Title: Changing health behaviour with rehabilitation in thoracic cancer: a systematic review and synthesis.

Authors: Jo Bayly, MRes MCSP[a] , Dominique Wakefield, DM MRCGP[a], Nilay Hepgul PhD[a], Andrew Wilcock DM FRCP[b], Irene J. Higginson FFPHM PhD FRCP[a], Matthew Maddocks PhD MCSP[b]

[a]King's College London, Cicely Saunders Institute of Palliative Care, Policy and Rehabilitation, [b]University of Nottingham and Nottingham University Hospitals NHS Trust, Nottingham, NG5 1PB

Corresponding Author: Jo Bayly, Kings College London, Cicely Saunders Institute of Palliative Care, Policy and Rehabilitation, Bessemer Road, Denmark Hill, London, SE5 9PJ. Tel: +44 (0)207 848 5679 Email: joanne.bayly@kcl.ac.uk

Abstract

Objectives

International guidelines recommend that rehabilitation be offered to people with thoracic cancer to improve symptoms, function and quality of life. When rehabilitation interventions require a change in behaviour, the use of theory and behaviour change techniques (BCTs) enhance participation. Our objective was to systematically identify BCTs and examine their use in relation to the Capability,Opportunity,Motivation-Behaviour model and known enablers and barriers to engagement in this population.

Method

Bibliographic databases and grey literature were searched for controlled trials of rehabilitation interventions for adults with lung cancer or mesothelioma, with no limits on language or date. Data on the application of behavioural change theory and BCTs were extracted, categorized using the BCT Taxonomy (v1) and described according to the 'Capability, Opportunity, Motivation-Behaviour' model.

Results

Twenty-seven studies of exercise (n=15) and symptom self-management (n=12) interventions were identified. Four studies reported use of behavioural change theory, one study used symptom theory. Across studies, a mean (range) of 7 (1-18) BCTs were used, representing 26 of 93 possible BCTs included in the taxonomy. Most frequent enabling BCTs were 'instructions on how to perform behaviours' (74%), 'behavioural practice' (74%) and 'action planning' (70%). BCTs to address barriers were less frequent and included 'information about health consequences' (22%), and 'verbal persuasion about capability' (7%) to change perceptions about benefits, burden and harms.

Conclusion

The application of behavioural change tools appears sub-optimal in this group of patients. Explicit use of BCTs targeting behavioural components upon which outcomes depend may improve the uptake and effectiveness of rehabilitation interventions.

Keywords: Behaviour Change, Lung Cancer, Mesothelioma, Oncology Rehabilitation, Systematic Review

Introduction

Despite their illness, people with thoracic cancer want to "carry on as before,"(1) "live as usual"(2) and "fulfil social and family roles for as long as possible".(3) Cancer rehabilitation aims to relieve symptom burden and prevent or delay the onset of disability, supporting people to remain active and independent.(4, 5) It is recommended that rehabilitation, such as exercise or interventions to support independent symptom management and self-care be integrated into the oncology treatment pathway starting from the point of diagnosis.(4, 6) The acceptability of rehabilitation interventions to patients with thoracic cancer is influenced by many factors including, the stage of disease, symptoms, comorbidities, cancer treatment intensity and overall health status. These factors interact with the patient, carer and clinician's recognition of rehabilitation need, and perceptions about the possible benefits, harms and demands of proposed rehabilitation intervention(s).(7-12) Where benefit is perceived as being important and achievable, the acceptability of an intervention increases.(7)

Most rehabilitation interventions require patients to carry out health-related behaviours.(13) For example, to improve muscle function, patients are required to undertake regular aerobic and resistance exercise or physical activity behaviours.(14) As outcomes depend on changes in health-related behaviour, it could be argued that intervention components must be selected to target the desired change in behaviour, to achieve change in the health outcome. The targeted behaviour(s) should also be underpinned by theory that explains how the intervention is expected to cause the outcome.(15-17) Established tools from behavioural science provide a theoretically derived framework to support the design of interventions that involve people changing or adopting behaviours related to health(18, 19) as demonstrated by recent cancer rehabilitation studies.(20, 21) The 'Capability, Opportunity, Motivation-Behaviour Model' (COM-B) developed by Michie and colleagues is a model used in practice to design and evaluate interventions involving changes in behaviour and illustrates the conditions needed for behaviour change. It posits that providers and recipients should have the capability (physical and psychological); opportunity (physical and social); and motivation (reflective and automatic) to adopt the behaviours for change to occur. The COM-B is widely recognised and has recently been used to explain barriers and enablers to rehabilitation in patients with thoracic cancer. These included patients' physical health, mood, lifestyle and beliefs, as well as organisational factors such as location, format and clinician encouragement.(11) Our review aimed to identify and critically appraise use of behavioural theory frameworks within trials of rehabilitation interventions for people with thoracic cancer. Our objectives were to identify health-related behaviours targeted; underpinning behaviour change theory; and behavioural change techniques (BCTs) used. We then appraised the use of BCTs relative to known enablers and barriers

to rehabilitation and, subject to the availability of data, assessed the influence on uptake and completion of rehabilitation interventions.

Method

The protocol was registered on the National Institute for Health Research International Prospective register of Systematic Reviews (PROSPERO) (ID42017056378).

Eligibility Criteria

Types of studies: Randomised controlled trials, quasi-experimental studies and mixed methods studies of rehabilitation interventions with any health-related outcome. Conference abstracts and papers not published in peer review journals were excluded.

Types of participants: Studies with adult (≥18 years) participants, where over 50% of participants had a clinical or histological diagnosis of inoperable non-small cell lung cancer (NSCLC), small cell lung cancer (SCLC) or mesothelioma, receiving any non-surgical treatment with curative, life extending or palliative intent.

Types of intervention: Pilot searches identified few studies using the term 'rehabilitation' in this population. Thus, studies were included if the intervention required participants (and/or carers) to acquire or maintain skills and behaviours for health in any first level domain of the World Health Organisation-International Classification of Function, Disability and Health: (body structure, body function, activities, participation, personal and environmental factors)(5) and satisfied the World Health Organisation definition of rehabilitation as:*"… a process aimed at enabling people with disabilities to reach and maintain their optimal physical, sensory, intellectual, psychological and social functional levels… and providing disabled people with the tools they need to attain independence and self-determination"* (World Health Organisation: www.who.int/topics/rehabilitation/en/). Educational interventions targeting self-management of medicines, pharmacological interventions (including nutritional supplements), injection therapies and psychological therapies delivered by psychologists were excluded.

Information Sources and Search Strategy

Medline (1946-), PsychINFO (1806-), Cinahl (1937-), CENTRAL, (Cochrane Central Register of Controlled Trials), PEDro (Physiotherapy Evidence Database), Embase (1974–) and the grey literature at http://opengrey.eu/ were searched by one reviewer (JB). The last search was run on February 7th, 2017. Pilot searches identified the search strategy for Medline (see Appendix 1) using study design, population and intervention as search categories and were adapted for use with other bibliographic

databases. Manual cross-checking of reference lists of included articles and relevant systematic reviews was conducted to identify additional studies. Study protocols were obtained when available from reference lists of included studies or trial registration databases. No language restrictions were imposed.

Study Selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)(22) flow diagram was used to report the study selection process. Two reviewers (JB, MM) screened titles and abstracts against the eligibility criteria. All full texts were reviewed by one reviewer (JB), and one of two independent reviewers (DW, NH) reviewed eight full texts selected at random. Any disagreement regarding eligibility was resolved through discussion between additional members of the review team. All references were stored and managed in Endnote software, Version 7 (Thomas Reuters, Philadelphia).

Data extraction and handling

Two reviewers (JB and DW / NH) independently extracted data on study design, participant and intervention characteristics, and participant flow using a data extraction form with any differences in extracted items resolved through discussion. JB received training on BCT coding at the Centre for Behaviour Change, University College London. We extracted the described intervention target health-related behaviours, BCTs, and information on the delivery of the intervention, using the TIDieR checklist.(23) BCTs describe the 'observable, replicable, irreducible components of an intervention designed to change behaviour', and were coded using the Behaviour Change Techniques Taxonomy (version 1)(24). The taxonomy comprises ninety-three discrete BCTs that target a person's capability, opportunity and/or motivation to maintain or adopt specific behaviours and skills.(18) BCTs were coded only where explicitly reported, in accordance with Michie et al.'s recommendations.(18) When relating BCTs to the COM-B model, text from study titles and main text including methods, and results (e.g. qualitative quotes) were drawn upon. Published protocols and supplementary papers, e.g. process evaluations were also used alongside primary articles.

Synthesis

A narrative synthesis of the findings was completed and informed by Popay's general framework.(25) The synthesis was carried out in four stages: (i) we summarised study characteristics and health-related behaviours targeted; (ii) we describe reported use of theory supporting intervention design and delivery; (iii) we coded BCTs performed by intervention providers and/or recipients by health behaviour targeted; (iv) we appraised coverage of COM-B domains provided by identified BCTs(26) to identify gaps in reporting; and (v) we make recommendations to consider in

future rehabilitation studies. Assessment of Risk of Bias and quality of intervention reporting was conducted to assess study quality.(23, 27)

Results

Study characteristics

27 studies involving a total of 2,105 participants were included, comprising seventeen randomised controlled trials (two mixed-method),(28-44) and ten quasi-experimental studies(45-54) (Fig. 1, Table 1, Appendix 2). 1710 and 1896 participants had gender and age reported. Where reported, 56% of participants were male with a mean age of 71 (range 31-88). Studies were conducted in Europe,(29, 31-33, 36-39, 42, 44-50, 54) USA,(28, 51-53) Australia,(40) Thailand,(41) China,(35) Canada,(34) Hong Kong(43) and Taiwan.(30) Patients with non-small cell lung cancer were included across all studies, in contrast, patients with small cell lung cancer, mesothelioma and metastatic lung cancer were included in nineteen, six and two studies respectively (Table 1).

Health behaviours targeted

All studies involved participants modifying health-related behaviours, though two main categories were apparent; exercise (15 studies, 761 participants) and symptom self-management (12 studies, 1,344 participants) (Table 1). Of the exercise studies, five studied group(47, 49, 51) or individual(29, 30) programmes using only supervised training in a health care setting with no home training component. Five programmes offered supervised training and a home training component. (34, 45, 46, 48, 50) Five programmes used unsupervised home training following an initial instruction session in a health care setting, three of which involved exercise with devices.(28, 31-33, 35). Four of the fifteen exercise studies also included symptom self-management (breathing techniques or relaxation) to support the delivery of the exercise intervention (Table S1).(45, 46, 49, 50) Of the symptom self-management studies, seven offered a breathlessness management intervention,(36-39, 44, 53, 54) one studied a fatigue management intervention,(41) and four reported on interventions targeting the management of multiple symptoms. (40, 42, 43, 52) Eleven symptom self-management studies tested one to one interventions. One, a psycho-education programme(43) tested a group intervention. Exercise plans(41, 44) or advice(43) were included in three symptom self-management interventions. Details of the plans/advice was not reported.

Reporting of behavioural theory

Only five of the 27 studies (19%) reported the behavioural rationale or theory underpinning the intervention design (Table S1). Greer et al.(53) used a cognitive behavioural approach and techniques to inform a behavioural intervention for dyspnoea management. Quist et al.(49) used the

'teachable moment' concept within patient activation(55) and identified patient exercise preferences to justify the design of a gym based supervised group exercise trial for patients commencing treatment. Schofield et al.(40) used coaching and reinforcement theory in the design of a supportive care intervention incorporating assessment, active listening and self-care education. Yorke et al.(42) focused on participant's internal locus of control for practicing skills to manage a respiratory symptoms using a psychoeducational counselling intervention. Finally, Chan et al.(43), based a psycho-educational intervention targeting breathlessness, fatigue and anxiety on 'Lenz's Theory of Unpleasant Symptoms' making explicit reference to 'behavioural components' and 'adaptive behaviours' required of participants in the intervention description. The remaining 22 studies (81%) contained no explicit reporting of theory, but typically provided general bio-psychosocial, pathophysiological or prior research as the rationales underpinning interventions.

Use of Behaviour Change Techniques (BCTs)

Twenty-six BCTs relating to provider and participant behaviours were identified across eleven of the sixteen hierarchical clusters in the Behaviour Change Techniques Taxonomy (Figure 2). Twenty-one BCTs were coded in both exercise and symptom self-management studies. One BCT was only used in exercise studies (generalisation of behaviour target) and four were only coded in symptom self-management studies (information about emotional consequences, self-belief, reducing negative emotions and conserving mental resources). Overall, studies reported a mean (range) of 7 (1-18) BCTs (exercise studies 7 (4-11); symptom self-management studies 7 (1-18). Full coding of behavioural components performed by providers and/or participants is shown in Table S1 in the online supplement. The range of BCTs used was smaller in the exercise studies as compared to symptom self-management studies (Figure 2). For example, three of the seven breathlessness studies included ten or more BCTs.(42, 44, 53)

Here, we present the main findings relating to the domains of the COM-B model (Figure S1, online supplement) and enablers and barriers to performing intervention behaviours.

BCTs to maximise participant recruitment and retention

These were rarely reported, though two studies had motivation to participate in group based exercise as an inclusion criteria (Table 1).(45, 46) Cheville et al. based an exercise intervention in the home to enable opportunity for busy patients to participate by reducing travel to a health care setting.(28) Likewise, Greer et al.(53) and Ferrell et al.(52) enabled participation by integrating symptom management interventions with routine clinical appointments.(53) Two symptom management studies investigated if provider costs and participant burden (influencing provider and

participant capability), could be reduced in a service to manage breathlessness delivered over one compared to three training sessions.(36, 39)

BCTs targeting capability

Those relating to 'Feedback and Monitoring', 'Shaping knowledge', 'Comparison of behaviours' and 'Repetition (including practice and graded tasks)' indicated that participants across studies were enabled to acquire skills and behaviours to improve capability. Interventions aimed to improve mobility,(28) physical function,(29) fitness and muscle strength(30-33, 45-51), and symptom self-management skills.(34-39, 41-44, 53, 54) The BCT 'Instruction on how to perform behaviour' was the most frequently observed; coded in 20/27 (74%) studies. Improvements in physical capability were enabled by use of monitoring and practice BCTs three times more frequently in exercise compared to symptom self-management studies (Figure 2). As examples, the BCT 'Behavioural Practice / rehearsal' was observed in all 15 exercise studies, but only in 5/12 (42%) symptom self-management studies, and 'Graded tasks or activities' was observed in all but one exercise study (14/15, 93%) compared to only 1 of 12 (8%) symptom self-management studies.

BCTs targeting opportunity

'Social support' BCTs were found in most studies, but were generally provided by health care professionals to promote adherence to intervention behaviours. Six of the symptom self-management studies (50%) reported health care professionals offering emotional support, to enhance psychological capability and motivation.(37, 38, 40, 42, 44, 53) 'Practical social support' for participants was provided within one group exercise study, whereby existing participants experienced in the intervention supported new group members.(46) Physical opportunity was afforded by 'adding objects to the environment', for example training equipment in 13/15 (87%) of the exercise studies and hand-held fans for the relief of breathlessness in 3/12 (25%) symptom self-management studies. Few studies involved carers to address social barriers to opportunity. In one symptom self-management study, carers were taught how to provide practical social support for patients using breathlessness self-management techniques as part of the intervention.(44) Physical opportunity also relates to location of delivery. All exercise interventions required at least one attendance in a health-care setting. In four symptom self-management studies, participants could receive the intervention in a health-care setting or home depending on participant preference.(39, 42, 44, 52)

BCTs targeting motivation

Those involving 'goals and planning' to improve participant's reflective motivation and psychological capability were the most frequently coded. 'Action planning' was observed in over half of all studies (19/27, 70%). This generally related to details about how to implement home exercise training or symptom self-management plans and was offered alongside goal setting. Despite this, use of 'problem-solving' BCTs, to support participants address motivational (and capability) barriers to complete action plans and achieve goals, were only observed in 1/15 (7%) exercise studies and 6/12 (50 %) symptom self-management studies. Andersen et al.(56) used problem-solving and behavioural experiments to equip participants with skills to manage breathlessness during exercise. Six symptom self-management studies used problem-solving techniques to upskill participants in identifying symptom triggers or when to involve medical services. Greer et al.(53) explicitly reported using problem-solving to manage obstacles to intervention adherence. For BCTs involving information and feedback, there was variation according to the health behaviour targeted. Participants were given information about the health consequences of performing or not performing health-related behaviours in 6/12 (50%) symptom self-management studies, compared to only 1/15 (8%) exercise studies. In contrast, the BCTs 'provider feedback' and 'self-monitoring' were coded in 11/15 (80%) exercise studies compared to 5/12 (42%) symptom self-management studies.

BCTs targeting other barriers relating to motivation (and psychological capability), including mood and beliefs, varied depending on health behaviour targeted. Negative emotions were identified in 8/12 (66%) self-management studies but in no exercise studies.

Screening and accrual data was incomplete and a visual review of the data (Table S1, online supplement) did not reveal any discernible patterns. As a result, we were not able to determine any relationship between BCTs used, intervention uptake and completion.

Methodological assessment of studies.

Fewer than 50% of studies were categorised as low risk of bias and more than 40% were deemed to have a high risk of bias (Figure 3, online supplement). Lack of blinding of personnel, participants and outcome assessors resulted in high risk of performance and detection bias in 26/27 studies. Risk of attrition bias was also high, with 13/27 studies not accounting for missing data. Regarding the quality of intervention reporting, the materials, mode and location of delivery were generally well reported, as were the frequency, intensity and duration of intervention components. However, few studies reported behavioural components, underpinning theory or provider expertise and training (Table S2, online supplement). The fidelity of intervention deli very was most commonly reported using adherence or attendance rates (15/27 studies) or self-report diaries, calendars or logbooks (11/27 studies). Fidelity was assessed by recording intervention delivery, reviewing study

documentation, follow-up telephone calls or qualitative interviews but findings were not consistently reported (Table S2, online supplement).

Discussion

This systematic review has identified that few rehabilitation interventions tested in people with lung cancer are based on behavioural theory. Studies universally targeted exercise or symptom self-management health behaviours. Other important health behaviours, for example physical inactivity were not the target of any study and few studies made explicit use of behavioural components to support participation in the research itself. We coded BCTs using an internationally recognized taxonomy and appraised those identified in relation to domains of the well-established COM-B model of behaviour. We observed variation in the selection of BCTs according to the type of intervention; exercise and symptom self-management; and consequently, the domains of the COM-B model targeted. Use of BCTs to overcome known barriers(10, 11) and to maximise changes associated with successful participation varied. Exercise studies aimed to enable physical capability and motivation through instruction, practice, action planning and feedback BCTs, supported by the provision of equipment and social support. Symptom self-management studies included BCTs addressing belief related barriers. BCTs to enhance knowledge and emotional support, along with action planning, goal setting and problem-solving targeted psychological capability and motivation to perform symptom management techniques. This suggests that interventions were targeting different mechanisms to bring about behaviour change.

It is not clear which mechanisms are more effective in supporting behaviour change. Systematic reviews in other health contexts suggest that use of BCTs does influence intervention outcomes(57-59), though not always positively.(60, 61) Varying combinations of BCTs (action planning, instructions, demonstration, behavioural practice, self-monitoring, feedback, risk communication, social support and graded tasks) were associated with positive outcomes in reviews of physical activity and dietary interventions across heterogeneous populations.(57-62) However in some reviews, goal setting, self-monitoring, graded tasks and social comparison were associated with poorer outcomes.(60, 61) A systematic review of evidence for interventions promoting habitual exercise in people living with cancer (no thoracic participants in sample)(63) found that use of self-monitoring, behavioural practice, generalisation of behaviours away from clinical settings and goal setting BCTs was associated with exercise adherence. These mixed findings reveal the importance of transparent selection and reporting of BCTs to permit evaluation of outcomes in relation to proposed mechanisms of action. We identified that exercise studies all included practice and frequently used self-monitoring BCTs however less than half used goal setting or generalisation of

behaviours away from the clinical setting. Pedometers to support step count goal setting were used in one exercise study,(28) however their potential to enhance behaviour change remains uncertain.(64) Other BCTs associated with positive study outcomes were identified less frequently in our review. These include goal setting with coping planning (problem-solving).(62, 65) No study reported explicit use of implementation intention plans, where goal setting, action planning and problem-solving are combined.(66) Otherwise known as 'if then' plans, they enable participants to manage the impact of problems on capability and motivation for a target behaviour. For example, 'If I don't feel in the mood to go for a walk, then I'll ask my friend to come with me'. We did not identify use of habit related BCTs to support practice and action planning. Habit related BCTs address barriers to motivation and capability and are associated with reduced cognitive demand.(67) For example, habit formation techniques could encourage performance of previously habitual physical activity behaviours that have been stopped due to fears and beliefs surrounding disease and treatment. Increasing the frequency and intensity of such habitual physical activities, rather than introducing an exercise programme, may be more appealing to patients facing a busy treatment schedule or who hold negative beliefs about physical exercise.

The format of rehabilitation services can act as an enabler or a barrier to participation.(10, 11) We identified intervention characteristics addressing barriers related to travel to clinical settings, number of contacts with providers and supervision. Studies delivering supervised group exercise over multiple sessions in a clinical setting may act as a barrier to motivation and opportunity for some patients, due to personal temperament, travel or schedule constraints, but as an enabler for others where social interaction is an important motivational factor. Equally, while some patients may be more motivated to participate in home-based interventions, the relative lack of available social or practical support and unchallenged beliefs or attitudes, may act as barriers to participation in this setting.(9, 68) Stage of disease may also influence an individual's capability, opportunity and motivation to change health-related behaviour. This will vary according to the aim and demands of the intervention. For example, someone with advanced stage disease, experiencing breathlessness may be highly motivated to learn breathing techniques but poorly motivated to perform strength training exercises.

This work has several strengths. We used robust systematic search methods and collated findings from a large body of studies meeting the WHO definition of rehabilitation conducted in populations with lung cancer or mesothelioma. We carefully extracted and coded behaviour change findings using established behavioural science tools, methods that have been conducted in other recent reviews characterising behavioural components of complex health interventions.(21, 69-72) Extracting data using the TIDieR checklist revealed limitations in the quality of intervention reporting

on the training and supervision of providers, how well the intervention was actually delivered and how well participants understood and enacted intervention components away from the clinical setting. The evaluation of whether, and to what degree, an intervention was implemented as intended enables evaluation of the degree to which observed trial outcomes can be attributed to the intervention or variations in the mode and location of delivery, materials and processes used and the providers training and level of expertise.(73) More detailed reporting will facilitate improved development, replication and evaluation of rehabilitation interventions and may unlock untested mechanisms of effect and outcomes.(74, 75)

It should not be assumed that when BCTs address the capability, motivation and opportunity to perform rehabilitation behaviours as part of an intervention, that patients will go on to incorporate potentially beneficial behaviours into daily life. A recent trial of exercise in people with lung cancer, published since the review was conducted, incorporated theoretically informed behaviour change sessions yet found no between group differences in self-reported fatigue and physical activity or in objective measures of fitness.(64) Patients may have other competing goals or concerns and prioritise other behaviours.(76) In addition, when behaviours with a mechanism of action to achieve a target rehabilitation outcome are performed, they may not achieve that outcome in all participants. No two studies in this review used the same behaviour change approach. We recommend that behaviour change tools, such as COM-B and the Behaviour Change Wheel(77) or Intervention Mapping(19) should be used to design future rehabilitation studies in this population. These should identify and report the behavioural components integral to the performance of the intervention, and on which the outcomes depend. A more explicit use of BCTs to target these components may help make rehabilitation interventions more effective and sustained.

Conclusion

Few rehabilitation interventions studied in patients with thoracic cancer are based on behavioural theory or use BCTs to optimise successful participation. A more comprehensive and standardised use of behaviour change techniques within interventions may support more acceptable and effective rehabilitation programmes for this patient group.

Study Limitations

We only coded explicit reports of techniques relating to behaviour change within generalised descriptions of interventions. This proved challenging and introduced subjective interpretation which we addressed through independent double-coding and discussion. We did not contact authors

for protocols, only obtaining those in the public domain. It is probable that during actual intervention delivery, other BCTs were used but not reported.

Clinical Implications

Known enablers and barriers to participation should be considered more explicitly when designing and reporting rehabilitation interventions. Interventions that are goal orientated, support self-belief and positive habitual behaviours, and which equip participants to self-monitor, action plan, and problem solve are lacking. Better use of patients' own knowledge about the consequences of health behaviours, and of social support may improve the reach of rehabilitation in this group.

Conflict of Interests

The authors report no conflict of interest.

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Table 1 Study and demographic characteristics

Citation	Country	Study Design	Eligibility Criteria	Age Mean (SD or Range)	Number (± gender) Male (M) Female (F)	Treatment[a]
Exercise Studies						
Andersen et al 2011	Denmark	Non RCT	LC, Able & motivated to exercise. Walking distance ≥ 50 meters. No severe heart disease (NYHA class IV) No cognitive or balance deficits compromising performance of exercise.	M 64 (55-77) F = 67 (48-76)	24 (14 M)	Pre- chemotherapy n=19; pre-radiation n=8; Surgery n= 5; during radiation n=4; during chemotherapy n=3; during TKI n=3; pre-TKI 1
Andersen et al 2013	Denmark	Non RCT	LC, motivated to exercise, any histology, stage, treatment. Exclusions= Symptomatic brain metastases, heart failure, (NYHA IV)	65 (8)	51 (31 M)	During chemotherapy n= 26; previous surgery n=10; during radiotherapy n= 3; during TKI during intervention n= 2
Barinow-Wojewodzki et al 2008	Poland	Non RCT	Men undergoing radiotherapy treatment.	Group 1 62 (48-78) Group 2 68 (53-80) Group 3 62 (51-78)	70 (70 M)	All participants recruited during radiotherapy
Cheville et al 2013	USA	RCT	Stage IV LC/colo-rectal cancer. AM-PAC score between 50-75 (capable of performing intervention & potential to benefit). Exclusion = Folstein Mini Mental State score ≤ 25, inadequate English proficiency, hospice enrolment, average pain rating score of ≥6/10	IG 64 (13) CG 66 (9)	66 (35 M)	Treatment either radiotherapy and or chemotherapy: percentage of whole sample recorded at enrolment and completion.

Henke et al 2014	Germany	RCT	Included: ≥18years. Histologically confirmed NSCLC/SCLC stage IIIA/IIIB/IV receiving in-patient platinum based palliative chemotherapy. Stable clinical condition. KPS >50. Exclusion= previous exercise study participation, epilepsy, symptomatic CVD, Rheumatic disorders, confined to bed.	Not reported	Not reported	100% receiving palliative platinum based chemotherapy.
Hwang et al 2012	Taiwan	RCT	Age 40-75 years. NSCLC Diagnosis >4weeks, ECOG PS 0-1, medically stable, only Rx = EGFR inhibitors for ≥4 weeks. Exclusion: diabetes, unstable condition from metastases, other primary lung disease, severe cardiac or musculo-skeletal conditions that might affect participation in exercise or influence performance.	60 (50-67)	24 (12 F)	EGFR inhibitors 100%. Previous treatment Chemotherapy n=15; Radiotherapy n=13; Surgery n= 9
Kuehr et al 2013	Germany	Non RCT	Scheduled for chemotherapy or radiotherapy, histologically confirmed NSCLC, BMI >18kg.m-2; ability to follow German instructions & questionnaires. Exclusion=: acute infections, inability to stand and walk, immobility >2 days; spinal metastases, severe neurological disease, severe cardiovascular, pulmonary or renal disease, alcohol, substance abuse/drug addiction.	60 (12) (22- 75)	40 (24 M)	Surgery n= 3; Chemotherapy n= 33 Concurrent or sequential radiotherapy & chemotherapy n= 7
Maddocks et al 2013	UK	RCT	NSCLC stage IV confirmed by histology or cytology. ECOG PS 0-2. Scheduled to receive first line pall chemo. Exclusion= malignant spinal cord compression, epilepsy, cardiac pacemaker	Median 69 (64-75)	49 (28 M)	100% chemotherapy

Maddocks et al 2009	UK	RCT	NSCLC - ECOG PS 0-1, Medicines stable for 1/52, exclusion=chemotherapy or radiotherapy in last month. Weight loss >10% of premorbid weight, IHD, Cardiac pacemaker, any problem limiting them from taking walking exercise test.	IG 56 (9), CG 64 (5)	16 (9= M)	Surgery n= 3; Chemotherapy n=16; Radiotherapy n=6
Molassiotis et al 2015	UK & Cyprus	RCT	Adults. Histological diagnosis of LC or mesothelioma. Refractory dyspnoea for two weeks (breathlessness daily for 3 months at rest or on minimal exertion with maximum treatment), prognosis of >3 months, O2 saturation >85% at rest. Exclusion= unstable COPD, requires urgent medical intervention, palliative radiotherapy to chest within 4 weeks or chemotherapy within 2 weeks, intractable cough, unstable angina, clinically significant pleural effusion needing drainage	Not reported	46 (37 M)	Chemotherapy alone n=16; chemotherapy & radiotherapy n= 15; surgery & chemotherapy or chemo/radiotherapy n= 11 radiotherapy alone n=2 ;surgery alone n=2;
Quist et al 2015	Denmark	Non RCT	NSCLC IIIb-IV, SCLC-ED, on chemotherapy. Exclusion= brain/bone metastases, prolonged bone marrow suppression, anti-coagulation, symptomatic heart disease, informed consent. WHO PS 0-2	66 (31-88)	114 (57 F)	100% on chemotherapy
Quist et al 2012	Denmark	Non RCT	>18 years, NSCLS II-IV, SCLC ED; Excluded brain/bone metastases, prolonged bone marrow suppression, symptomatic HD, Anti-coagulation Rx, unable to give informed consent.	63 (45-80)	29 (16 F)	100% chemotherapy

Temel et al 2009	USA	Non RCT	Histologically confirmed NSCLC ECOG PS 0-1. Able to read & respond to questions in English, able to ambulate for 6 minutes. Exclusion=unstable heart disease, baseline anaemia, untreated bone/brain metastases.	Median 68 (48-81)	25 (16 F)	Chemotherapy n= 18; chemotherapy & radiotherapy n= 5; Radiotherapy n= 2
Vanderbyl et al 2017	Canada	RCT	≥18 years; pathologically confirmed stage III-IV NSCLC or GI cancer; scheduled/eligible for anti-cancer treatment; ECOG PS 0-2; life expectancy >4 months.	IG 66 (12) CG 64 (8)	24 (14 M)	100% chemotherapy
Wangnum et al 2013	Thailand	RCT	Aged 45-65, stage III-IV LC, received ≥ 1 treatment platinum based chemotherapy, ECOG PS 0-1. Good physical fitness, self-care, minor side effects, no tinnitus, able to read & write Thai, willing to participate & give consent. Exclusion= high fever, nausea, vomiting, diabetes or cardiac arrhythmias requiring treatment, movement disabilities, muscular dystrophy or paralysis, unable to walk 10 metres.	56 (45-65)	60 (41 M)	100% chemotherapy
Zhang et al 2016	China	RCT	LC diagnosed clinically, chest x-ray, CT or histology; 2-4 courses cisplatin-based chemotherapy for 21-day cycle, age ≥18; ECOG PS 0-3, willing to participate in Tai Chi or low-impact exercise Exclusion= contraindications for resistance training e.g. Moderate to severe Heart failure, already doing tai chi pre-chemotherapy, unable to complete fatigue score assessment, unable to choose group.	≤60 n= 20 ≥60 n=26	91 (68 M)	100% chemotherapy

Symptom Self-Management Studies						
Barton et al 2010	UK	RCT	Adults with malignant lung disease Refractory breathlessness. Prognosis > 3months & KPS >40. Exclusion= intercurent illness/comorbidities making completion unlikely; requiring urgent medical intervention, chemotherapy or change in hormone treatments in last 2 months, palliative radiotherapy in last 4 weeks, radical radiotherapy in last 6 months	71 (58-85)	22 (12 M)	Not on chemo/radiotherapy/ surgery. Participants on opioids, benzodiazepines or steroids for breathlessness included.
Bredin et al 1999	UK	RCT	Completed treatment, subjective reporting of breathlessness causing distress.	Not reported	Not reported	All post treatment
Chan et al 2011	Hong Kong	RCT	Age ≥ 16 years, Stage 3 or 4 LC, scheduled to receive palliative radiotherapy, ability to communicate in Chinese, informed consent, abbreviated mini mental test score ≥8, KPS ≥60, Exclusion = known psychiatric morbidity, involvement in other clinical trials	Not reported	140 (116 M)	100% Participants scheduled to receive palliative radiotherapy
Corner et al 1996	UK	RCT	Advanced SCLC/NSCLC post treatment with breathlessness.	Median IG 55 CG 69	20 (12 M)	After chemotherapy or radiotherapy
Farquhar et al 2014	UK	RCT	Patients & carers= Appropriate referral to service; 18+ years; Exclusion = unable to give informed consent; previous use of service; demented/confused/learning difficulties/other vulnerable groups (head injury/severe trauma/mental illness)	69 (12)	67 (26 M)	Not reported

Ferrell et al 2015	USA	Non-RCT	Patients treated in outpatient thoracic surgery & medical oncology clinics, Pathologically Confirmed Stage I-IV NSCLC.	<65 n=228 65-74 n= 167 ≥75 n= 96	491 (302 F)	Chemotherapy n= 345 Surgery n=112
Greer et al 2015	USA	Non RCT	Stage III-IV NSCLS/extensive SCLC, ≥18 years, ECOG PS 0-2, on-going outpatient oncology treatment, English language literacy, Modified medical research council dyspnoea scale ≥2 (moderate symptoms).	63 (8)	32 (18 F)	Chemotherapy 1-2 cycles, n=18 ≥3 cycles n=14
Hately et al 2003	UK	Non RCT	NSCLC, SCLC, mesothelioma experiencing breathlessness. Exclusion= pleural effusion, <1 month after active treatment completed.	71	30 (24 M)	Prior treatment radiotherapy n= 22; surgery n= 8; chemotherapy n=3; no treatment n=3
Johnson et al 2015	UK	RCT	Any intra thoracic malignancy, 1° or 2° tumours. Refractory breathlessness ≥3/10 NRS; Clinician estimated prognosis ≥ 3 months; Exclusion= intercurent illness/comorbidities making trial completion unlikely, requiring urgent medical attention, prior breathing training.	69 (9)	156 (96M)	Not reported
Schofield et al 2013	Australia	RCT	Inoperable lung or pleural (including mesothelioma) cancer, scheduled to receive palliative external beam radiotherapy, palliative chemo or radical radiotherapy or chemotherapy. Understands English, Excluded: psychiatric disorder, ECOG PS >3, < 2 months since previous treatment.	IG = 62 (9) CG= 64 (11)	108 (65 M)	Radical chemotherapy or radiotherapy n= 44 Pall radiotherapy n=40 Pall chemotherapy n=24

Yorke et al 2015	UK	RCT	Adults with LC, prognosis >3months, WHO PS 0-2, self-report 'bothered' ≥ 2 of 3 symptoms- (dyspnoea, cough, fatigue). Exclusion= acute exacerbation COPD in last 4 weeks needing change in medicines; chemotherapy/radiotherapy in last 4 weeks; lung cancer surgery in last 6 weeks.	IG =68 (10) CG 68 (9)	101 (54 F)	Palliative cancer therapy n= 52; Post curative cancer treatment n= 37; No active cancer therapy n= 12

RCT= Randomised controlled trial; IG = Intervention group; CG = Control Group; LC= Lung cancer; NSCLC= Non-small cell lung cancer; SCLC= Small cell lung cancer; ED= Extensive disease; GI = Gastro-intestinal; CT = Computerised Tomography; PS= Performance Status; ECOG= Eastern Cooperative Oncology Group; NYHA= New York Heart Association; KPS= Karnofsky Performance Status; AM-PAC = Activity Measure for Post-Acute Care; CVD= Cardiovascular disease; IHD =Ischaemic Heart Disease; COPD = Chronic Obstructive Pulmonary Disease; NRS= Numerical Rating Scale; BMI= Body Mass Index; [a] Participants may receive more than one treatment so number may not equal number in study.

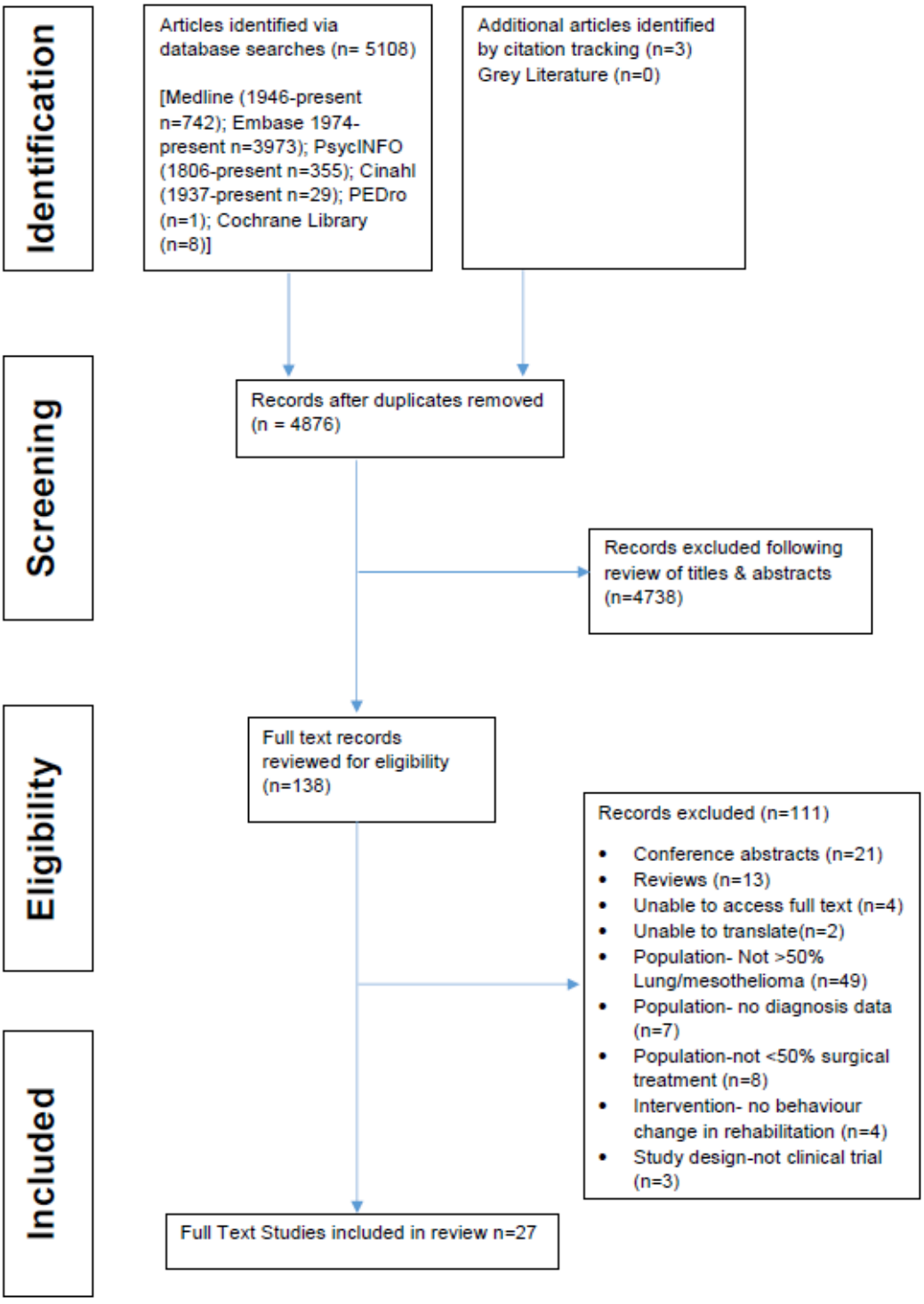

Figure 1 PRISMA Flow diagram of study selection process.(22)

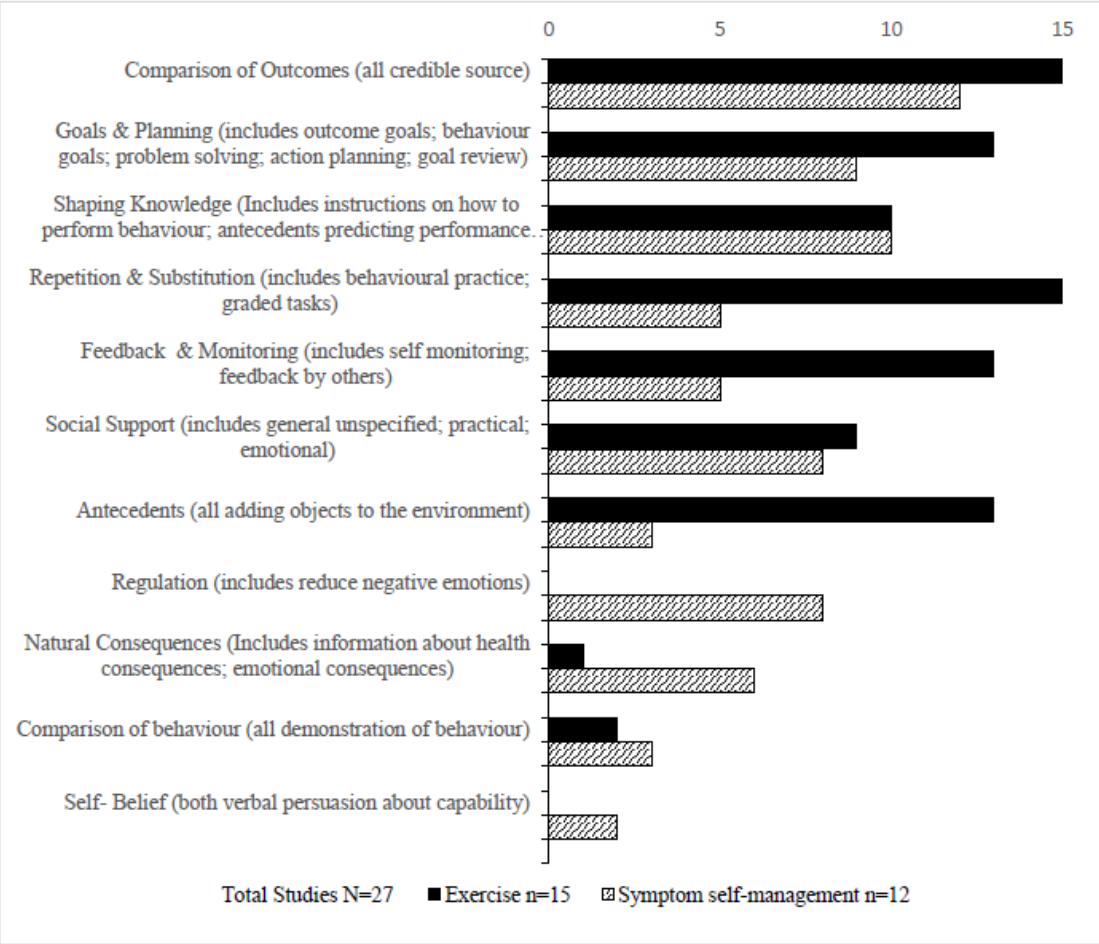

Figure 2 Number of studies including using Behaviour Change Techniques from each BCT group by health behaviour targeted (76) [BCTs from the following groups were not identified or coded in any of the studies reviewed: Associations; Rewards & Threats; Identity; Scheduled consequences; Covert Learning. BCT 9.1 Credible source, was coded in all studies and is not presented in the table]

	Capability		Opportunity		Motivation	
BCT group	**Exercise**	**Symptom Self-management**	**Exercise**	**Symptom Self-management**	**Exercise**	**Symptom Self-management**
1. Goals and planning	■	▨			■	▨
2. Feedback & monitoring	■	▨				
3. Social support			■	▨		▨
4. Shaping Knowledge	■	▨				
5. Natural consequences	■	▨				▨
6. Comparison of behaviour	■	▨				
8. Repetition & substitution	■	▨			■	
11. Regulation		▨				▨
12. Antecedents	■	▨	■	▨		
15. Self-belief						▨

Key: BCT = Behaviour Change technique; BCTs identified in: ■ exercise studies; ▨ symptom self-management studies.

Figure S1 BCT by COM-B as categorised by Cane et al (2012).

Table S1 Behaviour Change Techniques by Citation

Citation	Behaviour(s) Targeted	Primary Outcome	Behaviour Change Techniques (From Behaviour Change Techniques Taxonomy vs1)													
			1. Goals & planning	2. Feedback & monitoring	3. Social Support	4. Shaping Knowledge	5. Natural Consequences	6. Comparison of Behaviour	8.Repetition & substitution	11. Regulation	12. Antecedents	15. Self-belief	Total BCTs	Screened (n)	% Accrual	% Completion
Exercise interventions																
Andersen et al 2011	Supervised group & unsupervised home exercise; breathing techniques	VO_2 max (Incremental shuttle walking test)	1.2	2.3	3.1	4.1 4.4			8.1 8.6 8.7		12.5		**9**	NR	**NR (n= 45)**	**53**
Andersen et al 2013	Supervised group & unsupervised home exercise; breathing techniques	VO_2 max (Incremental shuttle walking test) & EORTC QLQ C30 QLQ LC15	1.4	2.3	3.1 3.2	4.1			8.1 8.6 8.7		12.5		**9**	NR	**NR (n= 59)**	**49**
Barinow-Wojewodzki et al 2008	Supervised group exercise	6 MWT 1RM			3.1				8.1 8.7		12.5		**4**	NR	**NR (n= 70)**	**100**
Cheville et al 2013	Unsupervised home-based exercise	Ambulatory Post-Acute Care Computer Adaptive Test- Self reported mobility	1.3 1.4 1.7	2.3	3.1	4.1			8.1 8.7		12.5		**9**	93	**71 (n= 66)**	**85**

Henke et al 2014	Supervised exercise during in-patient chemotherapy	Barthel Index	1.3 1.4	2.2	3.1				8.1 8.7		12.5		**7**	70	**66 (n= 46)**	**63**
Hwang et al 2012	Supervised exercise during targeted therapy	Primary= VO2peak (Cardiopulmonary Exercise Test)	1.4	2.2 2.6					8.1 8.7		12.5		**6**	44	**55 (n= 24)**	**79**
Kuehr et al 2013	Supervised & independent in-patient & home exercise	Feasibility- Adherence 1. Participants exercising x2 weekly in 6 of 8 weeks during treatment. Adherence 2. Ability to train per study guidelines- x5 sessions as in-patient, x3 home based session each week.	1.1 1.4	2.2 2.3		4.1	5.1	6.1	8.1 8.6 8.7		12.5		**11**	81	**49 (n= 40)**	**78**
Maddocks et al 2013	Independent use of NMES exercise device	Acceptability- adherence to recommended programme, self-report daily diary	1.1 1.4	2.2 2.3	3.1	4.1			8.1 8.7		12.5		**9**	85	**58 (n= 49)**	**57**
Maddocks et al 2009	Independent use of NMES exercise device	Acceptability- adherence to duration & frequency regime; self-report daily diary	1.1 1.4	2.2 2.3	3.1	4.1			8.1 8.7		12.5		**9**	53	**34 (n= 16)**	**89**
Molassiotis et al 2015	Independent use of inspiratory muscle training (IMT) device	No 1° outcome. Feasibility; inspiratory muscle training resistance & frequency of IMT use, Spirometry, MBorg, CRDQ SF & HADs	1.4	2.5					8.1 8.7		12.5		**5**	89	**53 (n= 46)**	**81**
Quist et al 2015	Supervised group exercise; relaxation technique during chemotherapy	VO_2peak- cycle ergometer W max test; 1RM (leg press, chest press, lateral press, abdominal crunch, leg extension); 6MWD; FACT-G; FACT-L; HADS	1.4	2.4	3.1	4.1			8.1 8.7		12.5		**7**	369	**31 (n= 114)**	**62**

Quist et al 2012	Supervised group & unsupervised home exercise; relaxation technique during chemotherapy	VO_2peak- cycle ergometer W max test; 1RM (leg press, chest press, lateral press, abdominal crunch, leg extension); 6MWD; FACT-G; FACT-L;	1.4	2.2 2.3 2.4	3.1	4.1			8.1 8.6 8.7		12.5		**10**	112	**29 (n= 29)**	**79**
Temel et al 2009	Supervised group exercise	Feasibility-adherence- 70% attendance at 16 sessions over 12 weeks	1.3	2.3					8.1 8.7		12.5		**5**	NR	**NR (n= 25)**	**56**
Vanderbyl et al 2017	Supervised & unsupervised qigong & standard group exercise therapy	HADS & FACT-G	1.4	2.5		4.1			8.1 8.6 8.7				**6**	301	**12 (n= 36)**	**53**
Zhang et al 2016	Tai chi & standard exercise	Multi-dimensional Fatigue Inventory-SF total score	1.4			4.1		6.1	8.1				**4**	124	**77 (n= 96)**	**95**
Symptom Management Interventions																
Barton et al 2010	Self-management techniques for breathlessness	Feasibility of RCT testing x3 sessions (IG) vs x1 session breathing training (CG)				4.1		6.1					**2**	53	**42 (n= 22)**	50
Bredin et al 1999	Self-management of breathlessness	NRS-Distress caused by breathlessness	1.2 1.3		3.3	4.1				11.2			**5**	NR	**NR (n= 103)**	58

Chan et al 2011	Self-management of breathlessness, fatigue & anxiety during radiotherapy	Composite outcome score (VAS 100mm Intensity of breathlessness/ Piper Fatigue/A-scale; State-Trait Anxiety Inventory)	1.1 1.2 1.4	2.3		4.1			8.1	11.2			**7**	255	**55** **(n= 140)**	73
Corner et al 1996	Self-management of breathlessness	No 1° outcome (VAS 100mm Breathing at best/worst/distress, Functional Capacity Scale, HADS)	1.3		3.1 3.3	4.1							**4**	NR	**NR (n= 34)**	59
Farquhar et al 2014	Self-management of breathlessness	Distress due to breathlessness by NRS 0-10	1.2 1.3 1.4	2.2	3.1 3.2 3.3	4.1 4.2	5.1 5.6	6.1	8.1 8.7	11.2 11.3	12.5	15.1	**18**	158	**42 (n= 67)**	70
Ferrell et al 2015	Self-management of symptoms/ concerns	FACT-L & Lung Cancer Subscale; FACT-L TOI. FACT-spirituality; Distress Thermometer (No 1° Outcome named)	1.2 1.3 1.4	2.2	3.1		5.1 5.6			11.2			**8**	544	**90 (n= 491)**	77
Greer et al 2015	Self-management of breathlessness	1st 1° Feasibility- enrolment & study completion rate. 2nd 1° Dyspnoea (Modified Medical Research Council Dyspnoea Scale)	1.2 1.4		3.1 3.3	4.1 4.2	5.1		8.1	11.2	12.5		**10**	57	**56 (n= 32)**	84
Hately et al 2003	Self-management of breathlessness	Rotterdam symptom checklist; VAS scores, dyspnoea at best, worst and distress caused in preceding 24 hours; functional capacity				4.1							**1**	68	**66 (n =30)**	67
Johnson et al 2015	Self-management techniques for breathlessness	NRS breathlessness intensity	1.3 1.4		3.1	4.1 4.2		6.1	8.1	11.2	12.5		**9**	528	**30 (n= 156)**	83

Schofield et al 2013	Self-care (including breathlessness)	38 item needs assessment for advanced lung cancer (NA-ALCP)			3.1 3.3		5.1			11.2			**4**	214	**52 (n= 108)**	70
Wangnum et al 2013	Self-management techniques for fatigue during chemotherapy	Piper fatigue	1.2 1.4	2.3		4.1	5.1						**5**	NR	**NR (n= 60)**	100
Yorke et al 2015	Self-management of breathlessness, cough & fatigue	Feasibility (No 1° outcome) 10 pt. NRS breathlessness average, worst, distress last 24 hrs; Dyspnoea 12 scale; Manchester Cough in lung cancer scale; FACIT-F; Lung Cancer Symptom Scale; EQ-5D-3L; HADS; Ease of use -10 pt. NRS scale.	1.3 1.4	2.3	3.1 3.3	4.1 4.2	5.1 5.6		8.1	11.2		15.1	**12**	715	**56 (n= 101)**	71

BCTTvs1 = Behaviour Change Techniques Taxonomy version1 (group 9 not presented as coded in all 27 studies); IG=Intervention Group CG = Control group; MBorg =Modified Borg Score; CRDQ SF= Chronic Respiratory Disease Questionnaire Short Form; HADS = Hospital Anxiety and Depression Scale; FACT-G = Functional Assessment of Cancer Therapy-General; FACT-L = Functional Assessment of Cancer Therapy –Lung; FACT-L TOI = Functional Assessment of Cancer Therapy -Lung Trial Outcome Index; EORTC = European Organization of Research and Treatment of Cancer Quality of Life; 6MWT= 6 Minute Walk Test; 1RM= x1 repetition maximum; VAS = Visual Analogue Scale NA-ALC = Needs Assessment-Advanced Lung Cancer Patients; NRS =Numerical Rating Scale.

BCTs: 1.1 Goal setting (behaviour); 1.2 Problem solving; 1.3 Goal setting (outcome); 1.4 Action planning; 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 behaviour without feedback; 2.6 Biofeedback 3.1 Social support (unspecified); 3.2 Social Support (practical); 3.3 Social support (emotional); 4.1 Instruction on how to perform the behaviour; 4.2 Information about antecedents; 4.4 Behavioural experiments; 5.1 Information about health consequences; 5.6 Information about emotional consequences; 6.1 Demonstration of the behaviour; 8.1 Behavioural Practice/rehearsal; 8.6 Generalisation of target behaviour; 8.7 Graded Tasks; 11.2 Reduce negative emotions; 11.3 Conserving mental resources; 12.5 Adding objects to the environment; 15.1 Verbal persuasion about capability.[17]

Table S2 TIDieR Checklist[23]

Citation	Name of Intervention	Behaviour Change Theory	Other theory/ causal assumptions reported	Materials & procedures	Intended frequency/ intensity & duration	Provider/ expertise/ specific training	Location/ Mode of delivery	Tailoring	Study modification	Planned strategies to maintain or improve fidelity of Intervention delivery/ adherence	Actual intervention fidelity reported
Exercise Studies											
Andersen et al 2011	Exercise & breathing techniques	No	Evidence based COPD-rehabilitation exercise protocol (background)	✓/✓	✓/✓	✓/✓/x	✓/✓	U	No	Conventional COPD supervised group and home exercise protocol, respiratory physiotherapy and training diary	Session attendance data and follow up phone call 4 weeks post intervention.
Andersen et al 2013	Exercise & breathing techniques	No	Evidence based COPD Exercise Protocol	✓/✓	✓/✓	✓/✓/x	✓/✓	Yes	No	Conventional COPD supervised group and home exercise protocol, respiratory physiotherapy, training log book and participant choice of home exercise	Session attendance data and follow up phone call 4 weeks post intervention.
Barinow-Wojewodzki et al 2008	Rehabilitation (Exercise training)	No	Pathological changes, potential response to exercise.	u/u	✓/✓	✓/x/x	✓/✓	Yes	No	Exercise protocol (no behaviour change required in non-clinical setting)	Session attendance data.
Cheville et al 2013	Home-Based Exercise Program to improve function, fatigue & sleep quality.	No	Evidence that physical activity interventions are safe, low cost, improve function & QOL for people with cancer.	✓/✓	✓/✓	✓/u/x	✓/✓	Yes	No	Home exercise protocol, illustrated instruction manual, participant completed exercise log and telephone calls to support adherence.	Pedometer step-counts and participant completed exercise log data.

Henke et al 2014	Strength & endurance training	No	Physiological effects & previous research that exercise training is beneficial & safe.	✓/✓	✓/✓	✓/x/x	✓/✓	Yes	No	Exercise protocol and adjuvant respiratory/ musculo-skeletal physiotherapy (no behaviour change required in non-clinical setting)	Session attendance data.
Hwang et al 2012	Exercise training	No	Physiological effects & previous research in surgically treated lung cancer patients.	✓/✓	✓/✓	✓/x/x	✓/✓	Yes	No	Exercise Protocol (no behaviour change required in non-clinical setting)	Session attendance data.
Maddocks et al 2013	Neuromuscular Electrical Stimulation (NMES) of the quadriceps during palliative chemotherapy.	No	Biomedical mechanism on muscle, may require lower levels of participant motivation than traditional exercise.	✓/✓	✓/✓	✓/x/x	u/✓	Yes	Yes	NMES protocol, Weekly telephones calls to support intervention usage and adherence	Self-report daily diary, data collected. Participant factors influencing adherence from qualitative interviews, reported briefly with no direct quotes.
Maddocks et al 2009	Neuromuscular Electrical Stimulation (NMES) of quadriceps	No	Via changes in muscle biochemistry	✓/✓	✓/✓	x/x/x	✓/✓	Yes	No	NMES Protocol, hospital and home visits to support device use and adherence	Self-report daily diary and semi-structured evaluation form.
Molassiotis et al 2015	Inspiratory Muscle Training (IMT) for breathlessness	No	Physiological effects & previous positive trials in other populations.	✓/u	✓/✓	x/x/x	✓/✓	Yes	Yes	Detailed protocol, supervision of research assistants, investigator meetings. Monthly home visits by intervention	Self-reported diary, frequency and duration of use.

										providers to monitor technique.	
Quist et al 2015	Multi-dimensional exercise intervention during chemotherapy	Patient Activation. Influence on study design not reported	Early intervention and physiological benefits of exercise/ physical activity.	✓/✓	✓/✓	✓/u/x	✓/✓	Yes	No	Supervised group exercise protocol. (no behaviour change required in non-clinical setting)	Session attendance data.
Quist et al 2012	Combined exercise intervention during chemotherapy	No	Physiological benefits	✓/✓	✓/✓	✓/u/x	✓/✓	Yes	No	Supervised group and home exercise protocol	Session attendance data. Self-report home exercise diary.
Temel et al 2009	Structured exercise program	No	Physiological benefits of exercise. Pulmonary rehabilitation based on commonalities between lung cancer & COPD.	✓/✓	✓/✓	✓/u/u	✓/✓	Yes	No	Supervised group exercise protocol (no behaviour change required in non-clinical setting).	Session attendance data.
Vanderbyl et al 2017	Medical Qigong vs Standard exercise therapy	No	Physiological responses to exercise training	✓/u	✓/✓	✓/✓/u	✓/✓	Yes	No	Supervised group & home exercise protocols	Self-report logbooks data not reported, authors report completion and return rates poor.

Zhang et al 2016	Tai chi for cancer related fatigue during chemotherapy.	No	Physiological mechanisms & previous research findings in other cancers	✓/u	✓/✓	✓/✓/x	✓/u	No	No	Supervised Tai chi protocol, instructional DVD	Session attendance data
Kuehr et al 2013	Exercise	No	Physiological mechanisms	✓/✓	✓/✓ no description of resistance exercises	u/✓/x	✓/✓	Yes	No	Supervised & home exercise protocol, training manual, participants trained to self-monitor symptoms to select intensity of exercise programme, weekly phone call.	Completed exercise sessions, Structured self-report diaries.
Symptom Self-management Studies											
Barton et al 2010	Breathing Techniques	No	Previous research of breathing interventions, National Guidelines	u/u	✓/✓	✓/ ✓/✓	✓/✓	No	No	Written and DVD reinforcement material. Telephone call by intervention physiotherapy specialist.	Proportion of planned interventions received.
Bredin et al 1999	Nursing intervention for breathlessness	No	Symptom has physical and psychological components.	u/u	✓/u	✓/u/✓	✓/✓	Yes	No	Practice guideline	Unclear
Chan et al 2011	Psycho-education program (PEI) for symptoms during palliative radiotherapy	No	Lenz's Theory of Unpleasant Symptoms, Psycho-educational Intervention model	✓/✓	✓/✓	✓/✓/✓	✓/✓	No	No	Intervention activity log & self-report diary recorded education session & practice.	Intervention activity log & self-report diary recorded education session & practice. Qualitative interviews

Corner Jet al 1996	Non-pharmacological intervention for breathlessness	No	Intervention based on COPD pulmonary rehab techniques	u/u	✓/u	✓/u/x	✓/✓	u	No	Unclear	Authors reports from qualitative interviews, but no participant quotes.
Farquhar et al 2014	Specialist Breathlessness Intervention Service (BIS)	No	Multi-disciplinary palliative care & psychologically informed approach	✓/✓	✓/✓	✓/✓/✓	✓/✓	Yes	No	Treatment manual	Qualitative interviews- quotes reported by impact level & outcome status.
Ferrell et al 2015	Inter- disciplinary Palliative Care	None	Previous evidence for benefits of early concurrent pall care on QoL.	u/u	✓/✓	✓/✓/✓	✓/✓	Yes	No	Education manual, Participants choose education topics. Action plan and 2 to 3 review questions at end of session to review learning.	Education sessions completed and referrals to other services.
Greer et al 2015	Brief behavioural intervention	CBT based	Previous trials of complex multi-component and non-pharmacological based interventions	✓/✓	✓/ ✓	✓/✓/✓	✓/✓	u	No	Intervention manual. Integration into clinic. MP3 recording of intervention to support home practice.	Planned interventions completed. Nursing documentation review to assess adherence to study protocol.
Hately et al 2003	Breathlessness Clinic in Specialist Palliative Care Setting	No	Previous evidence from RCTs of non-pharmacological management of breathlessness	u/u	✓/u	✓/✓/u	✓/✓	u	No	Unclear	Usefulness of intervention strategies rated.

Johnson et al		No	Previous evidence for breathlessness intervention services	✓/✓	✓/✓	✓/✓u	✓/✓	Yes	No	Standardised breathlessness techniques. Written and DVD reinforcement material. Telephone call by intervention physiotherapy specialist.	Study documentation reviewed to assess adherence to standardised techniques. Planned interventions received.
Schofield	Tailored Supportive Care Intervention	Yes- coaching & reinforcement	Systematic assessment & active listening encourages expression of unmet need & enable tailoring.	u/u	✓/✓	✓/u/u	✓/✓	Yes	No	Standardised, manualised intervention modules. First consultations recorded to assess fidelity to protocol.	Percentage of first consultations meeting intervention protocol. Number of participants receiving intervention.
Wangnum et al 2013	Multi-education program in self-care on fatigue during chemotherapy	No	Pathophysiology of fatigue; benefits of nutrition; mood & physical activity in self-care.	u/u	✓/✓	✓/x/x	✓/u	Yes	No	Standardised intervention	Participants asked to record exercise and nutrition intake- data not reported.
Yorke et al 2015	Management of respiratory distress symptom cluster	No	Cite previous development studies reporting theory and modelling stages.	u/u	✓/✓	✓/u/✓	✓/✓	u	No	Intervention protocol, explicit attention to supporting participants learn intervention techniques.	Number of participants receiving complete intervention. Structured diaries- frequency techniques used & ratings of usefulness over 12-week study period.

u= unclear; ✓= reported; x= not reported; COPD = Chronic Obstructive Pulmonary Disease; CBT = Cognitive Behaviour Therapy; QoL = quality of life

Appendix 1.

Medline Final Search 07 02 17

1. exp Mesothelioma/

2. mesothelioma.tw.

3. exp respiratory tract neoplasm$/

4. exp pleural neoplasm$/

5. exp lung neoplasm$/

6. exp tracheal neoplasm$/

7. lung neoplasm$.tw.

8. respiratory tract cancer.tw.

9. pleural neoplasm$.tw.

10. tracheal neoplasm$.tw.

11. lung cancer.tw.

12. (advanced adj cancer).tw.

13. exp palliative care/

14. exp neoplasm metastasis/

15. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14

16. exp rehabilitation/

17. exp Rehabilitation Research/

18. rehabilitation.tw.

19. exp "Physical and Rehabilitation Medicine"/

20. exp Physical Therapy Modalities/

21. exp exercise/

22. (physical adj activit$).tw.

23. exp self help devices/

24. exp self care/

25. (self adj care).tw.

26. (self adj management).tw.

27. exp Adaptation, Psychological/

28. exp "Attitude of Health Personnel"/

29. exp Illness Behavior/

30. Habits/

31. exp Information Seeking Behavior/

32. motivation/ or achievement/ or exp goals/ or exp intention/

33. behavioral sciences/ or behavioral medicine/ or behavioral research/

34. (behavio?r adj change adj technique$).tw.

35. (behavio?r adj change adj intervention$).tw.

36. exp Health Promotion/

37. (health adj promotion).tw.

38. Patient Education as Topic/

39. (patient adj education).tw.

40. (allied adj health adj professionals).tw.

41. allied health occupations/ or occupational therapy/ or physical therapy specialty/ or speech-language pathology/

42. physiotherap*.tw.

43. exp "rehabilitation of speech and language disorders"/

44. (speech adj therap$).tw.

45. (physical adj therap*).tw.

46. (occupational adj therap*).tw.

47. exp Dietetics/

48. dieti?ian$.tw.

49. 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48

50. "randomized controlled trial".pt.

51. (random$ or placeboe$ or single blind$ or double blind$ or triple blind$).ti,ab.

52. (retraction of publication or retracted publication).pt.

53. 50 or 51 or 52

54. (animals not humans).sh.

55. ((comment or editorial or meta-analysis or practice-guideline or review or letter or journal correspondence) not "randomized controlled trial").pt.

56. (random sampl$ or random digit$ or random effect$ or random survey or random regression).ti,ab. not "randomized controlled trial".pt.

57. 53 not (54 or 55 or 56)

58. controlled clinical trial.pt.

59. (mixed adj method$ adj research).tw.

60. (mixed adj method$ adj stud$).tw.

61. (mixed adj method$).ti,ab.

62. 57 or 58 or 59 or 60 or 61

63. 15 and 49 and 62

64. remove duplicates from 63

65. 63 not 64

66. from 63 keep 120,306-307,316

67. from 64 keep 13,18,30,36,61,64,68,71,74,78,81-82,85,88,94,96,99,105,109,111-112,116,119,121-122,145-146,154,156,158,160

68. from 64 keep 37,40,163,180,201,217-218,225,229,245,248,258,261,266,270,274,280,282,297,310,315,410,414-415,436,444,466,519,539

69. 15 and 49

70. exp clinical trial/

71. 69 and 70

72. 71 not 64

73. remove duplicates from 72

74. from 73 keep 10,19,27,31,33,37,54-56,61,73,82,85-86,91,94-95,103-104,107,119,123,126-127,130,132

75. 62 or 70

76. 15 and 49 and 75

Appendix 2: Excluded Papers (not including conference abstracts n=21)

Less than 50% or no lung cancer or mesothelioma patients in sample (n=49)

1. Adamsen L, Midtgaard J, Andersen C, Quist M, Moeller T, Roerth M. Transforming the nature of fatigue through exercise: Qualitative findings from a multidimensional exercise programme in cancer patients undergoing chemotherapy. European Journal of Cancer Care. 2004;13(4):362-70.
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5. Bausewein C, Booth S, Gysels M, Kuhnbach R, Higginson IJ. Effectiveness of a hand-held fan for breathlessness: A randomised phase II trial. BMC Palliat Care. 2010;9 (no pagination)(22).
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7. Bennett MI, Johnson MI, Brown SR, Radford H, Brown JM, Searle RD. Feasibility study of Transcutaneous Electrical Nerve Stimulation (TENS) for cancer bone pain. J Pain. 2010;11(4):351-9.
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13. Daly BJ, Douglas SL, Gunzler D, Lipson AR. Clinical trial of a supportive care team for patients with advanced cancer. J PAIN SYMPTOM MANAG. 2013;46(6):775-84.
14. Dodd MJ, Cho MH, Miaskowski C, Painter PL, Paul SM, Cooper BA, et al. A randomized controlled trial of home-based exercise for cancer-related fatigue in women during and after chemotherapy with or without radiation therapy. Cancer Nursing. 2010;33(4):245-57.
15. Doorenbos A, Given B, Given C, Verbitsky N. Physical functioning: effect of behavioral intervention for symptoms among individuals with cancer. Nursing Research. 2006;55(3):161-71.
16. Feldstain A, Lebel S, Chasen MR. An interdisciplinary palliative rehabilitation intervention bolstering general self-efficacy to attenuate symptoms of depression in patients living with advanced cancer. Support Care Cancer. 2016;24(1):109-17.
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21. Kazmierczak M, Hagner W, Kazmierczak U. The influence of physical exercises and manual lymphatic drainage on the quality of life in subjects with advanced neoplastic disease. [Polish, English]. Fizjoterapia. 2007;15(4):60-6.
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