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REVIEW ARTICLE

Understanding factors influencing physical activity and exercise in lung cancer: a systematic review

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Abstract

Purpose Despite evidence and clinical practice guidelines supporting physical activity (PA) for people with lung cancer, this evidence has not translated into clinical practice. This review aims to identify, evaluate and synthesise studies examining the barriers and enablers for patients with lung cancer to participate in PA from the perspective of patients, carers and health care providers (HCPs).

Methods Systematic review of articles using electronic databases: MEDLINE (1950–2016), CINAHL (1982–2016), EMBASE (1980–2016), Scopus (2004–2016) and Cochrane (2016). Quantitative and qualitative studies, published in English in a peer-reviewed journal, which assessed the barriers or enablers to PA for patients with lung cancer were included. Registered-PROSPERO (CRD4201603341).

Results Twenty-six studies ($n = 9$ cross-sectional, $n = 4$ case series, $n = 11$ qualitative) including 1074 patients, 23 carers and 169 HCPs were included. Barriers and enablers to PA were identified (6 major themes, 18 sub-themes): Barriers included patient-level factors (physical capability, symptoms, comorbidities, previous sedentary lifestyle, psychological influences, perceived relevance), HCP factors (time/knowledge to deliver information) and environmental factors (access to services, resources, timing relative to treatment). Enablers included anticipated benefits, opportunity for behaviour change and influences from HCPs and carers.

Conclusion This systematic review has identified the volume of literature demonstrating that barriers and enablers to PA in lung cancer are multidimensional and span diverse factors. These include patient-level factors, such as symptoms, comor-

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bidities, sedentary lifestyle, mood and fear, and environmental factors. These factors should be considered to identify and develop suitable interventions and clinical services in attempt to increase PA in patients with lung cancer.

Keywords Lung cancer · Physical activity · Exercise · Barriers · Systematic review

Introduction

Lung cancer is associated with significant multisystem disability and impairment [1]. Exercise intolerance occurs due to several confounding factors including the underlying pathological process, effect of surgical/adjuvant treatment, existing comorbidity and a history of sedentary behaviour [1–3]. Patients experience high symptom levels, particularly dyspnoea and fatigue [4]. These exacerbate patient distress and interfere with daily activities [4] and result in a vicious spiral of decline in physical function, cardiovascular fitness and muscle strength [5]. Ramifications for the patient (activity limitations, participation restrictions and diminished health-related quality of life [HRQoL]) and health care system (hospital utilisation) ensue [1, 5, 6].

Exercise is an effective means to improve physical and psychological outcomes in lung cancer [7–10]. The body of evidence has developed rapidly, and results from primary studies and systematic reviews/meta-analyses inform the current international clinical guidelines developed by the American College of Sports Medicine and American Cancer Society [2, 11]. These guidelines send a consistent message to consumers (patients, carers, health care providers [HCPs] and policy makers): Patients with cancer should engage in 150 min of moderate-intensity physical activity (PA) and two to three resistance sessions per week and avoid sedentary time [2, 11]. However, despite the large body of evidence, translation into lung cancer clinical practice and policy is almost non-existent. Exercise is not routinely delivered as part of the lung cancer model of care worldwide, as opposed to other populations such as chronic obstructive pulmonary disease (COPD) where pulmonary rehabilitation is standard practice [8]. This is problematic because patients with lung cancer have significant unmet needs, are inactive and rarely meet PA guidelines [5, 12]. The reason for the failure of evidence translation is not clear. Therefore, the aim of this systematic review was to identify, evaluate and synthesise studies examining the barriers and enablers for patients with lung cancer to participate in PA and thereby inform clinical practice, service delivery, policy and research aiming to enhance PA levels.

Methods

Protocol

The protocol is registered with the International prospective register of systematic reviews PROSPERO (CRD4201603341). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [13] and Enhanced Transparency of Reporting the Synthesis of Qualitative Research (ENTREQ) framework [14] were followed.

Eligibility criteria

Eligibility criteria are described in Table 1. Studies examining the barriers or enablers to patients with lung cancer participating in PA (any bodily movement produced by skeletal muscles that results in energy expenditure) [15] were included.

Information sources and search

Five electronic databases (Fig. 1) were searched by one reviewer (SP) using a pre-planned, systematic, comprehensive and reproducible search strategy to identify all published studies against defined eligibility criteria. Search terms and full search strategy are available in the online supplementary Table E1. Databases were accessed via the University of Melbourne. The last search was run on 1 February 2016. Additional references were identified by cross-referencing reference lists of included articles and hand-searching personal files.

Study selection

Eligibility assessment was performed in a standardised manner (Fig. 1). Two reviewers (CG, SP) independently screened abstracts and subsequently full-text articles for inclusion against defined eligibility criteria (Table 1). Disagreement was resolved by consensus, with a third reviewer (BC) involved if necessary. At each assessment stage, the agreement between reviewers was estimated with percentage agreement and the kappa statistic using SPSS for Windows statistical software package (SPSS Inc., Version 22.0.0, Chicago, IL). All references were stored in Endnote software 2016 version X7.4.

Data collection process and data items

Data extraction for *quantitative* studies was performed using a bespoke data collection form by reviewers (BC, KL) and cross-checked by a second (KL, BC). Independent reviewers (CG, SP) manually extracted and cross-checked all text under 'results/conclusions' from *qualitative* studies. To avoid double counting data, multiple reports on the same participant sample

Table 1 Eligibility criteria for inclusion of primary studies in the systematic review

Characteristics	Inclusion	Exclusion
Study design	• Quantitative including RCTs, pseudo-RCTs, cohort studies, case-control studies, case series, cross-sectional studies • Qualitative	• No original participant data (editorials, review papers, clinical guidelines) • Conference abstracts
Participants	• People with a current or previous diagnosis of lung cancer • Carers or relatives of people with lung cancer • HCPs working with patients with lung cancer	• Studies with less than five participants • Studies with mixed cancer cohorts if <50% of the cohort had lung cancer and/or cohort with lung cancer was not analysed separately
Exposure	• Participation in PA defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure' [15] by people with lung cancer. Includes PA domains of household, occupation, transport, activities of daily living, leisure, sport and structured exercise training	
Outcomes	• Barriers and enablers to PA for people with lung cancer	
Publication	• Published in English • Any date of publication	• Not published in a peer-reviewed journal

HCPs health care providers, PA physical activity, RCT randomised controlled trial

were identified by juxtaposing extracted data. Collected data were stored using Microsoft® Office Excel® 2016 software.

Risk of bias in individual studies

Independent reviewers (SP, CG) assessed the risk of bias of studies. Scoring agreement was estimated with percentage agreement and the kappa statistic. Case series were assessed using the Newcastle–Ottawa Quality Assessment Scale (NOS) [16]. Cross-sectional studies were assessed using the Agency for Healthcare Research and Quality Methodology Checklist for Cross-Sectional/Prevalence Studies [17]. *Qualitative* studies were assessed using the consolidated criteria for reporting qualitative research (COREQ) checklist [18]. Higher scores represent lower risk of bias (*quantitative* studies) [16, 17] or better comprehensiveness of reporting (*qualitative* studies) [18]. Results of studies were given the same weight regardless of their assessed risk of bias.

Synthesis of results

Quantitative data were summarised using descriptive statistics and frequencies using SPSS for Windows statistical software package (SPSS Inc., Version 22.0.0, Chicago, IL), and data on barriers and enablers to PA were synthesised in a narrative format. A meta-analysis was not possible due to variability in selection of reported outcome measures. Qualitative data on barriers and enablers were synthesised using thematic synthesis [19]. Two independent reviewers performed line-by-line coding of text from the qualitative studies (SP and CG), and similar concepts were grouped and new codes developed when necessary. Free codes were organised into descriptive major themes and sub-themes using an inductive approach [19]. Qualitative studies were cross-checked to ensure that relevant data were captured and integrated into the themes.

Results were mapped to the 'capability, opportunity and motivation-behaviour (COM-B) system' [20]. Capability refers to the capacity to engage in the behaviour; motivation refers to brain processes that energise and direct behaviour, and opportunity refers to factors external to the patient that act as a barrier or enabler to the behaviour [20]. The COM-B system links to the published 'Behaviour Change Wheel' [20] which provides a systematic framework to map behavioural analyses to specific interventions and policies aiming. Results of this review were interpreted within the COM-B system (i.e. whether barriers were related to capability, opportunity or motivational issues).

Results

Study selection

The search yielded a total of 2046 studies (Fig. 1). Assessment of title, abstract and full text resulted in 26 papers on 24 unique participant samples being selected for inclusion (Fig. 1). Agreement between reviewers of titles/abstracts was 'substantial' (kappa = 0.7, percentage agreement = 93%), and full-text articles were 'almost perfect' (kappa = 0.9, percentage agreement = 95%). Consensus was achieved on 100% of occasions when reviewers disagreed. Arbitration from a third reviewer was not required.

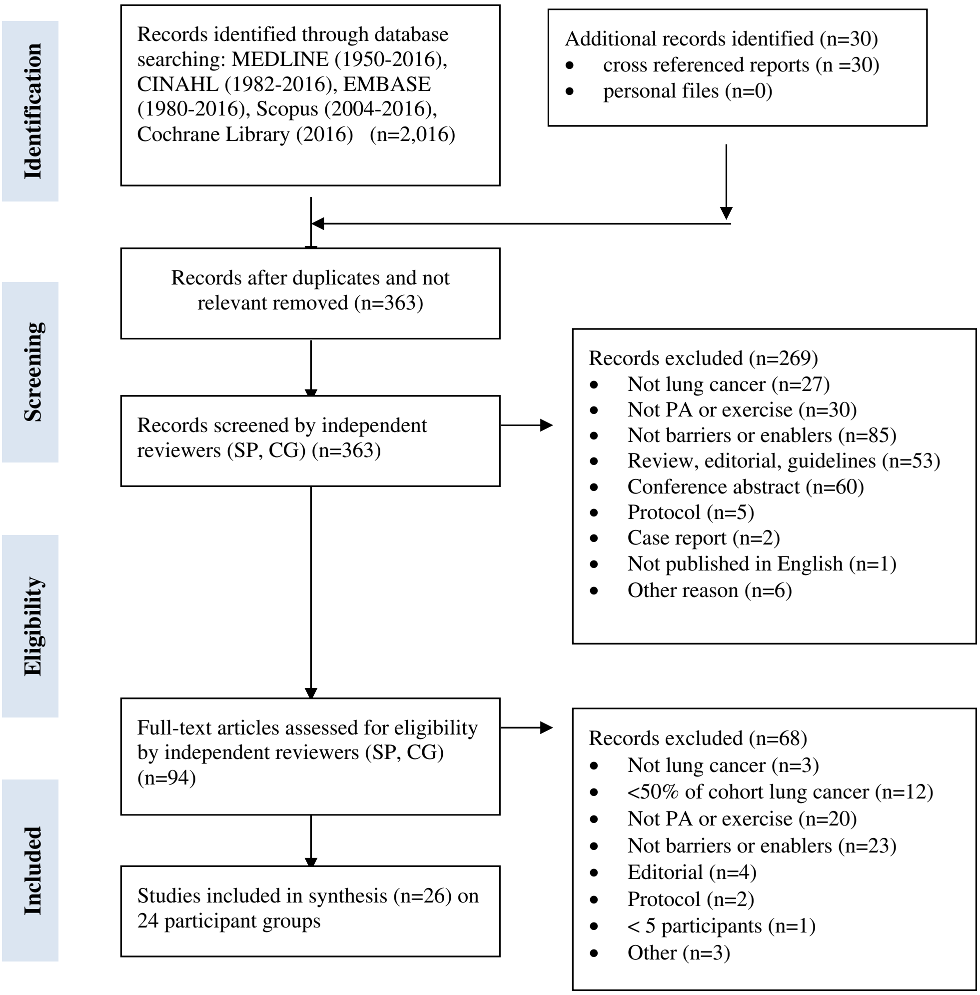

Fig. 1 PRISMA flow diagram of study selection process. < less than, *CINAHL* Cumulative Index to Nursing and Allied Health Literature, *EMBASE* the Excerpta Medica Database, *PA* physical activity

Study characteristics

This review included 4 prospective case series [21–24], 9 cross-sectional studies [25–35] and 11 *qualitative* studies (Table 2) [36–46]. Studies were conducted in eight different countries; the most common were USA (25% of studies), Canada (21%) and UK (17%) (Table 2). Most studies (79%) included only patients with lung cancer. Overall, 1074 patients with lung cancer, 169 HCPs and 23 carers were included in the review. Half of the studies included patients after treatment, and other studies included patients during (18%) or before (9%) treatment or at variable times (14%). The majority (73%) of qualitative studies used semi-structured interviews to collect data on barriers and enablers (online supplementary Table E2). All quantitative studies used questionnaires to collect data on barriers and enablers; however, there was not one consistent questionnaire used, and the majority (62%) used their own self-designed survey (online supplementary Table E2).

Risk of bias in studies

Agreement between reviewers for scoring was almost perfect (kappa = 0.9, percentage agreement = 97%). Consensus was achieved on all occasions when reviewers disagreed. Risk of bias was predominately attributed to be due to lack of comparability for case series and inadequate reporting of the recruitment time period or handling of missing data for cross-sectional studies. Qualitative studies scored poorly for lack of reporting of the interviewers' characteristics and the relationship between interviewers and participants. The mean (SD) risk of bias score for case series was 4.2 (1.0) out of 8 on the NOS [16], for cross-sectional studies was 8.2 (1.4) out of 11 on the Agency for Healthcare Research and Quality Methodology Checklist for Cross-Sectional/Prevalence Studies [17] and for qualitative studies was 16.4 (2.6) out of 32 on the COREQ checklist [18] showing that the overall risk of bias was moderate to high (online supplementary Table E3).

Table 2 Characteristics of primary studies

Author, year, country	Type of participants (number)	Gender M/F	Age years mean ± SD	Cancer type and stage (*n*) %	Time relative to cancer treatment (*n*) %	Cancer treatment (*n*) %
Qualitative studies						
Brown 2015, Australia [39]	Lung cancer (10)	8:2	Range 50–89	Lung (10) 100% Stage N/R	During treatment (2) 20%; post treatment (5) 50%; pall care (3) 30%	N/R
Kuijpers 2015, The Netherlands [38]	Lung cancer (14); breast cancer (21); HCPs (31): medical ($n = 7$, e.g. radiotherapists, nurse practitioners), paramedical ($n = 10$, e.g. physical therapists, dieticians) and psychosocial ($n = 14$, e.g. social workers, psychiatrist)	Lung cancer 7:7 Breast cancer 0:21 HCPs 6:25	Lung cancer 61.6 (range 52–79) Breast cancer 52.9 (range 27–76) HCPs 45.5 (range 24–62)	Lung (14) 40% Breast (21) 60%	Lung cancer <1 year after treatment, 14 (100) Breast cancer <1 year after treatment, 9 (43%); >1–5 years after treatment, 12 (57%)	N/R
Mas 2015, France [37]	Lung cancer (5)	4:1	69 (range 60–81)	NSCLC IIIB (5) 100%	During chemo	Surgery + chemo (4) 80%; chemo only (1) 20%
Missel 2015, Denmark [36]	Lung cancer (19)	8:11	63 (range 48–75)	NSCLC: IA (5) 26%; IB (1) 5%; IIA (9) 47%; IIB (2) 10%; III (2) 10%	Post-operative (day 1, 7 weeks and 4 months post)	Surgery only (11) 68%; surgery + chemo (8) 42%
Hoffman 2014, USA [40]	Lung cancer (6)	2:4	Range 53–73	NSCLC: I (1) 17%; II (3) 50%; III (2) 33%	12–18 months post-op	Surgery, chemo + RT (3) 50%; surgery + chemo (2) 33%; surgery only (1) 17%
Lehto 2013, USA [42]	Lung cancer (11)	5:6	69.8 ± 8.5	NSCLC: I–II (6) 55%; III–IV (5) 45%	>6 months post diagnosis	Surgery (7) 64%; chemo (3) 27%; RT+/or chemo (1) 9%
Maddocks 2013, UK [41]	Lung cancer (30)	16:14	70 (IQR 64–74)	NSCLC IV (30) 100%	During chemo	Palliative chemo
Adamsen 2012, Denmark [45]	Lung cancer (15)	8:7	66 (range 45–80)	NSCLC (13) 87%: IIIB (7) 54%; IV (2) 15%; unknown (4) 31% SCLC ED (2) 13%	During chemo	Chemo only (5) 33%; chemo + RT (10) 67%
Cheville 2012, USA [44]	Lung cancer (20)	10:10	Range 53–84	NSCLC: IIB (2) 10%; IV (18) 90%	NR	Chemo (11) 55%; RT (1) 5%; nil (8) 40%
Ellis 2012, UK [43]	Lung cancer (37); caregivers (23)	Lung cancer-22:15 Caregivers-NR	Lung cancer-69.5 ± 8.9 (range 48–91) Caregivers-NR	NSCLC (16) 43.2%; SCLC (19) 51.4%; mesothelioma (2) 5.4% I (1) 3.1%; II (7) 21.8%; III (10) 30.3%; IV (12) 44.8%; 5 missing data	During or post treatment	Chemo + RT (17) 45.9%; chemo only (12) 32.4%; RT only (6) 16.2%; surgery only (1) 2.7%; surgery + chemo (1) 2.7%
Jones 2009, UK [46]	Lung cancer (6)	2:4	Range 43–68	Lung 6 (100%)	Post-operative (6 weeks–16 months)	Surgery
Quantitative studies						
Kartolo 2016, Canada [25]	Lung cancer (60)	29:31	Range 41–50 ($n = 1$) Range 51–60 ($n = 11$)	Inoperable metastatic lung (60) 100%	Within 5 years of diagnosis	Current treatment: chemo (24) 42.1%; oral medication (7)

Table 2 (continued)

Author, year, country	Type of participants (number)	Gender M/F	Age years mean ± SD	Cancer type and stage (*n*) %	Time relative to cancer treatment (*n*) %	Cancer treatment (*n*) %
			Range 61–70 (n = 18) Range > 70 (n = 30)			12.3%; RT (9) 15.8%; nil (17) 29.8%
Leach 2015, Canada [27]	Lung cancer (66)	31:35	66.4 ± 9.1 (range 42–84)	NSCLC (57) 86%: I (8) 13.7%; II (6) 10.6%; III (18) 31.8%; IV (16) 30.3%; not known n = 9 SCLC (9) 13%	31.7 ± 22.9 months (range 4 months–11.5 years)	Surgery (13) 19.70%; chemo (53) 78.8%; RT (54) 81.8%
Philip 2014, 2015, USA [26, 28]	Lung cancer (175)	61:111	68.7 ± 9.6	IA (122) 69.7%; N/R (53) 30.3%	Mean (SD) 3.6 ± 1.2 years post treatment	Surgery only (160) 91.4%; N/R (15) 8.6%
Granger 2014, Australia [29]	Lung cancer (50)	32:18	68.5 ± 9.3	NSCLC: I (21) 43%; II (10) 20%; III (18) 37%	Pre-treatment	RT (11) 22%; chemo + RT (10) 20%; surgery + chemo (12) 24%; surgery only (12) 28%; surgery, chemo + RT (1) 2%; nil (1) 2%
Andersen 2013, Denmark [22]	Lung cancer (51)	31:20	M 65 ± 8 F 65 ± 7	NSCLC (39) 76%; SCLC (10) 20%; N/R (2) 4% Stage NR	NR	Surgery (10) 20%; during chemo (26) 51%; during RT (3) 6%; during TKI (2) 4%
Cavelheri 2013, Australia [32]	Physiotherapists (43)	N/R	N/R	N/A	N/A	N/A
Hoffman 2013, USA [24]	Lung cancer (7)	2:5	64.6 ± 6.5 (range 53–73)	NSCLC: IA (1) 14.3%; IB (1) 14.3%; IIA (1) 14.3%; IIB 2 28.6%; III (2) 28.6%	Post-op 100% (some during chemo)	Surgery only (2) 29%; surgery + chemo (4) 57%; surgery, chemo + RT (1) 14%
Lebel 2013, Canada[a] [31]	Lung cancer (107) Head and neck cancer (99)	43:64	64 ± 10.5	Lung cancer: local (91) 85.3%; advanced (16) 14.7%	Post treatment: mean (SD) 1.2 ± 0.9 years post diagnosis	Surgery only (73) 68.2%; surgery + chemo (28) 26.2%; surgery + RT (14) 13.1%; surgery + other (6) 5.6%
Lin 2013, Taiwan [30]	Lung cancer (81)	43:38	61.4 ± 11.4 (range 30–82)	Lung cancer: I (35) 43.2%; II (1) 1.2%; III (17) 21%; IV (20) 24.7%	Post treatment: mean (SD) 26.1 ± 28.2 months post diagnosis	Surgery (56) 69.1%; RT (15) 18.5%; chemo (43) 53.1%; target therapy (26) 32.1%
Peddle-McIntyre 2013, Canada [21]	Lung cancer (15)	6:9	67 ± 9.9	NSCLC (14) 93%; SCLC (1) 7% I/II/LS (11) 73%; III (4) 27%	Post treatment: mean (SD) 3.7 ± 2.1 years post treatment	Surgery (13) 87%; adjuvant chemo (5) 33%; chemo + RT (1) 7%; chemo only (1) 7%; RT only (2) 14%
Nwosu 2012, UK [33]	HCPs (59): nurses (22), doctors (20), discharge planner (4), physiotherapist (4), social worker (3), occupational therapist (2), pastoral care (2), MDT coordinator (1), other (1)	N/R	N/R	N/A	N/A	N/A
Coups 2009, USA [34]	Lung cancer (175)	61:111	68.4 ± 9.6	NSCLC IIA 122 69.7%; IB 53 30.3%		

Table 2 (continued)

Author, year, country	Type of participants (number)	Gender M/F	Age years mean ± SD	Cancer type and stage (*n*) %	Time relative to cancer treatment (*n*) %	Cancer treatment (*n*) %
					Post-op: mean (SD) 3.6 ± 1.2 years (range 1–6 years)	Surgery only (160) 91.4%; surgery + chemo (14) 8%; surgery + RT (1) 0.6%
Peddle 2009, Canada [23]	Lung cancer (19)	6:13	64 ± 10	NSCLC (13) 67% N/R (6) 33%	Pre-op	Surgery (after study)
Clark 2008, USA [35]	Lung cancer (272)	147:125	71 ± 9.9 (range 27–95)	NSCLC (261) 96%; SCLC (11) 4%	Post treatment (mean 5 years post diagnosis)	Chemo (68) 25%; surgery (106) 39%; RT (65) 24%

chemo chemotherapy, *M* male, *F* female, *HCPs* health care providers, *LS* late stage, *N/A* not applicable, *N/R* not reported, *NSCLC* non-small cell lung cancer, *pall* palliative, *SCLC* small cell lung cancer, *RT* radiotherapy, *MDT* multidisciplinary team, *TKI* tyrosine kinase inhibitor

[a] Demographics reported are for the lung cancer sub-group only

Synthesis of results

Six major themes and 18 sub-themes for barriers and enablers to PA were identified across the 24 studies (Table 3, Fig. 2). Patient quotes from primary qualitative studies are provided to reflect themes.

Theme 1: Patient motivation and beliefs

The anticipated impact of PA was reported by patients [25, 34, 36, 37, 39, 40, 42, 44–46], and this was predominately seen as an enabler and motivator for PA. Anticipated benefits included improvements in physical health, facilitating return to work and being able to fight the disease. Other patient beliefs were that PA would help gain control over the disease, be a distraction, relieve stress, improve HRQoL and provide social benefits especially from exercising in a group.

> "You hope that by exercising, you can improve physically and your quality of life, and also maybe prevent other illnesses" [36]

The expected impact of PA on symptoms varied with anticipated improvements [25, 42, 45] and harm [37, 44, 46] reported by patients. For the latter, patients expressed fear and avoidance of PA in the belief that it could worsen their symptoms, which may then not resolve.

Patients experienced positive outcomes from PA, and this was seen as an enabler to continue PA [23–25, 36, 40, 44, 45]. They reported improvements in physical health, psychological health and symptoms with PA, as well as functional deterioration following cessation of PA.

> "The Wii is – is a fantastic machine. I'm still using it, and I have almost 213 hours on it now. I look forward to using it in the morning because it gets endorphins in the brain going, and it starts me for the rest of the day" [40]

Theme 2: Patient pre-diagnosis PA habits and perceived relevance

Previous PA history strongly influenced patients' current participation in PA [25, 36, 37, 41, 42, 44, 45]. Patients who had exercised previously were more motivated to exercise after diagnosis. Patients described themselves, as being 'exercisers' or 'non-exercisers', and the non-exercisers preferred to do usual activities for PA, such as walking, as opposed to structured exercise. The experience of physical discomfort following PA (as a result of being unaccustomed to PA) was reported as a barrier and hindered adherence. Some patients recognised cancer as an opportunity for behaviour

Table 3 Summary of results from studies on barriers (−) and enablers (+) to PA

Themes	Sub-themes, description and references of primary qualitative studies	Results and references of primary quantitative studies
1. Patient motivation and beliefs		
Anticipated impact of PA	Physical health -Physical benefits including preventing other illnesses, fighting the disease, returning to work and prolonging life [36, 44, 45] (+) Mental health -Psychological benefits from participating in a study that could potentially help others [42] (+) -Exercise as a distraction and relief of disease related stress [37] (+) Symptoms -Improve symptoms [42, 45] (+) -Past/current experiences of physical weakness, fatigue, pain and breathing difficulties motivates patients to be active [45] (+) -Fear of exercise being harmful, triggering symptoms or persistence of symptoms after exercise [37, 44, 46] (−) Self-control: control over disease with exercise [40, 45] (+) Maintaining independence -Social usefulness, feeling of being useful to others and society [37] (+) -Pride by managing independently [39] (+) -Increase knowledge about PA [36] (+) -Strategies to maintain independence (ration energy, take rest breaks or complete tasks more slowly) rather than ask others for assistance [39] (−) Social engagement -Sense of community, belonging, not feeling alone [36] (+) -Peer support from patients with similar circumstances in group [46] (+)	Physical health -Improve strength, cardiovascular fitness, flexibility and daily function [25] (+) -PA outcome expectations significantly associated with engagement in moderate or strenuous PA [34] (+) -PA is important and helpful [25] (+) -Important for patient to set own goals [25] (+) Mental health -Improve HRQoL and sense of well-being [25] (+) Symptoms -Reduce fatigue and improve energy levels [25] (+)
Experienced impact of PA	Physical health -Improvement in physical and mental health [36, 44, 45] (+) -Deterioration in function (physical/lung) after stopping exercise [36] (+) Mental health -Exercise is a challenge [36, 45] (+) -Improvement in mental well-being, exercise as 'a break' [40, 45] (+) -Sense of satisfaction [44] (+) Symptoms -Positive impact including increased energy levels [36, 40, 44, 45] (+)	Physical health -Improvement in fitness, lung function, strength, weight loss and recovery from surgery [23] (+) -Physically stressful/challenge [25] (+ and −) -Not enjoyable [25] (−) -'Sore muscles' from participating in exercise program [23] (−) Mental health -Improvement in mental state and mood (37% of patients) [23] (+) Symptoms -Improvement in confidence in ability to manage fatigue [24] (+)
2. Patient pre-diagnosis PA habits and perceived relevance		
Sedentary lifestyle	-Past preferences/patterns inform choice and focus of PA [37, 44] (+ and −) -Physical discomfort associated with unaccustomed exercise [41, 45] (−)	-Past PA history = higher motivation to exercise [25] (+ and −)
Opportunity for behaviour change	-Trigger to restart exercise after being sedentary [36] (+) -Opportunity for behaviour change at time of loss of control [36] (+) -Lack of interest or willingness to try something new [42] (−)	
Patient perceived relevance	-Belief intervention is not relevant at the specific time point [43] (+ and −) -Expected timing of benefits—short [43] (+) or mid to long term [37] (−) -Poor prognosis and limited survival time [37] (−)	
3. Physical influences		
Symptoms, side effects, medical complications	-Symptoms strongly influence PA levels especially fatigue, nausea, malaise and cold intolerance [36, 37, 39, 40, 44, 45] (−)	-Lower PA: patients treated with combination surgery plus chemo or surgery plus RT [34]

Table 3 (continued)

Themes	Sub-themes, description and references of primary qualitative studies	Results and references of primary quantitative studies
	-Medical complications including infection and fever [36, 37, 39, 40, 45] (−) -Hospitalisation [41] (−) -Forgetfulness and cognitive changes [42] (−) -Post-operative SOB and pain in the first month after surgery [40] (−) -Post-operative complications result in delay to mobilisation immediately after surgery [36] (−)	and in patients with greater number of surgical complications [34] (−) -Poor adherence: medical illness [23], feeling unwell [25] (−) -Withdrawal from PA: decline in performance status, increasing fatigue [22] (−)
Comorbidities	-Comorbidities [43, 44] (−) -Functional limitations and patient perception of their ability to exercise [37, 42, 43] (−)	-Lower PA: older age, lower education, lower lung function, smokers, comorbidities [34] (−) -Better adherence: females [22], males [23] (+ and −) -Better uptake: females [28] (+) -Behaviour change: younger patients, RT, non-smoker [31] (+) -Higher motivation: non-COPD, no difference for age, gender, education, income, treatment status, smoking history, ESAS, performance status and other comorbidities [25] (+ and −)
4. Psychological influences		
Psychological factors	-Feeling overwhelmed with appointments and information [42] (−) -Becoming introverted after diagnosis [37] (−) -Difficulty adapting to diagnosis [46] (−) -Confusion: not sure how hard to push or how to handle [40] (−) -Fear of exercise [46] (−)	-Lower PA: higher depression, less intrinsic regulation (i.e. gaining pleasure from exercise) [29] (−) -Behaviour change: associated with behavioural self-blame [31] (+) -Higher motivation: associated with belief PA is important, helpful and easy [25], less symptoms [35] (+) -Self-efficacy for PA: associated with mod/strenuous PA [34] (+ and −) -Poor confidence in physical (54%) and emotional (53%) ability [25] (−)
5. Social influences		
Carers and relatives	-Carers, friends and family as source of motivation and encouragement [37, 43] (+) -Without carer motivation, PA is difficult [43] (−) -Heavy reliance on caregivers to recall information [43] (+) -Family and friends can promote inactivity to protect patient [37] (−)	-Social support from family: associated with walking [34], facilitated attendance [23], motivation [25] (+)
HCPs	-Physician encouragement or prescription of exercise [37, 44] (+) -Need advice from a specialist to guide PA practice (+) and lack of it is a barrier undertaking PA [37] (−) -Patient desire for a rehabilitation class including information about diet, exercise and lifestyle changes to allow information delivery and questions (similar to cardiac rehabilitation) [46] (+)	-Encouragement from HCP [25] (+) -Interaction with a nurse during telephone calls [24] (+)
6. Environment and structural influences		
Venue for exercise	Home—more convenient, less burdensome, more personal and better support [42, 43] (+) -Home—barrier if patient lacks discipline and self-drive to exercise alone and lacks initial motivation to start PA alone in home [45] (−) -Hospital—keep medical appointments distinct from home life [43] (+) -Flexibility for venue—potential for different locations (voluntarily choose home) or virtual sessions [42] (+)	Venue preference for PA (by % of patients) (+ and −) -Home 20% [28], 24% [27], 67% [25], 100% [24] (patients were more likely to prefer home if they were female, illiterate, not college educated, not undergone surgery or RT) [30] -Community centre or gym 17% [27], 29% [28], (<70 years and those with higher incomes preferred to exercise at gym) [28] -Outdoors 19% [27], 54% [30] -Cancer centre or hospital 17% [28], 27% [27] -No preference 25% [28] -Venue preference for PA counselling: community 9%, home 16%, cancer centre 36%, no preference 39% [30]

Table 3 (continued)

Themes	Sub-themes, description and references of primary qualitative studies	Results and references of primary quantitative studies
Access	-Transportation problems: inability to drive following surgery and potential difficulties with inclement weather, not accessing resources as feel other patients need it more [39, 42] (−) -Financial constraints [42] (−)	-Transportation: lack of transportation [23] and distance to home [25] (−), access to free parking [23] (+) -Better land-use mix access (i.e. access to shopping centres) [29] (+) Services (data from HCPs)[a] -Lack of rehab services: 39% of MDT felt rehabilitation services adequate [33]; long waiting lists for rehabilitation [33]; shortage of allied health staff [33]; 72% of physiotherapists reported <25% patients referred to PRP on discharge [32]; PRP facilities not taking patients without COPD [32] (−) -Lack of knowledge of HCP: Services available (29% of MDT) [33]; Lack of perception patients do not want rehab (22% of MDT) [33] (−); Lack of understanding of benefits [33] (−)
Format	Group training -Promotes social engagement/benefits (by exercising with people with similar circumstance) [36, 43, 45] (+) -Promotes adherence due to the belief that the other patients expect you to turn up [45] (+) -Preference for mix gender groups [45] (+) -Use of music [36] (+) -Dislike talking to other patients in a group environment [43] (−) Type of exercise -Individualised—target intervention to specific problems such as breathlessness and modification for comorbidities [42] (+) -Something the patient is interested in and enjoys [43] (+) -Preference for structured and supervised exercise [45] (+) -Offer a shortened trial [42] (+) -Outside of the supervised exercise setting patients prefer to do activities similar to those they did before their illness [45] (+) -Preference for usual activities over formal exercise programs [44] (+) -Walking preferred form of activity [44] (+) -Preference for activities that require the patients to focus continually on strategy and technique to achieving the goal of distraction (rather than activities such as cycling or walking) [24, 37] (+) Supervision -Provides a sense of security, leadership and motivation [36] (+) -Ability to be monitored and progressed [36, 38] (+) Virtual monitoring and prescription -HCPs expect that telemonitoring could be useful for specific rehabilitation goals [38] (+)[a] -HCPs believe telerehabilitation is good strategy for provision of relevant information but needs supervision [38] (+ and −)[a] -Patients believe that supervision during telerehabilitation is important to ensure that exercises are performed correctly [38] (+) -Patients and HCPs both believe that online rehab requires motivation of patients to read the information and to exercise at home [38] (−)[a] -Technical challenges for example ability to use a DVD [42] (−)	Group training -Preference for PA (by % of patients): (+ and −): Group: 19% [28], 29% [27]; One to two patients with cancer: 17% [27]; Alone: 22% [28], 26% [27], 44% [30], 49% [25]; No preference: 24% [27], 49%, [28]; Family: 5% [28] Type of exercise (by % of patients) (+ and −) -Preference for intensity of PA: Light: 36% [27], 39% [28], (57% felt capable) [25]; Moderate: 44% [28], 54% [30], 62% [27], (38% felt capable) [25] -Walking as main type 42% [28], 79% [27], 80% [25], 89% [30] -Recreational exercises 94% [27], 96% [30] -Same exercises 39% [27], 56% [30] -Different exercises 61% [27] -Variety prevent boredom [24], fun/engaging 18% [25] -Variety prevent boredom [24], fun/engaging 18% [25] Physiotherapists: 93% provide walking exercises following surgery, and in most facilities (88%), it was commenced as part of an early mobility program by physiotherapist [32] Supervision -Access to 'coaching' was considered to be an important facilitator to promote attendance by 11% of patients [23] -Preference for supervision (by % of patients): (+ and −) Yes: 62% [27], 85% [21] (64% supervised in gym and 36% at home) [21]; No: 64% [30] (<65 years preferred unsupervised) [30]

Table 3 (continued)

Themes	Sub-themes, description and references of primary qualitative studies	Results and references of primary quantitative studies
Convenience	-Fitting the exercise into daily routine [41, 43] (+) -Flexibility of time of exercise session [42] (+) -Reminders to exercise [42] (+)	-Duration of PA program: no consensus [25] -Hours: flexibility (facilitator to participation 16% of patients) [25], 16% [23] and 93% [30] preferred a flexible exercise program (+) -Time of day: 53% [30] and 56% [27] patients preferred to exercise in the morning and 32% had no preference [27]. Patients with comorbidities vs those with no comorbidities were more likely to prefer exercising in the morning [30] (+ and −) -Scheduled program favoured by 71% of patients [27] (+)
Time	-Lack of time due to tests, medical appointments and work [36, 45] (−) -Time commitment required [42] (−)	-Lack of time due to work commitments [23], family matters [23] (−) -Time commitment required [23] (−)
Timing of exercise	-Not preferred at diagnosis or during treatment due to time commitment required of patients and carers, feeling of being overwhelmed and high symptoms [43] (−) -Not responsive to information given at times the patient perceives to be inappropriate (i.e. when not experiencing symptoms, when too ill to take information on board, when waiting for treatment/appointments or when they were concerned about other issues) [43] (−) -Overwhelming to consider participation (in mindfulness treatment) at diagnosis [42] (−)	Commencement of exercise -Preference for timing of program (by % of patients): (+ and −) Before treatment: 22% [30], 26% [27], 60% [28]; During treatment: 14% [30], 17% [27]; Immediately post treatment: 10% [30], 14% [28], 23% [27]; 3–6 months post treatment: 13% [28], 22% [30], 23% [27], 23% [30]; No preference: 11% [30], 59% [25] -Most patients who had thoracic surgery preferred to start an exercise program during adjuvant treatment (43%) vs 11% of patients who did not have surgery. Most (57%) who did not have surgery preferred to start their exercise after completing treatment (+/−) [27] -Preference for timing of counselling (by % of patients): (+ and −) Before treatment: 14% [30], 22% [27], 68% [28]; During treatment: 17% [30], 28% [27]; Immediately post treatment: 14% [30], 23% [28], 28% [27]; 3–6 months post treatment: 12% [27], 21% [30]; No preference: 25% [30] -Physiotherapists: 91% commence physiotherapy on first post-operatively day, 9% on the day of surgery [32] (−)[a]
Weather	-Winter weather—fear of falling, the effects of cold on breathing, dislike of cold [44] (−) -Low resilience to finding alternative forms of PA when they cannot perform usual activities due to external variables such as weather or when the environment is not adaptable to their condition [37] (−)	-Bad weather [25] (−)
Delivery of information	-Rely almost exclusively on verbal information provided by their doctor on information about their diagnosis, management and prognosis [39] (+ and −) -Physician encouragement or prescription of exercise [44] (+) -Patient would be comfortable discussing PA/exercise with their oncologists but few had done so [44] (+ and −) -Would seek advice from either a physician or a physiotherapist [44] (+) -Direction from a physiotherapist was viewed as potentially beneficial, generally for support rather than to build strength and stamina. Opportunity for guidance about exercise was viewed as a benefit [44] (+) -Patients believe they may not be at a level of functional disability needing assistance from physiotherapist or nurse and or uncertain about its benefits [44] (−)	-Interest in receiving exercise counselling (by % of patients) (+ and −); Yes 23% [27], 63% [28], 85% [30]; No 42% [27]; Maybe 35 % [27] -Preference of HCPs to deliver advice (by % of patients): (+ and −) Medical doctor: 28% [30], 80% [26] (<70 years and higher income associated with this choice) [28] Nurse: 22% [30] Exercise specialist: 21% [30], 59% [27] (higher % preferred exercise specialist if they had attained a college education) [30] No preference: 49% [30] -Preference for method of delivery (by % of patients): (+ and −) In person: 48% [30], 87% [27], 95% [28], (this choice associated with being employed, college educated, and lack of comorbidities) [30]; Brochure: 21% [30]

Table 3 (continued)

Themes	Sub-themes, description and references of primary qualitative studies	Results and references of primary quantitative studies
	-Contradictory advice from different HCPs [43] (−) -Preferred same physiotherapy trainers at each session not different ones [36] (+ and −)	-Previous discussion with HCP about PA for 65% [26]: 70% of discussions initiated by the HCP; 49% did not receive advice to change their level of PA despite not meeting PA guidelines; less frequent discussions during cancer treatment (51%); male patients and higher income = more likely to have discussions regarding PA [26] -Physiotherapists: 44% routinely provide pre-operative education, pre-operative education initiated by surgeon referral 9% of the time [32] (−)[a]

Unless otherwise stated, data are from patients with lung cancer not carers or HCPs. Enabler to physical activity or exercise (+); barrier to physical activity of exercise (−)

ADLs activities of daily living, *HCPs* health care providers, *mod* moderate, *PA* physical activity, *PRP* pulmonary rehabilitation program, *rehab* rehabilitation, *SOB* shortness of breath

[a] Data are not from patients with lung cancer not carers or HCPs

change and a trigger to start exercising; others expressed lack of interest and were not willing to try something new. Perceived relevance was identified [37, 43] as an important factor for enabling PA [37, 43], and unless benefits were thought to be achieved in the short term, patients felt that they were unlikely to participate in PA especially given their poor prognosis.

> “I’ve never exercised before and I have never wanted to” [45]

Theme 3: Physical influences

Symptoms were reported as barriers to PA [23, 25, 35–37, 39, 40, 44, 45] and resulted in less PA, poor adherence and withdrawal from programs. Fatigue was the most commonly cited symptom, and symptoms during chemotherapy were a common barrier (Table 3). Medical complications including post-operative complications delaying mobilisation and hospital readmissions were barriers to PA [23, 34, 36, 37, 39–42, 45]. In six studies [25, 34, 37, 42–44], comorbidities were noted as a barrier to PA. Older age, lower education and smoking history were seen in patients who were less active or less motivated to be active/change behaviour [31, 34].

> “I have had my knees replaced. I have got arthritis, also. It is hard to blame this [on] lung cancer or chemo or being 66 years old. I mean it is some of all three, I’m sure” [44]

Theme 4: Psychological influences

Psychological factors were identified by patients as barriers to PA [25, 29, 31, 37, 40, 42, 46]. These included fear of exercise, lack of confidence, depression, anxiety, feeling overwhelmed, difficulty adapting to diagnosis and introversion. These factors were especially noted to be barriers at time of diagnosis and during treatment.

> “I don’t trust my body. Maybe at the last minute I will be paralysed by anxiety or I will be bothered by persistent constipation or a bronchial infection” [37]

Theme 5: Social influences

Carers and relatives were noted as a source of motivation and encouragement for PA [23, 25, 34, 37, 43]. Patients relied on caregivers to recall information. However, in two studies [37, 43], carers and relatives were seen as a barrier. Some patients reported that carers/relatives believed that they were not able to be active and that PA would be harmful. Patients identified that encouragement of PA by HCPs was a key enabler and lack of it was a large barrier [24, 25, 37, 44].

> “When you have a prognosis of six months, it is hard to motivate yourself to get in shape, knowing that at some point the disease will come…When you are sick, you lose a lot of psychic autonomy and your ability for decision making…However, if there is a professional PA teacher to push you, there is no need for questioning or thinking about this issue.” [37]

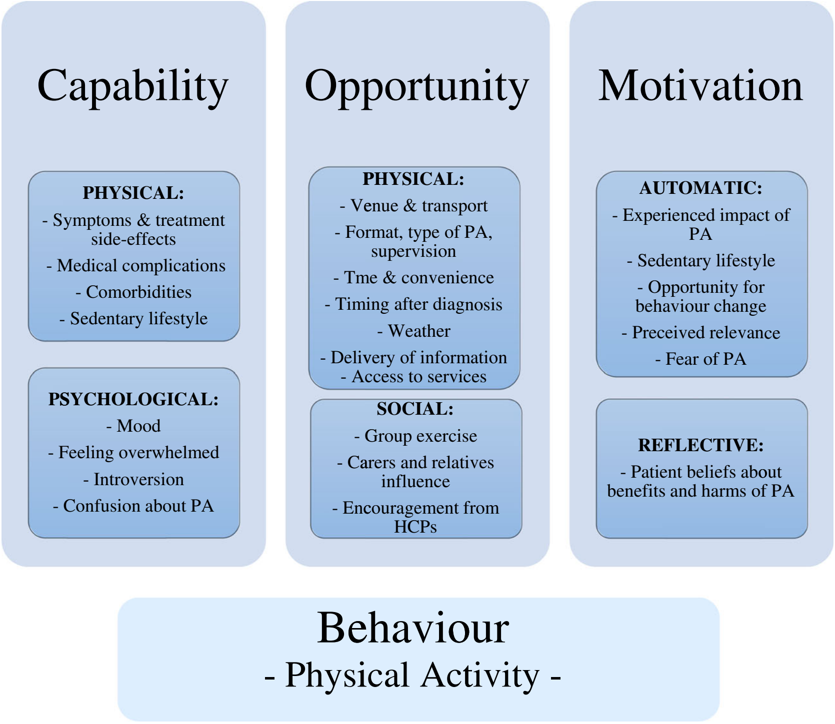

Fig. 2 Results: factors (barriers and enablers) influencing physical activity in lung cancer mapped using the COM-B model [20]. *COM-B* 'capability, opportunity and motivation-behaviour' system, *HCP* health care provider, *PA* physical activity

Theme 6: Environmental and structural influences

In 15 studies [21, 23–28, 30, 36–38, 42–45], patients reported preferences for PA, especially relevant for delivery of exercise programs, which included the venue of exercise, supervision, structure, schedule and exercise type. These factors were noted to either promote or hinder adherence to PA and are described in detail in Table 3. There were conflicting results regarding whether exercising at home was preferred. Preference for home-based exercise ranged from 20 to 100% of surveyed patients across the five studies [24, 25, 27, 28, 30]. Two studies [42, 43] highlighted that home-based exercise was an enabler in that it was more convenient, less burdensome (no travel/parking required) and more personal. However, a third study [45] identified home-based exercise as a barrier in that it required the patient to be self-motivated to perform the exercises. Social engagement and supervision were highly sought after by patients and a benefit of hospital-based exercise. Patients felt that supervision provided a sense of security, leadership and means to be monitored/progressed. Transportation was a barrier [23, 25, 39, 42] particularly when patients were medically unable to drive.

> "They wouldn't let me drive. I didn't have any way to get to town" [42]

Exercising in a group compared to alone was explored in seven studies [25, 27, 28, 30, 36, 43, 45] with conflicting results. However, generally, patients viewed group classes as positive in that it promoted social engagement and allowed them to be supervised (preference ranged from 19 to 27% of surveyed patients).

> "Training in a group is much better because you know that someone is keeping an eye out whether you come or not. It's a little more difficult when you have to do it on your own." "We inspire each other to come and it's nice to be expected and a part of the group" [45]

The type and format of PA preference were investigated in 10 studies [24, 25, 27, 28, 30, 37, 42–45]. Consistently walking was the preferred type of PA (42–89% of surveyed patients), and patients also wanted a variety of exercises to prevent boredom (56–61%). Moderate-intensity exercise was the most preferred intensity (44–62%). Overall, patients reported that they wanted an individualised program, with achievable/meaningful goals, and centred on symptom management and functional independence. The ability to adapt the program based on current symptoms and comorbidities was also important. Convenience of exercise (being able to fit into daily routine) was an enabler, and lack of it was a barrier. Time required to exercise was a barrier to PA [36, 42, 45]. Weather was also a barrier [25, 37, 44], and patients had low resilience to adapt in bad weather.

> "I was real afraid of the effect that winter was going to have on the lungs. The cold air did affect the breathing a

> lot when I went out. So, yes, I was quite afraid, especially of exercise. Because you just didn't know." [44]

There were diverse results with regards to patient preferences for when to commence a PA program and when to receive PA advice [25–28, 30, 42, 43]. Overall, the preferences were highest before treatment for both participation in a program (26–68%) and for receiving advice (14–68%). However, in two studies [42, 43], patients highlighted that they would not like receiving advice or to perform PA before or during treatment because they felt overwhelmed and incapable of taking on new information. Patients who received surgery preferred to start PA during adjuvant treatment, whereas patients who did not have surgery preferred to start after completion of treatment. Patients strongly relied on verbal information [27, 28, 30] predominately from their physician on PA [26, 28, 30, 39, 44]. Whilst patients were receptive to receiving PA information (23–85%) [27, 28, 30], few had received any advice. Patients were confused about how hard to exercise. Contradictory advice from different HCPs (across or within professions) was a frustration [36, 43]. Data from HCP (as opposed to patients) [32, 33] demonstrated a lack of understanding of the potential benefits of PA from the multidisciplinary team, lack of knowledge of services and lack of services as barriers to PA. Telerehabilitation was identified by HCPs as a potential strategy for provision of information [38].

Discussion

This review has identified the barriers and enablers to patients with lung cancer participating in PA, the evidence of which predominately comes from studies including patients themselves rather than from HCPs or carers. Lack of PA is a significant issue in lung cancer [5, 12], and limited evidence translation into clinical practice necessitates the development of new strategies and models of care aiming to enhance PA. Importantly, this review has identified a number of potentially modifiable patient-reported barriers and a variety of enablers, which should be targeted and utilised to inform future clinical practice. Implementing evidence into practice is a highly challenging task, and one strategy that has been developed to facilitate this is the COM-B model [20] and associated Behavioural Change Wheel [20]. Our results can be interpreted within the COM-B model. For example, capability-related barriers to PA included symptoms and comorbidities, opportunity-related barriers included lack of access to services, and motivation-related barriers included fear of PA and perceived relevance. In contrast, enablers for PA mapped to these domains included personal preferences for PA, encouragement from carers and HCPs (opportunity) and anticipated benefits from PA (motivation). To change practice or behaviour, one or multiple aspects of the COM-B model can be targeted with interventions (in research or clinical practice). Based on this framework and our results, we recommend that potential interventions to target in lung cancer are education (of patients, carers and HCPs), persuasion (of HCPs and patients), training (HCPs), environmental restructuring, modelling and enablement [20]. These strategies could be used to inform the development of new interventions attempting to reduce barriers and take advantage of enablers, and thus increase PA in lung cancer. Such an intervention could target a number of these factors at once. For example, a multidimensional interventional program which could be tested in the future may be one that educates HCPs working in the area of lung cancer about PA through an online training program, that, in turn, facilitates HCPs to educate their patients/carers about PA, combined with a system of integrated online prompts during patient consults for the HCP to ask their patients about their current PA levels.

Results show clear messages from patients about their desire for individualised care. This is evident across a number of aspects spanning from the delivery of exercise programs, type of PA and timing relative to treatment. Whilst there were a small number of trends found in patient preferences, for example, patients predominately preferred walking as their main type of PA, overall there was inconsistency within and across primary studies. We hypothesise that this is due to the diversity of patient personal preferences, which is also evident within the general population. Therefore, in attempt to enable patients with lung cancer to become and stay active, flexibility needs to be added into the delivery of health care services. An appealing model is one where patients could select from a variety of options, including when, where and how they will exercise. Individualised care is also highly important given the elderly age and high incidence of multimorbidities especially COPD in this population. In COPD, pulmonary rehabilitation was traditionally implemented in a standardised format, with little variability across institutions or countries. There is now a recent shift towards more individualised care in COPD, especially given the highly complexity of patients and impact of multimorbidities. Telerehabilitation is being actively investigated in COPD pulmonary rehabilitation [47] and may be a potential strategy to facilitate patients with lung cancer to exercise as well, particularly for those who have barriers to access services. In the COPD population, there are a number of different pulmonary rehabilitation models in use or being researched at present in attempt to improve PA levels. These include the use of smart phone applications to stimulate PA [48], communication with therapist via the internet for motivation [48] and supervised home exercise training with real-time remote videoconferencing [49]. These models could be applied to the lung cancer population as well. Flexibility is easier to implement in clinical practice, but challenging to use in a RCT design; however, studies investigating the efficacy of this model in lung cancer would be highly beneficial. Potentially, a stepped care model may be appropriate in lung cancer, where patients could be offered an escalating number of treatment options depending on their own need at that point in time.

This review found that patients preferred to receive information about PA initially from their treating doctor and prior to treatment commencing, reflecting the perceived high importance patients place on their primary doctor for their overall cancer management and is not a new finding for the cancer literature. Capitalising on the opportunity of lung cancer doctors to discuss and recommend PA during patient consultations represents a powerful strategy to directly influence behaviour. Patients deemed to be inactive could subsequently be referred to a physiotherapist, kinesiologist or accredited exercise specialist for a detailed assessment and treatment plan. In order to optimise success of this approach, efforts to enhance the education and training of the multidisciplinary team regarding PA, to address the barrier of perceived lack of knowledge on the part of HCPs, would be required. Symptom modification from PA was also evident as both a barrier and enabler. We found that many patients expected positive outcomes from PA including reduction in symptoms, yet others feared and avoided PA due to the belief that PA may worsen symptoms. In addition, carers often blocked PA with the thought that it may be harmful. Evidence from systematic reviews shows that exercise is associated with strong and consistent improvements in fitness, muscle strength, HRQoL and symptoms in cancer [2, 11], and therefore, this is an important message to be relayed to patients and carers by all HCPs as patients move along the care pathway. Reinforcement of this message by the entire multidisciplinary team is important.

Our results are not dissimilar to findings from other cancer populations [50, 51]. In breast cancer, factors influencing PA are psychological (motivation, fear, dislike), physical (ageing, cancer treatment, comorbidities, fatigue, weight gain) and contextual and environment barriers [50]. Similarly, in prostate cancer, factors include clinician and spouse influences, comorbidities, fatigue and lack of advice [51]. This suggests that a larger approach may be needed to effectively implement exercise into the model of cancer care, more broadly that for just the lung cancer population.

This review is strengthened by inclusion of qualitative and quantitative data [14]. In particular, the ‘patient voice’ has featured prominently in this review. However, there is a clear gap in the data from the limited number of studies including HCPs. These studies found important barriers, and further research is required to explore these issues. We followed a robust protocol, review guidelines [13, 14] and incorporated duplicate screening, data extraction and risk of bias assessment to enhance review rigour. Only one study was excluded through non-publication in English. All studies were included regardless of risk of bias, and therefore, results from primary studies should be taken with caution. The study is also limited by the lack of randomised trials and overall low level of evidence of included primary studies; however, these are clear gaps in the literature which should be addressed with future research.

This systematic review has identified the volume of literature reporting on barriers and enablers to physical activity in lung cancer. Barriers and enablers are multidimensional and span diverse factors. Patient barriers include physical capability (symptoms, comorbidities), psychological influences, previous sedentary lifestyle and perceived relevance. Enablers include anticipated benefits of PA, opportunity for behaviour change and social influences from HCPs and carers. Patients strongly desire individualised PA programs. Considering these factors in a structured behavioural change framework has elucidated potential mechanisms for enhancing interventions and clinical services to increase PA in patients with lung cancer.

COM-B system, capability, opportunity, motivation-behaviour; *COPD*, chronic obstructive pulmonary disease; *COREQ*, consolidated criteria for reporting qualitative research; *ENTREQ*, Enhanced Transparency of Reporting the Synthesis of Qualitative Research; *HCPs*, health care providers; *HRQoL*, health-related quality of life; *NOS*, Newcastle–Ottawa Quality Assessment Scale; *PA*, physical activity; *PRISMA*, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; *PROSPERO*, international prospective register of systematic reviews

Compliance with ethical standards

Conflict of interest The work of two authors (CG, LD) was included as a primary study in this review [29].

The authors declare that they have no conflicts of interest.

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References

1. Jones L, Eves N, Haykowsky M, Freedland S, Mackey J (2009) Exercise intolerance in cancer and the role of exercise therapy to reverse dysfunction. Lancet Oncol 10:598–605
2. Schmitz K, Courneya K, Matthews C, Demark-Wahnefried W, Galvao D, Pinto B, Irwin M, Wolin K, Segal R, Lucia A, Schneider C, von Gruenigen V, Schwartz A (2010) ACSM roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc 42:1409–1426
3. Brunelli A, Charloux A, Bolliger CT, Rocco G, Sculier JP, Varela G, Licker M, Ferguson MK, Faivre-Finn C, Huber RM, Clini EM, Win T, De Ruysscher D, Goldman L (2009) ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients (surgery and chemo-radiotherapy). Eur Respir J 34:17–41
4. Cheville A, Novotny P, Sloan J, Basford J, Wampfler J, Garces Y, Jatoi A, Yang P (2011) The value of a symptom cluster of fatigue, dyspnea, and cough in predicting clinical outcomes in lung cancer survivors. J Pain Symptom Manag 42:213–221
5. Granger C, McDonald C, Irving L, Clark R, Gough K, Murnane A, Mileshkin L, Krishnasamy M, Denehy L (2014) Low physical activity levels and functional decline in individuals with lung cancer. Lung Cancer 83:292–299
6. Australian Institute of Health and Welfare (2014) Cancer in Australia: an overview, 2014. Cancer series no. 78. Cat. no. CAN 75. Canberra: AIHW
7. Granger C, McDonald C, Berney S, Chao C, Denehy L (2011) Exercise intervention to improve exercise capacity and health related quality of life for patients with non-small cell lung cancer: a systematic review. Lung Cancer 72:139–153
8. Granger C (2016) Physiotherapy management of lung cancer. J Physiother 62:60–67
9. Bade BC, Thomas DD, Scott JB, Silvestri GA (2015) Increasing physical activity and exercise in lung cancer: reviewing safety, benefits, and application. J Thorac Oncol 10:861–871
10. Stigt J, Uil S, Riesen S, Simons F, Denekamp M, Shahin G, Groen H (2013) A randomized controlled trial of postthoracotomy pulmonary rehabilitation in patients with resectable lung cancer. J Thorac Oncol 8:214–221
11. Rock C, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya K, Schwartz A, Bandera E, Hamilton K, Grant B, McCullough M, Byers T, Gansler T (2013) Nutrition and physical activity guidelines for cancer survivors. CA: Cancer J Clin 62:242–274
12. Coups E, Park B, Feinstein M, Steingart R, Egleston B, Wilson D, Ostroff J (2009) Physical activity among lung cancer survivors: changes across the cancer trajectory and associations with quality of life. Cancer Epidemiol Biomark Prev 18:664–672
13. Moher D, Liberati A, Tetzlaff J, Altman D (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. PLoS Med 6
14. Tong A, Flemming K, McInnes E, Oliver S, Craig J (2012) Enhancing transparency in reporting the synthesis of qualitative research: ENTREQ. BMC Med Res Methodol 12:1–8
15. Caspersen C (1985) Physical activity, exercise and physical fitness: definitions and distinctions for health related research. Public Health Rep 100:126–131
16. Wells G, Shea B, O'Connell D, Peterson J, Welch V, Tugwell P (2000) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Available at: http://www.ohrica/programs/clinical_epidemiology/oxfordhtm
17. Zeng X, Zhang Y, Kwong JSW, Zhang C, Li S, Sun F, Niu Y, Du L (2015) The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. J Evid Based Med 8:2–10
18. Tong A, Sainsbury P, Craig J (2007) Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care 19:349–357
19. Thomas J, Harden A (2008) Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Med Res Methodol 8
20. Michie S, van Stralen M, West R (2011) The behavioural change wheel: a new method for characterising and designing behavioural change interventions. Implement Sci 6
21. Peddle-McIntyre CJ, Bell G, Fenton D, McCargar L, Courneya KS (2013) Changes in motivational outcomes after a supervised resistance exercise training intervention in lung cancer survivors. Cancer Nurs 36:E27–E35
22. Andersen A, Vinther A, Poulsen L, Mellemgaard A (2013) A modified exercise protocol may promote continuance of exercise after the intervention in lung cancer patients-a pragmatic uncontrolled trial. Support Care Cancer 21:2247–2253
23. Peddle CJ, Jones LW, Eves ND, Reiman T, Sellar CM, Winton T, Courneya KS (2009) Correlates of adherence to supervised exercise in patients awaiting surgical removal of malignant lung lesions: results of a pilot study. Oncol Nurs Forum 36:287–295
24. Hoffman AJ, Brintnall RA, Brown JK, Av E, Jones LW, Alderink G, Ritz-Holland D, Enter M, Patzelt LH, Vanotteren GM (2013) Too sick not to exercise: using a 6-week, home-based exercise intervention for cancer-related fatigue self-management for postsurgical non-small cell lung cancer patients. Cancer Nurs 36:175–188
25. Kartolo A, Cheng S, Petrella T (2016) Motivation and preferences of exercise programmes in patients with inoperable metastatic lung cancer: a need assessment. Support Care Cancer 29:129–137
26. Philip E, Coups E, Feinstein M, Park J, Wilson D, Ostroff J (2015) Patient-provider discussion of physical activity among early stage lung cancer survivors. Psychooncology 24:359–362
27. Leach H, Devonish J, Bebb D, Krenz K, Culos-Reed S (2015) Exercise preferences, levels and quality of life in lung cancer survivors. Support Care Cancer 23:3239–3247
28. Philip EJ, Coups EJ, Feinstein MB, Park BJ, Wilson DJ, Ostroff JS (2014) Physical activity preferences of early-stage lung cancer survivors. Support Care Cancer 22:495–502
29. Granger CL, Denehy L, McDonald CF, Irving L, Clark RA (2014) Physical activity measured using global positioning system tracking in non-small cell lung cancer: an observational study. Integr Cancer Ther 13:482–492
30. Lin Y, Lai Y, Lu H, Lai Y, Lin C (2013) Physical activity preferences among patients with lung cancer in Taiwan. Cancer Nurs 36: 155–162
31. Lebel S, Feldstain A, McCallum M, Beattie S, Irish J, Bezjak A, Devins GM (2013) Do behavioural self-blame and stigma predict positive health changes in survivors of lung or head and neck cancers? Psychol Health 28:1066–1081
32. Cavalheri V, Jenkins S, Hill K (2013) Physiotherapy practice patterns for patients undergoing surgery for lung cancer: a survey of hospitals in Australia and New Zealand. Intern Med J 43:394–401
33. Nwosu A, Bayly J, Gaunt K, Mayland C (2012) Lung cancer and rehabilitation-what are the barriers? Results of a questionnaire survey and the development of regional lung cancer rehabilitation standards and guidelines. Support Care Cancer 20:3247–3254
34. Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, Ostroff JS (2009) Correlates of physical activity among lung cancer survivors. Psychooncology 18:395–404
35. Clark M, Novotny P, Patten C, Rausch S, Garces Y, Jatoi A, Sloan J, Yang P (2008) Motivational readiness for physical activity and quality of life in long-term lung cancer survivors. Lung Cancer 61:117–122
36. Missel M, Pedersen J, Hendriksen C, Tewes M, Adamsen L (2015) Exercise intervention for patients diagnosed with operable non-

small cell lung cancer: a qualitative longitudinal feasibility study. Support Care Cancer 23:2311–2318

37. Mas S, Quantin X, Ninot G (2015) Barriers to, and facilitators to physical activity in patients receiving chemotherapy for lung cancer: an exploratory study. J Palliat Care 31:89
38. Kuijpers W, Groen W, Loos R, Oldenburg H, Wouters M, Aaronson N, van Harten W (2015) An interactive portal to empower cancer survivors: a qualitative study on user expectations. Support Care Cancer 23:2535–2542
39. Brown N, Lui C, Robinson P, Boyle F (2015) Supportive care needs and preferences of lung cancer patients: a semi-structured qualitative interview study. Support Care Cancer 23:1533–1539
40. Hoffman A, Brintnall R, von Eye A, Cooper JJB (2014) The voice of postsurgical lung cancer patients regarding supportive care needs. Lung Cancer Targets Ther 5:21–31
41. Maddocks M, Halliday V, Chauhan A, Taylor V, Nelson A, Sampson C, Byrne A, Griffiths G, Wilcock A (2013) Neuromuscular electrical stimulation of the quadriceps in patients with non-small cell lung cancer receiving palliative chemotherapy: a randomized phase II study. PLoS One 8:e86059
42. Lehto R, Wyatt G (2013) Perceptions about using mindfulness therapy: a lung cancer focus group study. Cancer Nurs 36:E51–E60
43. Ellis J, Wagland R, Tishelman C, Williams M, Bailey C, Haines J, Caress A, Lorigan P, Smith J, Booton R, Blackhall F, Molassiotis A (2012) Considerations in developing and delivering a nonpharmacological intervention for symptom Management in Lung Cancer: the views of patients and informal caregivers. J Pain Symptom Manag 831
44. Cheville A, Dose A, Basford L, Rhudy L (2012) Insights into the reluctance of patients with late-stage cancer to adopt exercise as a means to reduce their symptoms and improve their function. J Pain Symptom Manag 44:84–94
45. Adamsen L, Stage M, Laursen J, Rørth M, Quist M (2012) Exercise and relaxation intervention for patients with advanced lung cancer: a qualitative feasibility study. Scand J Med Sci Sports 22:804–815
46. Jones K, Rice A (2009) Rehabilitation needs of patients with lung cancer after surgery. Cancer Nursing Pract 8:23–28
47. Spruit MA, Singh SJ, Garvey C, ZuWallack R, Nici L, Rochester C, Hill K, Holland AE, Lareau SC, Man WDC, Pitta F, Sewell L, Raskin J, Bourbeau J, Crouch R, Franssen FME, Casaburi R, Vercoulen JH, Vogiatzis I, Gosselink R, Clini EM, Effing TW, Maltais F, van der Palen J, Troosters T, Janssen DJA, Collins E, Garcia-Aymerich J, Brooks D, Fahy BF, Puhan MA, Hoogendoorn M, Garrod R, Schols AMWJ, Carlin B, Benzo R, Meek P, Morgan M, Rutten-van Mölken MPMH, Ries AL, Make B, Goldstein RS, Dowson CA, Brozek JL, Donner CF, Wouters EFM (2013) An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med 188:e13–e64
48. Vorrink S, Kort H, Troosters T, Zanen P, Lammers J (2016) Efficacy of an mHealth intervention to stimulate physical activity in COPD patients after pulmonary rehabilitation. Eur Respir J 48:1019–1029
49. Holland A, Hill C, Rochford P, Fiore J, Berlowitz D, McDonald C (2013) Telerehabilitation for people with chronic obstructive pulmonary disease: feasibility of a simple, real time model of supervised exercise training. J Telemed Telecare 19:222–226
50. Hefferon K, Murphy H, McLeod J, Mutrie N, Campbell A (2013) Understanding barriers to exercise implementation 5-year post-breast cancer diagnosis: a large-scale qualitative study. Health Educ Res 28:843–856
51. Keogh JW, Patel A, MacLeod RD, Masters J (2014) Perceived barriers and facilitators to physical activity in men with prostate cancer: possible influence of androgen deprivation therapy. Eur J Cancer Care (Engl) 23:263–273