

3.5.4 Subjective measurement of physical activity

Subjective measures of PA engagement were reported in five studies [31, 32, 35, 37], with some studies using multiple tools, such as activity diaries [31-33, 37], Behaviour Exercise Regulation Questionnaire (BREQ-3), Physical Activity Stages of Change tool (PASC), International Physical Activity Questionnaire (IPAQ) [35] and the Modified Baecke Questionnaire [33]. Activity diaries were utilized in three studies [31, 32, 37] to record steps-per-day, as displayed by pedometer or accelerometer.

Rausch *et al* (2021) [35] did not report differences between groups following an intervention of counselling during PR. Varas *et al* (2018) [33] however, reported improvements in self-reported Baecke scores (total increase in score by 1.7 ± 2.2) at all measurement time-points ($p=0.002$ at 10 weeks, $p=0.00$ at 3 months, $p=0.00$ at 12 months) in the intervention group following a community-based exercise programme. This is reflected by statistically and clinically significant improvements in steps-per-day increased by 3158 ± 2192 (45% overall) ($p=0.001$ at 10 weeks, $p=0.00$ at 3 months, $p=0.009$ at 12 months) and exercise capacity (EST increased by 6.1 ± 5.7 mins, 491.4 ± 484.5 m overall) ($p=0.00$ at 10 weeks, $p=0.00$ at 3 months, $p=0.00$ at 12 months) post-intervention. Steele *et al* [31], although demonstrating some concerns regarding their randomization processes, present statistically significant results of self-reported minutes of activity change in the intervention group up to 20 weeks (IG 3 ± 39 , CG -13 ± 26 , $p=0.015$) but no significant lasting change in either group at 52 weeks (IG 1 ± 45 , CG -8 ± 31 , $p=0.355$).

3.6 Health-related outcomes

3.6.1 Quality of life

All studies included reports on QoL measurements. Various tools were used to subjectively assess participants perceptions of their QoL at multiple timepoints throughout the trials, such as the Chronic Respiratory Disease questionnaire (CRQ) [29, 36, 38, 39], St. Georges Respiratory Questionnaire (SGRQ) [30, 32], the COPD Assessment Test (CAT) [30, 37], Clinical COPD Questionnaire (CCQ) [34, 36], and the Short-form-36 (SF-36) [31], with some studies using more than one tool. Statistically significant improvements in QoL scores from baseline were reported in intervention groups in eight studies [31-34, 36, 38-40]. Improvements between control and intervention groups were reported in CRQ at 8 weeks IG 11 (3.0, 20.0), CG 20 (8.0, 27.0), $p=0.008$, and at 24 weeks IG 3.0(-8.0, 16.0), CG 10(-2.0, 19.0), $p=0.07$ [38] and at 12 weeks $p=0.006$ [36] and within groups at one year $p<0.01$ [39]. Improvements in intervention groups in SGRQ were reported at 24 weeks IG 23.1 ± 10.3 , CG 26.2 ± 15.3 $p<0.001$ (ES n^2 partial 0.41) [32] and at 10 weeks -5.5 $[-8.4, -2.6]$ $p=0.00$ at 12 weeks -9 $[-12, -5.5]$ $p=0.00$, at 1 year -8.9 $[-12, -5.6]$ $p=0.00$ [33] and within groups at eight weeks IG 10(5,14), CG 6(1,11) and at 14 months IG -6 (-10, -2), CG -4 (-9, 0.4) [40], all of which were above the MCID for this outcome. Demeyer *et al* [34] reported improvements in CCQ within groups at 12 weeks 0.64 (0.060 to 1.23), -0.203 (-0.382 to -0.024) $p=0.026$, while Steele *et al* [31] reported intervention group improvements at 20 weeks 35 ± 9 ($p<0.05$) using the SF-36.

3.6.2 Dyspnea

Eight of the 12 included studies reported on participants perceptions of dyspnea, utilizing five measurement tools: The Functional Status and Dyspnea Questionnaire

(FSDQ) [31] CCQ [34], CRQ [29, 38, 39], mMRC [30] and SGRQ [40]. There were statistically significant improvements in self-reported dyspnea in intervention groups in two studies ($p=0.026$, $p=0.046$) where the intervention consisted of telecoaching and pedometer feedback respectively [34, 39]. Two studies consisting of both exercise interventions and telephone follow-up reported improvements within groups despite demonstrating risk of bias concerns [30, 40], mMRC ($p<0.001$) [30], and Wootton *et al*, SGRQ M(SD)(IG 3(2,4), CG 2(0,3) [40]. Three of the four studies that utilized the Chronic Respiratory Disease Questionnaire (CRQ) reported statistically significant changes favouring intervention groups [36, 38, 39]. Kawagoshi *et al* [39] reported statistically and clinically significant differences in CRQ scores in favour of intervention group at one year M(SD), 95% CI (IG 98 ± 20 to 108 ± 19 , within group difference $p<0.027$, CG 99 ± 19 to 110 ± 19 , within group difference $p<0.01$) following a low intensity home-based PR programme. The study however, demonstrated high risk of bias across three domains, so results should be interpreted with caution. A higher quality study by Nolan *et al* [38] reported improvements between groups in total CRQ outcomes at eight weeks, following PR using targeted stepcount interventions (median (IQR)) (IG 11 (3.0, 20.0), CG 20 (8.0, 27.0), $p=0.008$) but not at six months ($p=0.07$). One further study [36] reported statistically and clinically significant changes in CRQ (where the MCID is 0.5 units per item [46]) favouring the intervention group at three months in the secondary care setting, where experimental group participants had received a counselling intervention M(SD), 95% CI (IG 114(96-126), CG 112(91-122, $p=0.006$)).

4. Adverse events

Adverse events were explicitly reported in two of the 12 included studies [34, 38]. One study reported acute exacerbations of COPD (30% ($n=48$) in control group, 27%

(n=43) in intervention group) resulting in five hospitalisations, 11 musculoskeletal events in the intervention groups versus two in the control group, as well as cardiovascular, urinary and gastrointestinal issues (n=7) and melanoma (n=1) [34]. Adverse events reported in the second study were similar between groups [38], with one reported allergic reaction and 56 hospital admissions, 30 of which were for COPD (control group n=16, intervention group n=14, p=0.29), with two deaths recorded in each group.

5. Risk of Bias

All studies were judged to have some risk of bias concerns in at least one domain, with six studies assessed as presenting with some concerns overall [29, 31, 33, 35, 38, 40] and six studies presenting with high risk of bias overall [30, 32, 34, 36, 37, 39]. While all studies scored low risk of bias for missing outcome data, measurement of the outcome was the domain most commonly assessed as high risk [30, 32, 34, 36, 37, 39]. The resulting overall judgements of some concerns and high risk of bias across all 12 studies (in supplementary material) indicated that results should be interpreted cautiously.

6. Certainty of the quality of the evidence

The certainty of the evidence for the impact of behaviour change interventions on some outcomes was low or very low (steps-per-day, sedentary time, subjective reporting of PA exercise capacity, QoL and dyspnea). Although some studies reported significant improvement in these outcomes, there were some concerns regarding risk of bias, inconsistency, and imprecision across all studies. See Table 2 for Summary of Findings.

Table 2 Summary of Findings **ABOUT HERE**

7. Discussion

The aim of this systematic review was to evaluate behaviour change interventions targeting PA and health-related outcomes in adults with COPD. The interventions were mapped to the BCT [9] and the TDF [11]. Overall, six studies [31-34, 36, 39] demonstrated some significant short-term improvements in objective PA outcomes. When interventions were mapped to the TDF, the domains of social influences and behavioural regulation were common to all. In a meta-analysis of comparable studies, there was no difference between groups with respect to the outcome of steps-per-day (SMD 0.16, 95% CI -0.03, 0.36; $p=0.10$). Significant improvements in health-related QoL at various timepoints were also reported in eight studies [31-34, 36, 38-40] favouring behaviour change intervention groups. All included papers presented some concerns or high risk of bias and the overall certainty of the quality of the evidence was judged as moderate, low or very low.

7.1 Physical activity:

Various methodologies have been employed to determine activity levels throughout existing literature, reflecting the complex nature of both PA as a concept and the measurement thereof. In this review, steps-per-day were most frequently monitored as a measurement of PA across ten studies. Seven of these studies incorporated behaviour change interventions within a structured exercise or PR programme [30, 32, 35, 36, 38, 40]. Five of these studies demonstrated an increase in steps-per-day post intervention [32, 33, 36, 38, 40], however, only two of these studies met the criteria for valid stepcount monitoring [32, 33] [42, 43]. Meta-analysis of five studies which met recommended valid stepcount monitoring [29, 30, 32, 33, 37] [43], showed little difference overall in stepcount in favour of the behaviour change

interventions . These studies included interventions pertaining to domains of reinforcement and social influences, combining step counter use with various other behaviour change interventions, such as counselling, goal setting, tele coaching and feedback, in various locations with different providers. Across all studies in this review, these results are supported by other less frequently used PA outcome measures e.g. 6MWD and PA time, where only three studies reported statistically significant improvements in intervention groups in 6MWD ($p<0.001$ at 24 weeks [32], $p<0.01$ at one year [39], $p=0.023$ at 20 weeks) [31], and only one reported improvements in PA time ($p=0.030$ at 24 weeks) [32]. Where improvements are reported, these findings may suggest that multiple interventions, rather than just one, could result in statistically and clinically significant short-term increases in activity, as supported elsewhere in COPD literature [47-50]. Our findings are supported by a recent Cochrane review [51] consisting of 76 studies ($n= 8018$) examining interventions for increasing PA in COPD, where quality of the evidence was similarly reported as low, but various interventions including, counselling and PR resulted in some short-term increases in PA. Large RCTs utilizing different outcome measures and other domains of the TDF may be more useful in evaluating changes in PA in this population.

7.2 Behaviour change interventions and the theoretical domains:

Corresponding authors were contacted and invited to contribute to our interpretation of their interventions and subsequent mapping to the TDF. All studies included more than one behavioural change intervention with the target of increasing PA. Twenty six techniques from the BCT taxonomy were identified [9] and when mapped to the 14 domains of the TDF [11], five domains were identified.

499 Of the 10 studies that reported improvements in steps-per-day, eight utilized goal
500 setting techniques [29, 32-38] and eight utilized PA monitoring techniques [29, 32,
501 34-37, 40]. Nine of these studies were mapped to the TDF domains of “social
502 influences” [29, 30, 32-34, 36-38, 40], eight to “goals” [29, 32-34, 36-38, 40] and
503 eight to “behaviour regulation” [29, 32-37, 40]. Most studies demonstrating increased
504 PA levels post intervention also reported utilizing a greater number of behaviour
505 change techniques (overall between three and 12 techniques per study), but long-
506 term improvements in PA were rare. NICE guidelines “Behaviour change: Individual
507 approaches” (2014) suggest delivery of feedback and monitoring for at least one
508 year post-intervention to elicit behaviour change [52], however, despite four studies
509 describing interventions lasting up to one year, only one study in this review [39]
510 reported improvements in walking time ($p=0.036$) exercise capacity (6MWD $p<0.01$)
511 and QoL (CRQ $p<0.027$) following one year of home-based PR with pedometer
512 feedback when compared to PR only. Recent RCTs examining the effects of
513 interventions such as adding counselling (including feedback and goal-setting) to
514 outpatient PR [50] and use of a pedometer during three weeks in-patient PR [53]
515 report some clinically, but not statistically, relevant short-term improvements in PA
516 post intervention in COPD. Burtin *et al* [50] suggest future research should focus on
517 interventions in the later stages of PR and early in the period post PR, which could
518 help to determine if interventions can help participants maintain their PR gains over
519 the longer term and translate them into everyday life. This review highlights not only
520 the lack of clarity regarding the optimal “dose” for ensuring behaviour change in
521 COPD, but also that not all behaviour change techniques or theoretical domains
522 have been fully explored in the literature, and so scope remains for future studies to
523 examine new techniques and their effect, if any, on PA in COPD.

7. 3 Health-related outcomes:

All included studies in this review reported on various health-related outcomes using multiple outcome measurements. Eight studies [31-34, 36, 38-40] reported statistically significant QoL improvements in intervention groups, including three studies reporting results greater than the MCID for SGRQ [30, 32, 33]. Of those studies that reported improvements in QoL, seven also reported statistically significant improvements in PA and exercise capacity outcomes at approximately 12 weeks post intervention [31-34, 36, 39, 40]. Dyspnea has been described as the most characteristic symptom of COPD and a major cause of disability [3], and as such was included in this review. All included outcome measures for dyspnea (mMRC, CCQ, SGRQ, CRQ, FSDQ) capture the patients perception of dyspnea on activity, with some short-term improvements reported. Due to the variety of health-related outcome measures used across studies it is difficult to synthesise findings, and despite improvements reported in this review, the evidence of a reciprocal link between both outcomes in the wider literature is currently modest [54]. In COPD, where PA levels and QoL are generally lower than in healthy populations, standardized measurement of patient-important outcomes for this cohort could serve to clarify the relationship between PA and QoL and thus inform relevant behaviour change interventions [55].

7. 4 Limitations

To our knowledge, a review of RCTs and subsequent mapping of reported behaviour change interventions for PA in COPD to the TDF has not yet been published. While this review aimed to answer a specific question utilizing rigorous and reproducible methods, there were some limitations, including relatively low overall number of

participants (n=1211). Only RCTs where participants had a diagnosis of COPD as specifically referenced by the GOLD criteria were included. This fairly narrow diagnostic criteria resulted in the exclusion of some studies (for example [50, 56-58]) which may have strengthened the impact of the overall results and clinical interpretation of the findings, however in relation to other reviews, our findings appear consistent [51, 59, 60]. Synthesis of results across all outcomes with respect to the effectiveness of specific interventions was difficult due to the complex nature of both PA and behaviour, which suggests there is a gap in relation to identifying, including and reporting on behaviour-change theory among researchers/clinicians. This gap in competency is reflected in the Global Action Plan for Physical Activity where the importance of training and education for physical activity interventions in healthcare professionals is identified [7].

This review primarily explored the effectiveness of behaviour change interventions on PA and secondarily on health-related outcomes in COPD. Including health-related outcomes could be considered a limitation of the review, and it could be argued that the behaviour change interventions identified in the included studies were unlikely to directly influence health-related outcomes such as QoL or dyspnea. Given the importance of such health-related outcomes in COPD, however, it was felt important to report the overall impact of these interventions in COPD.

7.5 Conclusion

This systematic review and meta-analysis considered behaviour change interventions for PA in COPD. Utilizing a framework has been useful in helping to identify behaviour change interventions and subsequent theoretical domains in the literature. A similar approach may be useful for researchers, clinicians and people

with COPD in order to identify, develop and incorporate effective behaviour change strategies for PA in COPD, as well as to highlight possible deficits in existing programmes. Future studies may benefit from examining awareness and use of behaviour change theory for PA and health-related outcomes in COPD in order to determine existing knowledge and perceived effectiveness of these interventions. While the overall certainty and quality of the evidence included in this review is low, we have attempted to address this important topic where a paucity of evidence currently exists. This review highlights that people with COPD may benefit from multiple behaviour change interventions pertaining to domains of goals, behaviour regulation and social influences to increase PA levels and health-related outcomes in the short-term.

Funding statement

This research forms part of CH's PhD which is being funded by University College Cork, Ireland.

The authors have no competing interests to declare.

Acknowledgements: The following authors of the original papers are acknowledged for their input into the classification of the interventions used in their studies: Heleen Demeyer, Alda Marques, Fanny Wai San Ko, Dario Kohlbrenner, Claire Nolan, Anne Kathrin Ruasch, Sally Wootton. Our sincere appreciation also to Professor Thierry Troosters for his advice and contribution to this paper.

595 Extended data available:

596 Figshare: Sample search strategy for CINAHL.docx.

597 <https://doi.org/10.6084/m9.figshare.15173262>.

598 Figshare: Draft data extraction table. <https://doi.org/10.6084/m9.figshare.15173265>.

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600 Captions of figures:

601 Figure 1 PRISMA flow

602 Figure 2 Meta analysis of all studies that reported steps-per-day as an outcome

603 Figure 3 Meta analysis of studies that measured steps-per-day as an outcome and
604 met the valid measurement criteria for physical activity

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Table 1 Behaviour change interventions mapped to the behaviour change taxonomy and the theoretical domains framework

Author	Control/intervention description	Delivered by	Frequency of intervention	Duration of intervention	Behaviour change techniques mapped to taxonomy [9]	Theoretical domains [11]
Altenburg et al (2015) [36]	Control: 12 week usual care Intervention: 12 week PA counselling plus usual care Location: Primary care, secondary care or PR setting	2 trained exercise counsellors	5 individual 30 minutes counselling sessions	12 weeks	1.1 Goal setting (behaviour) 1.4 Action planning 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 3.3 Social support (emotional)	Goals, social influences, behavioural regulation
Cruz et al (2016) [32]*	Control: 12 week PR only Intervention: 12 week PA focussed behaviour change intervention during PR programme including pedometer monitoring, goal setting, psychosocial support and social support for 12 weeks after PR Location: Primary care	Physiotherapist	Daily pedometer monitoring, weekly goal setting and psychosocial support (20-30 minute sessions). Social support Weekly in first month, fortnightly in second and third month after PR	6 months	1.2 Problem solving 1.3 Goal setting (outcome) 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 2.4 Self-monitoring of outcomes(s) 2.7 Feedback on outcomes(s) of behaviour 3.1 Social support (unspecified), 3.3 Social support (emotional) 9.1 Credible source 10.4 Social reward 12.5 Adding objects to the environment	Knowledge, reinforcement, goals, environmental context and resources, social influences, behavioural regulation

Demeyer et al (2017) [34]*	Control: 12 week usual care Intervention: 12 week Usual care plus semi-automated PA tele-coaching Location: Primary, tertiary care and rehabilitation centres	Investigator, step counter and semi-automated application	Daily app coaching, weekly goal setting, daily and weekly feedback	12 weeks	1.1 Goal setting (behaviour) 1.2 Problem solving 1.4 Action planning 1.5 Review behaviour goal(s) 1.6 discrepancy between current behaviour and goal 2.2 Feedback on behaviour 2.3 self-monitoring 5.1 information on health consequences 7.1 Prompts/cues 8.7 graded tasks 11.1 Pharmacological support (bronchodilator) 15.1 Verbal persuasion about capability	Goals, environmental context and resources, social influences, behavioural regulation
Kawagoshi et al (2015) [39]	Control: One year PR only Intervention: One year PR with monthly feedback from pedometer Location: Home-based	PR staff	Monthly feedback	1 year	2.2 Feedback on behaviour 2.6 Biofeedback 3.1 Social support (unspecified) 4.1 Instruction on how to perform the behaviour 6.1 Demonstration of the behaviour	Skills, social influences, behavioural regulation
Ko et al (2021) [30]*	Control: One year usual care Intervention: 4-8 weeks low intensity exercise training (in physiotherapy department), followed by phonecalls every 2 weeks for 1 year Location: At home	Physiotherapist and case manager	4-8 weeks exercise training, two hours per session, twice a week. Feedback every two weeks for one year	1 year	3.1 Social support (unspecified) 4.1 Instruction on how to perform the behaviour 9.1 Credible source	Knowledge, skills, reinforcement, social influences

Kohlbrener et al (2020) [37]*	Control: One year usual care Intervention: 12 weeks motivational support, activity diary, stepcount goals and monitored pedometer use, followed by 9 months observation of PA using pedometer Location: Outpatient department and community-based/home	Respiratory physiotherapist	Daily activity diary and pedometer use, monthly phonecalls for first three months followed by 9 months observation of PA using pedometer	1 year	1.1 Goal setting (behaviour) 1.2 Problem solving 2.3 Self-monitoring of behaviour 2.4 Self-monitoring of outcome(s) of behaviour 2.6 Biofeedback 3.3 Social support (emotional) 9.1 Credible source 12.5 Adding objects to the environment	Reinforcement, goals, environmental context and resources, social influences, behavioural regulation
Nolan et al (2017) [38]*	Control: 8 weeks supervised PR Intervention: 8 weeks supervised PR plus weekly reviewed step targets (based on pedometer feedback) Location: Outpatient PR class	Respiratory physiotherapists	Twice weekly PR, weekly counselling and review of step count for 8 weeks, use of diary for 6 months	6 months	1.1 Goal setting (behaviour), 1.2 Problem solving 1.3 Goal setting (outcome) 1.7 Review outcome goal(s) 2.7 Feedback on outcomes of behaviour 3.1 Social support (unspecified) 5.1 Information about health consequences 12.5 Adding objects to the environment	Beliefs and consequences, goals, environmental context and resources, social influences
Rausch et al (2021) [35]*	Control: 12 weeks PR only Intervention: 12 weeks PR plus 30 minutes PA counselling/ motivational interviewing at weeks 1, 3, 6, 9, 12 Location: Outpatient clinic	Physiotherapists	12 week PR programme plus five 30 minute face-to-face MI counselling sessions at weeks 1, 3, 6, 9 and 12	12 weeks	1.1 Goal setting (behaviour), 1.3 Goal setting (outcome), 1.4 Action planning, 2.2 Feedback on behaviour, 2.3 Self- monitoring of behaviour, 3.3 social support (emotional)	Behavioural regulation

Steele et al (2008) [31]	Control: 8 weeks PR only Intervention: 8 weeks PR plus 12 weeks PA adherence intervention; weekly phone calls, home visit, counselling Location: Outpatient department and participants home	Physical therapists	8 weeks PR plus weekly phone calls and one home visit over 12 weeks	20 weeks	1.2 Problem solving 2.3 Self-monitoring of behaviour 3.3 Social support (emotional) 4.1 Instruction on how to perform the behaviour 12.5 Adding objects to the environment	Knowledge, goals, environmental context and resources, social influences, emotion, behaviour regulation
Varas et al (2018) [33]	Control: 8 weeks with instruction only to walk daily with pedometer use Intervention: 8 weeks exercise training programme using pedometer feedback Location: Community-based	Physiotherapist	8 weeks exercise training, 5 days/week, 30-60 minutes. Daily step monitoring, weekly outcome review and goal setting by physiotherapist. Monthly phonecall post intervention for 3 months	1 year	1.2 Problem solving 1.3 Goal setting (outcome) 1.4 Action planning 2.1 Monitoring of behaviour by others without feedback 2.2 Feedback on behaviour 3.3 Social support (emotional) 9.1 Credible source	Skills, reinforcement, goals, social influences, behavioural regulation
Vorrink et al (2016) [29]	Control: 12 weeks PR only plus usual care Intervention: 12 weeks PR plus use of monitored smart-phone PA application Location: Primary care setting	Smart phone application and physiotherapists	Weekly setting of daily step goal for 6 months	6 months (post 12 weeks PR programme for all)	1.3 Goal setting (outcome) 1.7 Review outcome goal(s) 2.1 Monitoring of behaviour by others without feedback 2.7 Feedback on outcome(s) of behaviour 4.1 Instruction on how to perform the behaviour 9.1 Credible source 12.1 Restructuring the physical environment 15.1 Verbal persuasion about capability	Knowledge, skills, reinforcement, goals, environmental context and resources, social influences, behavioural regulation

Wootton et al (2019) [40]*	Control: 8 weeks ground-based walking training followed by 12 months walking maintenance programmes without feedback Interventions: 8 weeks ground-based walking training followed by 12 month walking maintenance programme with feedback; telephone calls, pedometer biofeedback, goal setting Location: Community-based	Physiotherapist	One individual education and motivation session post training programme, activity diaries to record step-count of unsupervised walking, telephone call every 2 weeks for first 3 months, and once/month until month 14 of trial	1 year	1.2 Problem solving 2.1 Monitoring of behaviour by others without feedback 2.3 Self-monitoring of behaviour 3.3 Social support (emotional) 4.1 Instruction on how to perform the behaviour 9.1 Credible source 12.5 Adding objects to the environment	Skills, goals, environmental context and resources, social influences, behavioural regulation

PA; physical activity, PR; pulmonary rehabilitation

BCT Taxonomy (v1): 93 hierarchically-clustered techniques: 1.1. Goal setting (behavior) 1.2. Problem solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behavior goal(s) 1.6. Discrepancy between current behavior and goal 1.7. Review outcome goal(s) 1.8. Behavioral contract 1.9. Commitment Feedback and monitoring. 2.1. Monitoring of behavior by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behavior without feedback 2.6. Biofeedback 2.7 Feedback on outcome(s) of behavior. 3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional). 4.1. Instruction on how to perform the behavior 4.2. Information about Antecedents 4.3. Re-attribution 4.4. Behavioral experiments. 5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.7. Information about emotional consequences. 6.1. Demonstration of the behavior 6.2. Social comparison 6.3. Information about others' approval. 7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning. 8.1. Behavioral practice/rehearsal 8.2. Behavior substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behavior 8.7. Graded tasks 9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes. 10.1. Material incentive (behavior) 10.2. Material reward (behavior) 10.3. Non-specific reward 10.4. Social reward 10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11 Future punishment. 11.1 Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions. 12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behavior 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes. 13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behavior. 14.1. Behavior cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behavior 14.8. Reward alternative behavior 14.9. Reduce reward frequency 14.10. Remove punishment. 15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful performance 15.3. Focus on past success 15.4. Self-talk 16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences [9]

* Interaction with authors on the classification of the intervention.

Table 2 Summary of Findings

Summary of findings:

Behaviour change interventions compared to usual care for COPD

Patient or population: COPD

Setting: community

Intervention: behaviour change interventions

Comparison: usual care

Outcomes	Impact	№ of participants (studies)	Certainty of the evidence (GRADE)
Steps-per-day follow-up: range 8 weeks to 15 months	Ten studies [29, 30, 32-38, 40] reported on steps-per-day. Statistically significant improvements between groups were reported in 5 studies [32-34, 36, 40]. Clinically significant outcomes between groups, exceeding the MCID (600-1000steps/day), were reported in 6 studies [29, 33-35, 37, 38]	1150 (10 RCTs)	⊕○○○ Very low ^{a,b,c,d}
Sedentary time follow-up: range 12 weeks to 12 months	Four studies reported on sedentary time [30, 32, 35, 40]. Two studies reported statistically significant improvements between groups at final measurement timepoints [30, 32]. Two studies did not demonstrate statistically significant improvements but trended towards less sedentary time in intervention groups [35, 40].	297 (4 RCTs)	⊕⊕○○ Low ^{b,g,h}
Subjective measure of physical activity follow-up: range 12 weeks to 12 months	Five studies [31-33, 35, 37] reported subjective measures of physical activity. Various measurement tools were utilized across studies. Two studies [31, 33] reported statistically significant improvements in self-reported activity levels.	295 (5 RCTs)	⊕○○○ Very low ^{b,i,j}
Exercise capacity follow-up: range 8 weeks to 15 months	All 12 studies reported on exercise capacity. Four studies [31, 32, 36, 39] reported statistically significant improvements in 6MWD between groups at final timepoints. One study [33] reported statistically and clinically significant improvements between groups in EST (at 10 weeks and at one year).	1351 (12 RCTs)	⊕○○○ Very low ^{b,e,f}
Quality of life follow-up: range 8 weeks to 15 months	All 12 studies reported on quality of life. Various measurement tools were utilized across studies. Statistically significant improvements in QoL were reported across 8 studies [31-34, 36, 38-40].	1351 (12 RCTs)	⊕○○○ Very low ^{b,k,l}
Dyspnea follow-up: range 8 weeks to 12 months	Eight studies [29-31, 33, 34, 38-40] reported on participants perceptions of dyspnea. Various measurement tools were utilized across studies. Statistically significant improvements between groups at final measurement timepoints were reported in three studies [30, 34, 39] and one study reported within group differences at 8 weeks only [40].	1047 (8 RCTs)	⊕○○○ Very low ^{b,m,n}

Summary of findings:

Behaviour change interventions compared to usual care for COPD

Patient or population: COPD

Setting: community

Intervention: behaviour change interventions

Comparison: usual care

Outcomes	Impact	№ of participants (studies)	Certainty of the evidence (GRADE)
Adverse events follow-up: range 8 weeks to 12 months	Two studies [34, 38] reported adverse events, such as exacerbations of COPD, musculoskeletal events and deaths.	571 (2 RCTs)	⊕⊕⊕○ Moderate ^a

^aThe risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Explanations

a. Five of the ten studies were assessed as overall high risk of bias, with the remaining five assessed as having some concerns. The most common high risk domain (5/10) was Domain 4 in RoB2, bias in measurement of the outcome. b. There was considerable heterogeneity between studies in relation to interventions and outcomes. c. The results of included studies were relevant to the review question. d. The overall total number of participants for this outcome was low at 1150, which may have affected the precision of the results. e. Six studies were assessed as overall high risk of bias, six were assessed as having some overall concerns. f. The overall total number of participants in the review is low at 1351, with total number of participants in individual trials ranging from 27 to 343, which may have affected the precision of the results. g. Two of the studies were assessed as high risk of bias, two presented with some concerns only. h. Total number of participants in the studies reporting on sedentary time was low at 297, which may impact the precision of the reported results. i. Two of the studies which reported on subjective measures of physical activity were assessed as having high risk of bias (both in measurement of the outcome and one deviation from the protocol), while three had some concerns only. j. The total number of participants in the 5 studies reporting on subjective measures of physical activity and sedentary time was low at 295 which may affect precision of reporting effectiveness of interventions. k. Five of the ten studies were assessed as overall high risk of bias, with the remaining five assessed as having some concerns. The most common high risk domain (5/10) was Domain 4 in RoB2, bias in measurement of the outcome. l. Various tools were used to subjectively assess participants perceptions of their quality of life at multiple timepoints throughout the trials, such as the chronic respiratory disease questionnaire (CRQ), St. Georges respiratory questionnaire, the COPD assessment test (CAT), clinical COPD questionnaire (CCQ) and the short-form-36 (SF-36), with some studies using more than

one tool which have affected precision of results. m. Three of the studies reporting on dyspnea were assessed as high risk of bias in measurement of the outcome. The remaining 5 studies presented some concerns overall. n. The total number of participants in the studies which included measurement of dyspnea was low at 1047 which may have affected precision of results. o. Adverse events were only reported in two studies resulting in inconsistency of reporting across studies