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How is physical activity measured in lung cancer? A systematic review of outcome measures and their psychometric properties.

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. **Abbreviations**

ACSM	American College of Sports Medicine
BREQ-2	Behavioural Regulation of Exercise Questionnaire Version 2
COPD	chronic obstructive pulmonary disease
COSMIN	COnsensus-based Standards for the selection of health status Measurement INstruments
ECOG-PS	Eastern Co-operative Oncology Group Performance Status
EE	energy expenditure
EORTC	European Organisation for Research and Treatment of Cancer
QLQ-C30	Quality of Life Core Questionnaire
ES	effect size
FACT-L	functional assessment of cancer therapy-lung
GLTEQ	Godin Leisure Time Exercise Questionnaire
HADS	Hospital Anxiety and Depression Scale
LOS	length of stay
LS-ES	limited stage-extensive stage
MET	metabolic equivalent
MRC	Medical Research Council
NMES	neuromuscular electrical stimulation
NSCLC	non-small cell lung cancer
PA	Physical activity

PAL	Physical activity levels
PASE	Physical Activity Scale for the Elderly
PPC	post-operative pulmonary complications
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
PROM	patient reported outcome measures
PROSPERO	International prospective register of systematic reviews
PSQI	Pittsburg Sleep Quality Index
QoL	quality of life
SCLC	small cell lung cancer
SD	standard deviation
VO_{2max}	peak oxygen uptake
WHO	World Health Organisation
6MWD	six-minute walk distance

ABSTRACT

Physical activity (PA) levels are low in people with lung cancer. Emerging evidence supports the use of interventions to increase PA in this population. We aimed to (1) identify and synthesise outcome measures which assess PA levels in people with lung cancer, and (2) to evaluate, synthesize and compare the psychometric properties of these measures. A systematic review of articles from searches conducted of five electronic databases and personal records. Eligible studies were those which assessed PA using either performance-based or patient-reported measures. For aim two, studies identified in aim 1 reporting on at least 1 psychometric property (validity, reliability, responsiveness or measurement error) were included. Two independent reviewers assessed eligibility and risk of bias with the consensus-based standards for the selection of health status measurement instruments.

Thirty-four studies using 21 different measures of PA were identified. Seventeen studies used performance-based measures. The Godin Leisure Time Exercise Questionnaire (GLTEQ) was the most frequently used patient-reported measure. Psychometric properties were reported for 13 of these measures and most frequently for movement sensors. Two studies reported on properties of the GLTEQ. Quality ratings for risk of bias were low. Conclusion: There is significant heterogeneity amongst studies regarding method of PA measurement along the lung cancer continuum. Greater consensus could be achieved by using a consensus approach

such as a Delphi process. Future studies should include assessment of psychometric properties of the measurement tool being used. Currently, it is recommended where feasible, both performance-based and patient-reported measurements of PA should be undertaken.

Keywords: Motor Activity, Lung Neoplasms, Patient Outcome Assessment, Review, Physical Modalities

Short title: Physical activity measures in lung cancer

INTRODUCTION

Physical activity (PA) is defined as 'any bodily movement produced by skeletal muscles that requires energy expenditure'.[1] American College of Sports Medicine (ACSM) recommendations for PA in cancer survivors are in line with current recommendations for the healthy population; 150 minutes of moderate-intensity (or 75 minutes vigorous-intensity) aerobic exercise and two to three resistance-training sessions per week.[2] Those unable to meet these recommendations should aim to be as physically active as possible. PA levels are low in cancer survivors; 18 percent of UK cancer survivors meet current guidelines.[3] In an Australian study, 40 percent of patients with non-small cell lung cancer (NSCLC) met current guidelines at the time of diagnosis, compared with 71 percent of healthy individuals.[4] Global data demonstrate 77 percent of adults are sufficiently active.[5] Daily step counts also fall well below recommendations.[6] In people with advanced NSCLC, self-reported exercise behaviours are associated with a survival benefit approaching statistical significance – with a median survival of 25.63 months in those performing ≥ 9 metabolic equivalent (MET)-hrs/week of PA, compared to 12.89 months in those performing < 9MET-hrs/week.[7] Nine MET-hours/week is equivalent to walking at an average pace for 3 hours/week.[8]

Emerging evidence supports the use of PA interventions as a safe and feasible way of improving outcomes for people with NSCLC.[9, 10] PA is measured either objectively or subjectively. Objective methods involving accelerometry are often cost-prohibitive

in a clinical setting. Cheaper options, such as pedometers, may not be accurate in chronic disease populations with slower walking speeds.[11] Self-report methods are relatively quick and simple to perform, but may be subject to recall bias.[12] As the body of evidence supporting the use of PA interventions grows, development of a core set of outcomes is needed for the measurement of PA for both clinical and research purposes.

Reporting on the psychometric properties of outcome measures is important to determine their validity and reliability in lung cancer. The psychometric properties discussed in this review include validity (criterion and construct), reliability and responsiveness. For further details readers are referred to Portney and Watkins, Chapters 5 and 6 [13] and Supplementary Appendix S1.

The findings of this review will assist clinicians and researchers to determine the most appropriate outcome measures to use in the measurement of PA in patients with lung cancer. The COnsensus-based Standards for the selection of health status Measurement INstruments (COSMIN) guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (where appropriate) were used in the design and reporting of this review.[14, 15]

The aims of this review are to 1) identify and describe outcome measures which have been used to assess level of physical activity in people with lung cancer and 2) evaluate, synthesize and compare the psychometric properties of each of these outcome measures.

METHODS

Protocol

The protocol for this systematic review was registered on the International prospective register of systematic reviews (PROSPERO) (registration number CRD42015024909).

Eligibility criteria

Studies

This review considered any type of quantitative study design. Peer reviewed journal articles published in English from 1980 were included. Conference abstracts were excluded due to the inability to effectively evaluate risk of bias. Specifically for aim 2 the review included studies which aimed to develop a new outcome measure or evaluate the psychometric properties of an existing outcome measure identified as part of aim 1.

Participants

Participants with any type of lung cancer, at any stage of disease were considered. A minimum of 50% of participants in the study were required to have lung cancer. Studies without original participant data (such as editorials, literature reviews) were excluded.

Outcomes

Outcomes of interest were outcome measures which, based on face validity, aimed to measure participant PA levels (performance-based or self–reported).

For aim 2 the outcomes of interest were the psychometric properties reliability (inter-rater/intra-rater), measurement error, criterion validity (concurrent/predictive), construct validity (hypotheses testing) and responsiveness of one of the outcome measures identified against aim 1 (Table 1 and Supplementary Appendix S2).

Information sources, search and study selection

Prior to conducting this review the Cochrane Library, Physiotherapy Evidence

Database, COSMIN list of systematic reviews [16] and International Prospective Register of Systematic Reviews were searched to ensure no similar systematic reviews had been published. Five electronic databases were searched by one reviewer (CG) using a systematic, comprehensive and reproducible search strategy to identify all published studies (Figure 1). Databases were accessed via The University of Melbourne. The last search was run on 10/4/2015.

The search terms used to search all databases were grouped into three categories according to 1) patient population; 2) the method of measuring PA and 3) the outcome of interest (see Supplementary Appendix S2). These terms were adapted from a similar previously published systematic review on outcome measurement. [17]

All studies identified by the search strategy were assessed based on title/abstract for eligibility against aim 1 and aim 2 by two independent reviewers (CG and LE; Figure 1). Full-text versions of all relevant studies was obtained and read to ensure inclusion criteria were met. Consensus was required by both reviewers. Disagreements were settled by a third independent reviewer (LD). Agreement between reviewers was estimated with percentage agreement and Kappa statistic using SPSS for Windows statistical software package (IBM® SPSS® Statistics Version21.0.0). References were stored in RevMan.

Data collection process and data items

A data collection form was specifically developed and used to extract data from studies by one reviewer (SJ) and a second reviewer cross-checked extracted data (RA). Data items extracted were adapted from the COSMIN generalizability checklist[15] (see Supplementary Appendix S2). Collected data were stored in Microsoft(R) Office Excel(R) 2010 software spreadsheets.

Risk of bias of studies

Two independent reviewers (SP/LE) evaluated the risk of bias using the four-point COSMIN checklist [18] for all studies included for aim 2 (measurement properties). This checklist was originally developed to assess the methodological quality of patient reported outcome measures (PROM), however, it has been suggested for use with non-PROM as well.[15] Four items from the checklist are not relevant to non-PROM.

The item score was obtained by using the lowest score recorded for a question within that item.[18]

RESULTS

Study selection

The search identified 1783 studies. Assessment of title/abstract and full text resulted in 34 articles, using 21 different outcome measures to assess PA being included (Figure 1). Of the 34 articles included against aim 1, 18 of these assessed measurement properties of the outcome measure and therefore also met the criteria for aim 2. A list of outcome measures was generated (Table 1) which included: six questionnaires, four methods of patient-report, seven accelerometers, two pedometers and whole-body indirect calorimetry. Excellent percentage agreement between reviewers of potentially relevant titles/abstracts (CG, LE) (95.34%, Kappa=0.394) and full-text articles (CG, LE) (85.12%, Kappa=0.740) was obtained. Consultation with the third reviewer (LD) was not required.

Aim 1

Study characteristics

The 34 included studies for aim 1 reported on 26 unique samples, consisting of a total of 4,970 patients with lung cancer. The majority of studies were observational.

Lung Cancer Type and Stage

More than half of the studies identified (19/34, 56%) involved only patients NSCLC. Seven studies (21%) comprised a mixed sample of both NSCLC and small cell lung cancer (SCLC). Fourteen (41%) studies included subjects across the spectrum of disease stage (Tables 2, 3 and Supplementary Appendix S3).

Study Setting and Timing

In 17 (50%) studies data collection was conducted in the hospital outpatient clinic or laboratory setting. Three of these studies also involved inpatient data collection.[19-21] In seven (21%) studies data were collected through the use of surveys either mailed to the participant's home or completed by telephone.

PA was measured pre-treatment (surgery, chemotherapy or radiotherapy) in 11 (32%) studies. Two of these studies also measured PA post-operatively [22, 23] and one during and following chemotherapy or radiotherapy.[22] Eight (24%) studies involved patients who were currently undergoing treatment (chemotherapy, radiotherapy or targeted therapy). Post-treatment (surgery, chemotherapy or radiotherapy) measurements were reported by eight (24%) studies (Tables 2, 3 and Supplementary Appendix S3).

Outcome Measures Identified

Two studies identified involved both performance-based and patient-reported measures of PA.[4, 19]

Performance-Based Outcome Measures

Seventeen (50%) studies measured PA objectively through the use of: accelerometers, pedometers or whole body indirect calorimetry. Seven different accelerometers and two different pedometers were used by these studies to measure PA (Table 2). The watch-like wrist Actigraph (Ambulatory Monitoring Inc., NY, USA) was reported in four separate papers, three of which involved the same patient sample.[20, 21, 24] Accelerometers were used to measure PA levels in people with lung cancer pre-operatively, during treatment and post-operatively. Common outcomes reported include mean activity duration, peak activity, circadian cycle, sleep time, step count, time spent sitting/lying/standing, time spent in discrete activity levels (by METs) and energy expenditure. Duration of wear and minimum data requirements vary in the current literature. Accelerometers were commonly worn 24 hours per day for four-seven days (Table 2).

Patient-Reported Outcome Measures

Nineteen (56%) studies measured PA using patient self-reported questionnaires, surveys or diaries (Table 3). The most commonly used questionnaire was The Godin Leisure Time Exercise Questionnaire (GLTEQ), or a modified version, being used in seven studies.[7, 25-31] Other questionnaires utilised include the Physical Activity Scale for the Elderly (PASE), Baecke Physical Activity Questionnaire, Rotterdam Symptom

checklist and Stage of Change Physical Activity Questionnaire. Daily patient diary cards, the WHO physical activity scale, Eastern Co-operative Oncology Group Performance Status (ECOG-PS) and whether or not patients were meeting guidelines were also used.

Aim 2

Eighteen studies reported on at least one psychometric property of the outcome measure used to quantify PA. Twelve (67%) studies included in aim 2 involved performance-based methods of measurement (Supplementary Table S1).

Risk of Bias

Percent agreement between reviewers was excellent (percent agreement 89% (25/28), Kappa = 0.801) with the third independent reviewer required on three occasions to resolve reviewer disagreements. A summary of quality ratings for each psychometric property reported is provided in Supplementary Table S2. Overall quality ratings were predominantly fair or poor. Studies reported on construct validity (n=16), criterion validity (n=5), responsiveness (n=5), reliability (n=1) and internal consistency (n=1). Of the 16 studies that reported on the construct validity of the outcome measure, 11 (69%) were rated ‘fair’ and five (31%) ‘poor’. The item which most frequently received low ratings related to the adequate reporting of the

measurement properties of the comparator instrument. Ratings for criterion validity were variable with one study being rated excellent.[7]

Performance-Based Measures

Of the studies which reported on the psychometric properties of performance-based measures of PA, the majority provide evidence of construct validity by means of hypothesis testing (11 studies). Four studies provide evidence of responsiveness, one of predictive validity and one of criterion validity (through comparison with the gold-standard).

Psychometric properties are reported for Actigraph, ActivPAL, KinetaMap, Sensewear and Lifecoder accelerometers. Responsiveness and construct validity are reported for the OMRON pedometer.[23, 32] In the only study identified to use the 'gold-standard' measure of PA, whole-body indirect calorimetry, the bicarbonate-urea tracer method predicted CO_2 production and energy expenditure close to that of the gold-standard.[33] Further details are provided in Supplementary Appendix S3 and Table S1.

Patient-Reported Measures

Seven studies used patient-reported methods to assess PA level. Again, the majority of studies reported evidence of construct validity, through hypothesis testing. Two of these reported on the GLTEQ, finding moderate correlations between higher activity levels and QoL.[30] There was a trend towards improved median survival in those who

reported ≥9MET-hrs/week compared to their less active counterparts.[7] The PASE questionnaire is reported to have moderate convergent and construct validity, be responsive to change and, when performed at diagnosis, is predictive of future physical function.[22] For further details refer to Supplementary Appendix S3 and Table S1.

DISCUSSION

This review identified 34 studies measuring PA in 21 different ways in 4,970 people with lung cancer. The majority of studies were observational in nature, with 19 prospective cohort and 12 cross-sectional studies. Numerous variables contributing to the heterogeneity within this body of evidence have been identified. These include lung cancer type and stage, timing of measurement along the cancer treatment continuum and treatment type. Only one study collected data solely in the inpatient setting. PA has been measured in people with lung cancer both pre and post-operatively and also pre, during and post-chemotherapy/radiotherapy or targeted therapy. Given previous observational work by our group has demonstrated a decline in self-reported PA from diagnosis to 6-month follow-up,[4] we would recommend measuring PA across all stages of the cancer treatment continuum.

Fifty percent of included studies reported on performance-based measures of PA, through use of seven types of accelerometers, two types of pedometers and one study of whole-body indirect calorimetry and a tracer method. The most commonly used accelerometer was the watch-like wrist Actigraph (Ambulatory Monitoring Inc., NY, USA), which was reported by four studies comprising two patient samples.[20, 21, 24, 34] Outcomes reported from these different devices varied greatly, including mean duration of daytime activity, peak activity, mean activity (accelerations per minute), sleep/activity cycles, daily or weekly step count, step rate, time spent

sitting/lying/standing, time spent in activity categories according to MET levels, total energy expenditure and distance walked. Fifty-six percent of included studies used patient-reported measures. The most frequently used patient-reported outcome measure was the GLTEQ, being reported in seven studies of five patient samples.[7, 25-27, 30, 31, 35] Next commonly, the PASE was reported in two studies.[4, 22] Of note, ECOG-PS was used to measure PA in one study.[36] ECOG-PS is a five-point ordinal scale measure of physical function as distinct from a measure of PA levels.[37]

The variability in reporting makes comparison of PA levels between different study samples difficult. Greater consensus regarding PA outcome reporting could be achieved by using an approach such as a Delphi process. Use of variables which can be compared across different studies is recommended (eg. step counts or energy expenditure in METs).[38]

Only two studies used both performance-based and patient-reported measures of PA.[4, 19] In a surgical population, Agostini and colleagues measured pre-operative activity levels using an eight-point Likert scale questionnaire and then collected four days of post-operative accelerometer data. Pre-operative PA level significantly predicted post-operative PA levels.[19] Granger et al collected data using an accelerometer and the PASE questionnaire. No significant difference in steps/day over time was found using the accelerometer, however self-reported PA levels declined significantly.[4, 19] This finding highlights the importance of using both methods of measurement. Indeed it may be that these two methods are measuring

different constructs. Self-reported methods also take into account the patient's perception of their activity levels; this has been previously demonstrated in a population following critical illness.[39] Patient perceptions may be impacted by many factors, including: stage along the cancer treatment continuum, level of social support and pre-morbid activity levels.

Few studies report on the psychometric properties of the measures. Most report construct validity through hypothesis testing of associations with other outcomes of interest, for example depression. The overall quality of these studies was generally 'poor' to 'fair', indicating that findings should be interpreted with caution. Evidence of construct validity exists for the Actigraph,[20, 21, 34] ActivPaL,[40] Sensewear[19] and Lifecoder[41] accelerometers. The KinetaMap accelerometer demonstrated weaker evidence of construct validity.[42] Responsiveness of the ActivPaL,[43] Sensewear[19] and Lifecoder[41] devices was reported using step count changes over time. No other reporting of measurement properties for accelerometers was identified. The only pedometer with reported psychometric properties was the OMRON pedometer. The OMRON demonstrated construct validity and was found to be responsive to change and predictive of post-operative peak oxygen uptake.[23, 32] The bicarbonate-urea method of measuring total energy expenditure was reported to be valid when compared to the 'gold standard' of whole-body indirect calorimetry and showed excellent agreement with patient reported PA levels. Few details of how patient-reported PA data were obtained are provided by this study.[33] The GLTEQ was the most frequently used patient-reported measure identified by this review and for this

reason we would recommend its use in future studies. Psychometric properties have only been reported in two studies involving the target population. These studies demonstrated moderate evidence of construct validity[30] and a trend towards predictive validity.[7] The study by Jones and colleagues was the only study in this review to receive an 'excellent' quality rating.[7] Future studies using the GLTEQ in the lung cancer population should include assessment of the measure's psychometric properties. The only study reporting on psychometric properties of the PASE questionnaire provided evidence of moderate construct validity, responsiveness and predictive validity[22] – therefore further investigation of the PASE in this population is warranted.

Given that people with lung cancer commonly present with co-morbidites such as chronic obstructive pulmonary disease (COPD),[44] it may be possible to extrapolate findings from these populations to those with lung cancer. Performance-based devices are validated more extensively in chronic disease populations[45, 46] and comparisons made to the healthy population.[47] Accelerometers are reported as being more sensitive for detecting walking than pedometers. Dynaport, Actigraph GT3X and Sensewear accelerometers are valid and responsive for measurement of PA in COPD.[45] Consideration needs to be given to appropriate duration of wear; reliability of measurements may be impacted by disease severity with less severe COPD stages requiring longer duration of wear.[46] Four weekdays of at least eight-hours wear has recently been reported as optimal duration in COPD.[48]

A limitation of this review may be that only articles published in English were eligible for inclusion. It is therefore possible that relevant studies were excluded. Publication bias is possible as studies included were only those identified through electronic database searching and published research from the authors' personal records.

In conclusion, whilst it would be ideal to be able to provide recommendations as to which outcome measures are most appropriate to use in which cohorts of people with lung cancer (operable or inoperable) and at which time points along the cancer treatment continuum, this is not possible at this stage due to the lack of consistency in outcome measure tools used in the studies identified by this review.

Future studies should be designed to incorporate testing of psychometric properties of PA outcome measures in people with lung cancer. This would provide more data upon which to make recommendations. Validation studies pertaining to the particular device being used also need to be conducted, as results from one device cannot be generalized to others and rapidly developing technology means new alternative devices are often available and used.

Ideally, both performance-based and patient-reported PA measurements should be performed. We recommend researchers using both forms of measurement where possible, or apply performance-based measures to a subset of populations in studies reporting PA in large mail or telephone-based surveys.

We recommend greater consensus on the PA variables reported to enable further comparison between studies. This could be undertaken using a consensus approach such as a Delphi process where an expert panel review literature to suggest a core outcome set for measurement in lung cancer, including both performance and self-report measures. If these are then implemented by researchers and clinicians comparison of data across different studies will be possible. This will facilitate the current emerging field of study to use the best possible measure at the most appropriate time point to measure patient outcomes.

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REFERENCES

1 World Health Organisation. Global recommendations on physical activity for health. 2010.

2 Schmitz KH, Courneya KS, Matthews C, Demark-Wahnefried W, Galvao DA, Pinto BM, Irwin ML, Wolin KY, Segal RJ, Lucia A, Schneider CM, von Gruenigen VE, Schwartz AL. American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Medicine and science in sports and exercise. 2010; 42: 1409-26.

3 Stevinson C, Lydon A, Amir Z. Adherence to physical activity guidelines among cancer support group participants. European journal of cancer care. 2014; 23: 199-205.

4 Granger CL, McDonald CF, Irving L, Clark RA, Gough K, Murnane A, Mileshkin L, Krishnasamy M, Denehy L. Low physical activity levels and functional decline in individuals with lung cancer. Lung Cancer. 2014; 83: 292-9.

5 World Health Organisation. http://www.who.int/mediacentre/factsheets/fs385/en/. Accessed: 1st August 2016.

6 Tudor-Locke C, Craig CL, Aoyagi Y, Bell RC, Croteau KA, De Bourdeaudhuij I, Ewald B, Gardner AW, Hatano Y, Lutes LD, Matsudo SM, Ramirez-Marrero FA, Rogers LQ, Rowe DA, Schmidt MD, Tully MA, Blair SN. How many steps/day are enough? For older adults and special populations. The international journal of behavioral nutrition and physical activity. 2011; 8: 80.

7 Jones LW, Hornsby WE, Goetzinger A, Forbes LM, Sherrard EL, Quist M, Lane AT, West M, Eves ND, Gradison M, Coan A, Herndon JE, Abernethy AP. Prognostic significance of functional capacity and exercise behavior in patients with metastatic non-small cell lung cancer. Lung Cancer. 2012; 76: 248-52.

8 Holmes MD, Chen WY, Feskanich D, Kroenke CH, Colditz GA. Physical activity and survival after breast cancer diagnosis. Jama. 2005; 293: 2479-86.

9 Crandall K, Maguire R, Campbell A, Kearney N. Exercise intervention for patients surgically treated for Non-Small Cell Lung Cancer (NSCLC): a systematic review. Surgical oncology. 2014; 23: 17-30.

10 Granger CL, McDonald C, Berney S, Chao C, Denehy L. 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. 2011; doi:10.1016/j.lungcan.2011.01.006.

11 Cyarto EV, Myers A, Tudor-Locke C. Pedometer accuracy in nursing home and community-dwelling older adults. Medicine and science in sports and exercise. 2004; 36: 205-9.

12 Macko R, Haeuber E, Shaughnessy M, Coleman K, Boone D, Smith G, Silver K. Microprocessor-Based Ambulatory Activity Monitoring in Stroke Patients. Medicine and science in sports and exercise. 2002; 34: 6.

13 Portney L, Watkins M. Foundations of clinical research. Applications to practice. 1 ed. Pearson Education, New Jersey, 1993.

14 Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ (Clinical research ed). 2009; 339: b2700-.

15 Mokkink LB, Terwee CB, Knol DL, Stratford PW, Alonso J, Patrick DL, Bouter LM, de Vet HC. The COSMIN checklist for evaluating the methodological quality of studies on measurement properties: a clarification of its content. BMC medical research methodology. 2010; 10: 22.

16 Terwee CB, and the COSMIN group. The COSMIN checklist for evaluating the methodological quality of studies on measurement properties: a clarification of its content. BMC medical research methodology. 2010; 10.

17 Granger C, McDonald C, Parry S, Oliveira C, Denehy L. Funcitonal capacity, physical activity and muscle strength assessment of individuals with non-small cell lung cancer: a systematic review of instruments and their measurement properties. BMC cancer. 2013; 13.

18 Terwee CB, Mokkink LB, Knol DL, Ostelo RW, Bouter LM, de Vet H. Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for the COSMIN checklist. Quality of Life Research. 2012; 21: 651-7.

19 Agostini PJ, Naidu B, Rajesh P, Steyn R, Bishay E, Kalkat M, Singh S. Potentially modifiable factors contribute to limitation in physical activity following

thoracotomy and lung resection: a prospective observational study. Journal of cardiothoracic surgery. 2014; 9: 128.

20 Du-Quiton J, Wood PA, Burch JB, Grutsch JF, Gupta D, Tyer K, Lis CG, Levin RD, Quiton DF, Reynolds JL, Hrushesky WJ. Actigraphic assessment of daily sleep-activity pattern abnormalities reflects self-assessed depression and anxiety in outpatients with advanced non-small cell lung cancer. Psycho-oncology. 2010; 19: 180-9.

21 Grutsch JF, Wood PA, Du-Quiton J, Reynolds JL, Lis CG, Levin RD, Ann Daehler M, Gupta D, Quiton DF, Hrushesky WJ. Validation of actigraphy to assess circadian organization and sleep quality in patients with advanced lung cancer. Journal of circadian rhythms. 2011; 9: 4.

22 Granger CL, Parry SM, Denehy L. The self-reported Physical Activity Scale for the Elderly (PASE) is a valid and clinically applicable measure in lung cancer. Support Care Cancer. 2015; 23: 3211-8.

23 Novoa N, Varela G, Jimenez MF, Aranda JL. Influence of major pulmonary resection on postoperative daily ambulatory activity of the patients. Interactive cardiovascular and thoracic surgery. 2009; 9: 934-8.

24 Grutsch JF, Ferrans C, Wood PA, Du-Quiton J, Quiton DF, Reynolds JL, Ansell CM, Oh EY, Daehler MA, Levin RD, Braun DP, Gupta D, Lis CG, Hrushesky WJ. The association of quality of life with potentially remediable disruptions of circadian sleep/activity rhythms in patients with advanced lung cancer. BMC cancer. 2011; 11: 193.

25 Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, Ostroff JS. Physical activity among lung cancer survivors: changes across the cancer trajectory and associations with quality of life. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2009; 18: 664-72.

26 Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, Ostroff JS. Correlates of physical activity among lung cancer survivors. Psycho-oncology. 2009; 18: 395-404.

27 Feinstein MB, Krebs P, Coups EJ, Park BJ, Steingart RM, Burkhalter J, Logue A, Ostroff JS. Current dyspnea among long-term survivors of early-stage non-small cell lung cancer. Journal of thoracic oncology : official publication of the International Association for the Study of Lung Cancer. 2010; 5: 1221-6.

28 Jacobsen PB, Phillips KM, Jim HS, Small BJ, Faul LA, Meade CD, Thompson L, Williams CC, Jr., Loftus LS, Fishman M, Wilson RW. Effects of self-directed stress management training and home-based exercise on quality of life in cancer patients receiving chemotherapy: a randomized controlled trial. Psycho-oncology. 2013; 22: 1229-35.

29 Jones LW, Peddle CJ, Eves ND, Haykowsky MJ, Courneya KS, Mackey JR, Joy AA, Kumar V, Winton TW, Reiman T. Effects of presurgical exercise training on cardiorespiratory fitness among patients undergoing thoracic surgery for malignant lung lesions. Cancer. 2007; 110: 590-8.

30 Lin YY, Wu YC, Rau KM, Lin CC. Effects of physical activity on the quality of life in taiwanese lung cancer patients receiving active treatment or off treatment. Cancer nursing. 2013; 36: E35-41.

31 Philip EJ, Coups EJ, Feinstein MB, Park BJ, Wilson DJ, Ostroff JS. Physical activity preferences of early-stage lung cancer survivors. Support Care Cancer. 2014; 22: 495-502.

32 Novoa NM, Varela G, Jimenez MF, Ramos J. Value of the average basal daily walked distance measured using a pedometer to predict maximum oxygen consumption per minute in patients undergoing lung resection. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery. 2011; 39: 756-62.

33 Gibney E, Elia M, Jebb SA, Murgatroyd P, Jennings G. Total energy expenditure in patients with small-cell lung cancer: results of a validated study using the bicarbonate-urea method. Metabolism: clinical and experimental. 1997; 46: 1412-7.

34 Levin RD, Daehler MA, Grutsch JF, Quiton J, Lis CG, Peterson C, Gupta D, Watson K, Layer D, Huff-Adams S, Desai B, Sharma P, Wallam M, Delioukina M, Ball P, Bryant M, Ashford M, Copeland D, Ohmori M, Wood PA, Hrushesky WJ. Circadian function in patients with advanced non-small-cell lung cancer. British journal of cancer. 2005; 93: 1202-8.

35 Jones LW, Eves ND, Peddle CJ, Courneya KS, Haykowsky M, Kumar V, Winton TW, Reiman T. Effects of presurgical exercise training on systemic

inflammatory markers among patients with malignant lung lesions. Appl Physiol Nutr Metab. 2009; 34: 197-202.

36 Cooley ME, Short TH, Moriarty HJ. Symptom prevalence, distress, and change over time in adults receiving treatment for lung cancer. Psycho-oncology. 2003; 12: 694-708.

37 Buccheri G, Ferrigno D, Tamburini M. Karnofsky and ECOG performance status scoring in lung cancer: a prospective, longitudinal study of 536 patients from a single institution. European journal of cancer (Oxford, England : 1990). 1996; 32a: 1135-41.

38 Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR, Jr., Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS. 2011 Compendium of Physical Activities: a second update of codes and MET values. Medicine and science in sports and exercise. 2011; 43: 1575-81.

39 Denehy L, Nordon-Craft A, Edbrooke L, Malone D, Berney S, Schenkman M, Moss M. Outcome measures report different aspects of patient function three months following critical care. Intensive care medicine. 2014; 40: 1862-9.

40 Maddocks M. Physical activity level as an outcome measure for use in cancer cachexia trials: a feasibility study. Supportive Care in Cancer. 2010; 18: 1539-44.

41 Arai H, Hirai K, Harada K, Tokoro A. Physical Activity and Psychological Adjustment in Japanese Advanced Lung Cancer Patients in Chemotherapy: The Feasibility of Intervention. International Journal of Sport and Health Science 2010; 8: 15-21.

42 Granger CL, Denehy L, McDonald CF, Irving L, Clark RA. Physical activity measured using global positioning system tracking in non-small cell lung cancer: an observational study. Integrative cancer therapies. 2014; 13: 482-92.

43 Maddocks M, Lewis M, Chauhan A, Manderson C, Hocknell J, Wilcock A. Randomized Controlled Pilot Study of Neuromuscular Electrical Stimulation of the Quadriceps in Patients with Non-Small Cell Lung Cancer. Journal of pain and symptom management. 2009; 38: 950-6.

44 Islam KM, Jiang X, Anggondowati T, Lin G, Ganti AK. Comorbidity and Survival in Lung Cancer Patients. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2015; 24: 1079-85.

45 Van Remoortel H, Giavedoni S, Raste Y, Burtin C, Louvaris Z, Gimeno-Santos E, Langer D, Glendenning A, Hopkinson NS, Vogiatzis I, Peterson BT, Wilson F, Mann B, Rabinovich R, Puhan MA, Troosters T. Validity of activity monitors in health and chronic disease: a systematic review. The international journal of behavioral nutrition and physical activity. 2012; 9: 84.

46 Watz H, Pitta F, Rochester CL, Garcia-Aymerich J, ZuWallack R, Troosters T, Vaes AW, Puhan MA, Jehn M, Polkey MI, Vogiatzis I, Clini EM, Toth M, Gimeno-Santos E, Waschki B, Esteban C, Hayot M, Casaburi R, Porszasz J, McAuley E, Singh SJ, Langer D, Wouters EF, Magnussen H, Spruit MA. An official European Respiratory Society statement on physical activity in COPD. The European respiratory journal. 2014; 44: 1521-37.

47 Vorrink SN, Kort HS, Troosters T, Lammers JW. Level of daily physical activity in individuals with COPD compared with healthy controls. Respir Res. 2011; 12: 33.

48 Demeyer H, Burtin C, Van Remoortel H, Hornikx M, Langer D, Decramer M, Gosselink R, Janssens W, Troosters T. Standardizing the analysis of physical activity in patients with COPD following a pulmonary rehabilitation program. Chest. 2014; 146: 318-27.

49 Maddocks M, Wilcock A. Exploring physical activity level in patients with thoracic cancer: implications for use as an outcome measure. Support Care Cancer. 2012; 20: 1113-6.

50 Le Guen Y, Gagnadoux F, Hureaux J, Jeanfaivre T, Meslier N, Racineux JL, Urban T. Sleep disturbances and impaired daytime functioning in outpatients with newly diagnosed lung cancer. Lung Cancer. 2007; 58: 139-43.

51 van der Meij BS, Langius JA, Spreeuwenberg MD, Slootmaker SM, Paul MA, Smit EF, van Leeuwen PA. Oral nutritional supplements containing n-3 polyunsaturated fatty acids affect quality of life and functional status in lung cancer patients during multimodality treatment: an RCT. European journal of clinical nutrition. 2012; 66: 399-404.

52 Hoffman AJ, Brintnall RA, Brown JK, Eye A, Jones LW, Alderink G, Ritz-Holland D, Enter M, Patzelt LH, Vanotteren GM. 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 nursing. 2013; 36: 175-88.

53 Coups EJ, Ostroff JS, Steingart RM, Feinstein MB, Wilson D. Exercise patterns in lung cancer survivors. Psycho-oncology. 2006; 15: 498.

54 Bleehen NM, Girling DJ, Machin D, Stephens RJ. A randomised trial of three or six courses of etoposide cyclophosphamide methotrexate and vincristine or six courses of etoposide and ifosfamide in small cell lung cancer (SCLC). II: Quality of life. Medical Research Council Lung Cancer Working Party. British journal of cancer. 1993; 68: 1157-66.

55 Cheville AL, Novotny PJ, Sloan JA, Basford JR, Wampfler JA, Garces YI, Jatoi A, Yang P. The value of a symptom cluster of fatigue, dyspnea, and cough in predicting clinical outcomes in lung cancer survivors. Journal of pain and symptom management. 2011; 42: 213-21.

56 Souhami RL, Spiro SG, Rudd RM, Ruiz de Elvira MC, James LE, Gower NH, Lamont A, Harper PG. Five-day oral etoposide treatment for advanced small-cell lung cancer: randomized comparison with intravenous chemotherapy. Journal of the National Cancer Institute. 1997; 89: 577-80.

57 Clark MM, Vickers KS, Hathaway JC, Smith M, Looker SA, Petersen LR, Pinto BM, Rummans TA, Loprinzi CL. Physical activity in patients with advanced-stage cancer actively receiving chemotherapy. The journal of supportive oncology. 2007; 5: 487-93.

58 Cooley ME, Finn KT, Wang Q, Roper K, Morones S, Shi L, Litrownik D, Marcoux JP, Zaner K, Hayman LL. Health behaviors, readiness to change, and

interest in health promotion programs among smokers with lung cancer and their family members: a pilot study. Cancer nursing. 2013; 36: 145-54.

59 Geddes DM, Dones L, Hill E, Law K, Harper PG, Spiro SG, Tobias JS, Souhami RL. Quality of life during chemotherapy for small cell lung cancer: assessment and use of a daily diary card in a randomized trial. European journal of cancer (Oxford, England : 1990). 1990; 26: 484-92.

60 Ishihara Y, Sakai H, Nukariya N, Kobayashi K, Yoneda S, Matsuoka R, Hohjo T, Nishiwaki Y, Hoshi A, Kuratomi Y, Nagai A, Kagawa J, Kitamura S. A diary form quality of life questionnaire for Japanese patients with lung cancer and summarization techniques for longitudinal assessment. Respirology (Carlton, Vic). 1999; 4: 53-61.

61 Denehy L, Hornsby WE, Herndon JE, 2nd, Thomas S, Ready NE, Granger CL, Valera L, Kenjale AA, Eves ND, Jones LW. Prognostic validation of the body mass index, airflow obstruction, dyspnea, and exercise capacity (BODE) index in inoperable non-small-cell lung cancer. Journal of thoracic oncology : official publication of the International Association for the Study of Lung Cancer. 2013; 8: 1545-50.

62 Schofield E, Ward C, Hickson M, Elkin S. Physical activity levels of lung cancer survivors. Cancer Nursing Practice. 2014; 13: 31-7.

Table 1: List of outcome measures identified

Type		Measure	Number of articles
Subjective	Questionnaire	Baecke Physical Activity Questionnaire	1
		Godin Leisure Time Exercise Questionnaire	5
		Modified version of Godin Leisure Time Exercise Questionnaire	2
		Physical Activity Scale for the Elderly	2
		Stage of change for physical activity level questionnaire	1
		European Organisation for the Research and Treatment of Cancer Questionnaire (one question only)	1
		Activities of daily living (daily activity) scale	1
	Patient or	Daily diary	5

	clinician report		
		Self-reported level of physical activity compared to published guidelines	5
		Adherence to an exercise program	1
		Patient reported pre-operative activity level	1
		Patient report walking level	1
Objective	Movement sensor – accelerometer	SenseWear Pro3 armband motion sensors (APC Cardiovascular Ltd, Crewe, UK)	1
		Wrist actigraph (Ambulatory Monitoring, Inc, AMI, Ardsley, NY USA)	4
		Wrist accelerometer (ActiwatchTM, Cambridge Neurotechnoloy Ltd., United Kingdom)	1
		ActivPAL monitor (PAL Technologies Ltd., Glasgow, UK)	3
		Physical activity monitor (PAM) accelerometer	1

		(model AM101, 28 190 g, 59_43_10mm3; PAM B.V., Doorwerth, The Netherlands)	
		Uniaxial accelerometry monitor (Lifecoder EX, Suzuken, Co., Ltd, Nagoya, Japan)	1
		KinetaMap device (tri-axial accelerometer) (Sparkfun Electronics GPS-08725, Colorado)	2
	Movement sensor – pedometer	Sportsline Step and Distance Pedometer	1
		OMROM Walking Style Pro Pedometer	2
	Calorimetry	Whole body calorimetry	1

Table 2: Studies implementing performance-based measures of physical activity

Device	Author, Year, Country	Study design	n	Diagnosis	Disease stage	Treatment status	Setting	Outcomes	Timing	Measurement duration
Accelerometers										
Watch like wrist Actigraph (Ambulatory Monitoring Inc., NY, USA)	Du-Quinton, 2010, USA[20]	Prospective cohort	84	NSCLC[†]	IIB - IV or recurrent NSCLC	Pre-chemotherapy	In/ outpatient clinics	Mean duration of daytime activity, peak activity	Immediately prior to first chemotherapy treatment, or during the first 3 days of first treatment (for inpatients)	24 hours a day for 3 - 7 days

Grutsch, 2011, USA[24]	Pre-chemotherapy (or failed first course of chemotherapy)	Laboratory/ inpatients and outpatients	Activity (accelerations /0.5hr), mean activity (accelerations /min)	Inpatients: 4-7 days prior to first treatment, Outpatients: during the week prior to the first treatment	24 hours a days over 4 - 7 days
Grutsch, 2011, USA[21]	During chemotherapy	2 centres (inpatient vs outpatients/	Daily circadian cycle; sleep/activity	Pre-chemotherapy and where possible	48 hours prior to 1st chemo then during where possible

						home)	cycle	during chemotherapy	or 4-7 days depending on setting
Levin, 2005, USA[34]	Prospective cohort	33	NSCLC	IIIA - IV	One site prior to chemotherapy, 1 site during chemotherapy	2 sites (home vs inpatient)	Mean activity, total, during wakefulness, sleep % wakefulness spent sleeping and sleep quality	One week prior to therapy vs immediately before or during and following 1st line chemotherapy	24 hours a day for 4-7 day periods

ActivPAL Uniaxial monitor (PAL Techologies LTD, Glasgow, UK)	Maddocks, 2010, UK [40]	Prospective cohort	58	Lung cancer, (NSCLC, SCLC[§]), mesothel -ioma	Local and advanced disease	Patients were not undergoing chemo or radiotherapy or had surgery in the last 4 weeks	Hospital or home	Step count, rate of stepping, time spent sitting, lying or standing and sit-to - stand transitions	Baseline	24 hours a day for 1 week
	Maddocks, 2009, UK [43]	RCT	16	NSCLC	III - IV		Home	Daily number of steps	Baseline and start of week 4	1 week
	Maddocks,	Prospective	84	Lung	IIIb - IV		Hospital or	Step count,	At baseline	24 hours a day for

	2012, UK [49]	cohort		cancer, (NSCLC, SCLC, mesothel -ioma)			home visit	time spent sitting, lying or standing and sit-to - stand transitions	and removed 1 weeks later	7 days (required min 5 days of data) for 1 week
Tri-axial KinetaMap (Sparkfun Electronics, US)	Granger, 2014, Australia[4]	Prospective cohort	50	NSCLC	I-IIIB	Pre-treatment (chemotherapy, radiotherapy or surgery)	Clinic or lab	Daily step count; self reported activity scored as sufficient, insufficient or sedentary	At diagnosis, 10 weeks and 6 months later	Waking hours for 5 consecutive days (minimum of 3 days ≥ 8hrs of data)

Granger, 2014, Australia[42]	Cross-sectional		against WHO** PA‡ guidelines	Steps per day, time spent outdoors per day, outdoor walking per day, furthest distance travelled from	Pre-treatment (chemo and/or radiotherapy and or surgery)

							home, time spent at distances from home			
SenseWear Pro3 (APC Cardiovascular Ltf, UK)	Agostini, 2014, UK [19]	Prospective cohort	99	93 % lung cancer; does not detail type	operable	Post-operative	clinic (or lab or inpatient ward)	Steps per day, time spent in sedentary (< 3 METs*) or moderate (3-6 METs), total energy	Postoperative day 1-4	24 hours a day for 3 days

							expenditure and active energy expenditure			
Lifecoder EX, Suzuken, Co., Ltd, Nagoya, Japan	Arai, 2012, Japan [41]	Prospective cohort	6	NSCLC and SCLC	IIIB - IV	During chemotherapy	Chest medical centre	Mean steps per week	Start of control period, after week 1, after week 2 and after week 4	Daily for 4 weeks
Actiwatch, (Cambridge	Le Guen, 2007,	Cross-sectional	29	NSCLC and	I - IV	Newly diagnosed -	Clinic	Sleep time, latency and	Baseline	24 hours/day for 5

Neuro-technology LTD, UK)	France[50]			SCLC		pre-treatment		efficiency. Mean activity score fragmentation index and immobile time		consecutive days
Physical Activity Monitor (modelAM101, Doorwerth, The Netherlands)	Van der Meij, 2012, The Netherlands[51]	RCT	40	NSCLC	IIIa - IIIb	Multimodality treatment - had not undergone surgery, chemo or radiotherapy in past month	Clinic	Mean daily activity (accelerations of the hip), low and moderate	Baseline, 3 and 5 weeks	7 consecutive days (required min at least 3 full days)

								intensity activity		
Pedometers										
OMROM Walking Style Pro	Novoa, 2009, Spain[23]	Prospective cohort	21	NSCLC	operable	Pre-op and post op	Clinic and then at hospital discharge	Pre and post op walked distance, total steps and aerobic steps	Pre-op and from hospital discharge until 30 days after discharge	24 hours a day
	Novoa, 2011, Spain[32]	Cross-sectional	38	NSCLC	operable	Pre-op	Clinic	Total steps, aerobic steps, time and	Pre-op, time before surgery	During waking hours

								distance		
Sportsline Step and Distance	Hoffman, 2013, USA[52]	Prospective cohort	7	NSCLC	IA - IIIA	Pre-op	Clinic and home	Pedometer steps in addition to Wii Fit	Pre-op and post surgery and at week 1- 6 -during the intervention	Baseline and during 6 weeks exercise intervention
Whole body indirect calorimetry										
Bicarbonate-urea method	Gibney, 1997, UK[33]	Prospective cohort	8	SCLC	Non operable	Post chemotherapy and/or radiotherapy	Clinic	PA level	At least 1 month following chemotherapy	24 hours of whole-body calorimetry and 24 hours

		and/or radiotherapy.	free-living with continuation of 14C-bicarbonate infusion

Footnotes: [*]MET = metabolic equivalent; [†]NSCLC = non-small cell lung cancer; [‡]PA = physical activity; [§]SCLC = small cell lung cancer; [**]WHO = World Health Organisation

Table 3: Studies implementing self-report measures of physical activity

Measurement tool	Author, Year, Country	Study design	n	Diagnosis	Disease stage	Treatment status	Setting	Physical Activity Outcomes	Timing	Measurement duration
GLTEQ[§]	Jones, 2007, Canada [29]	Prospective cohort	20	NSCLC[***]	I-IIIA	Pre-operative	Clinic/lab	Average frequency of mild, moderate, strenuous intensity, total exercise behaviour	Baseline, pre and post surgery	3 time points

							reported in METs[††]		
Coups, 2009, USA [53]	Cross-sectional	175	NSCLC	IA -IB	1- 6 years post-operative	Telephone survey or mailed paper	Minutes engaged in moderate/ strenuous activity, engagement in leisure walking	1-6 years post operative	Single time point question-naire
Philip, 2014, USA [31]	Cross-sectional						Weekly frequency and average number		

				of minutes spent performing activity	
Coups, 2009, USA [25]	Retrospective cohort		Minutes engaged in moderate/ strenuous activity		Retrospective measurement for timepoints of: 6 months prior to surgery, 6 months post surgery and current time

								point (1-6 years post surgery).	
Feinstein, 2010, USA[27]	Cross-sectional	342	NSCLC	I	Post operative - 1-6 years after resection	At home mailed questionnaire or telephone survey	Moderate/ strenuous activity- dichotomised; any vs none	1-6 years post curative surgery, mean (SD) 3.5 (1.2) years	
Jones, 2012, USA[7]	Cross-sectional	118	NSCLC	IIIB - IV or recurrent metastatic (inoperable)	Palliative	Clinic	Average frequency of mild, moderate, strenuous	Average weekly exercise since adjuvant	One-time survey

							intensity, total ex behaviour reported in METS	treatment and average duration within each level of exercise intensity	
Lin, 2013, China[30]	Cross-sectional	185	Lung cancer survivors	I - IV	On or off treatment	Clinic	Average frequency and duration of mild, moderate and strenuous activity and	Baseline	One-time Survey

								frequency		
PASE‡‡‡	Granger, 2014, Australia[4]	Prospective cohort	50	NSCLC	I - IIIB	Pre-treatment (chemo, radiotherapy or surgery)	Clinic or lab	Self reported activity scored as sufficient, insufficent or sedentary against WHO**** PA††† guidelines	At diagnosis, 10 weeks later and 6 months later	Four time points over 6 months
	Granger, 2015, Australia[22]	Prospective cohort	69	NSCLC	I - IV	Pre-treatment (surgery/chemo /radiotherapy, none), during		PASE score	Diagnosis and 2, 4 and 6 month follow up	

						and post-treatment					
WHO physical activity scale, MRC[§§] patient diary card	Bleehen, 1993, UK[54]	Prospective cohort	458	SCLC[§§§]	Not stated	All undergoing chemotherapy	Outpatient clinic	Level of PA	Clinician assessment: pre-chemotherapy, at each attendance for chemotherapy, monthly to 12 months then every 3	Clinician assessment in clinic monthly, patient question-naire for 21 weeks	

										months thereafter. Patient assessment: every evening for the first 21 weeks of treatment
Baecke Physical Activity Questionnaire	Cheville, 2011, USA[55]	Prospective cohort	240 5	NSCLS/ SCLC	I - IV, LS-ES**	Post diagnosis	At home mailed quesitonaire	Binary answer to 'I currently engage in regular physical	Within 6 months of diagnosis and thereafter	Single time point question-naire

								exercise'	each year until death	
Rotterdam symptom checklist and diary cards	Souhami, 1997, UK[56]	Prospective cohort	155	SCLC	Palliative SCLC	Palliative patients having chemo	Oncology department	Physical activity and activity form checklist and diary cards respectively	Baseline, then every 3 weeks at each treatment cycle and first 2 follow-up visits	21 days and 2 follow up visits
Stage of change for physical	Clark, 2007, USA[57]	Cross-sectional	272	NSCLC/ SCLC	75% early stage, 25% late stage.	Post treatment (at least 5 years post	At home mailed questonnaire	Score 1-5 on questionnaire	Once at least 5 years post diagnosis	Single time point question-

activity questionnaire					diagnosis)					naire
ECOG-PS† Questionnaire	Cooley, 2013, USA[58]	Cross-sectional	37	NSCLS/ SCLC	I - IV	Undergoing treatment	Phone interview or in clinic	Score 0-4 on questionnaire	Post diagnosis	Single time point question-naire/ interview
Diary card and EORTC‡ questionnaire	Geddes, 1990, Australia[59]	Prospective cohort	53	SCLC	Not stated	Pre-chemotherapy	Clinic visits and one home interview	Combined 'Activity' score	Every 3 months from start of chemotherapy	Single time point question-naire

Diary-type questionnaire for Japanese Lung cancer inpatients	Ishihara, 1999, Japan[60]	Prospective cohort	53	NSCLC/ SCLC	II-IV	Undergoing cancer treatment	Inpatients	5 scales physical and psychological well being including daily living (activity) in hospital	During chemotherapy as an inpatient	3 times per week during 2 weeks of chemo
Exercise behaviour - meeting ASCM* guidelines or	Denehy, 2013, USA[61]	Cross-sectional	100	NSCLC	IIIB - IV	Non operable	Clinic	'Yes'/'no' meeting ASCM guidelines	Mean (SD) 27 (22) months post inoperable diagnosis	Single time point question-naire

not											
Likert scale patient reported pre-operative activity level	Agostini, 2014, UK [19]	Cross-sectional	99	93 % lung cancer; does not detail type	Operable	Pre-operative	Clinic	8-point Likert scale: bedbound, wheelchair/bed to chair, 5m across a room, 25m/length of ward, 100m/length of football pitch, 400m/distance	Pre-operative assessment clinic	Single time point question-naire	

								between bus stops, 2km/30 min walk, >2km/no exercise limitations		
Questionnaire (unvalidated)	Schofield, 2014, Australia [62]	Cross-sectional	79	Any lung cancer	Not stated	Post surgery or post chemotherapy and/or radiotherapy	Posted surveys (home)	Perceived level of activity (multiple response answers no details reported)	Surgical group 6-12 months after surgery; inoperable group within less than 3	One-time Survey

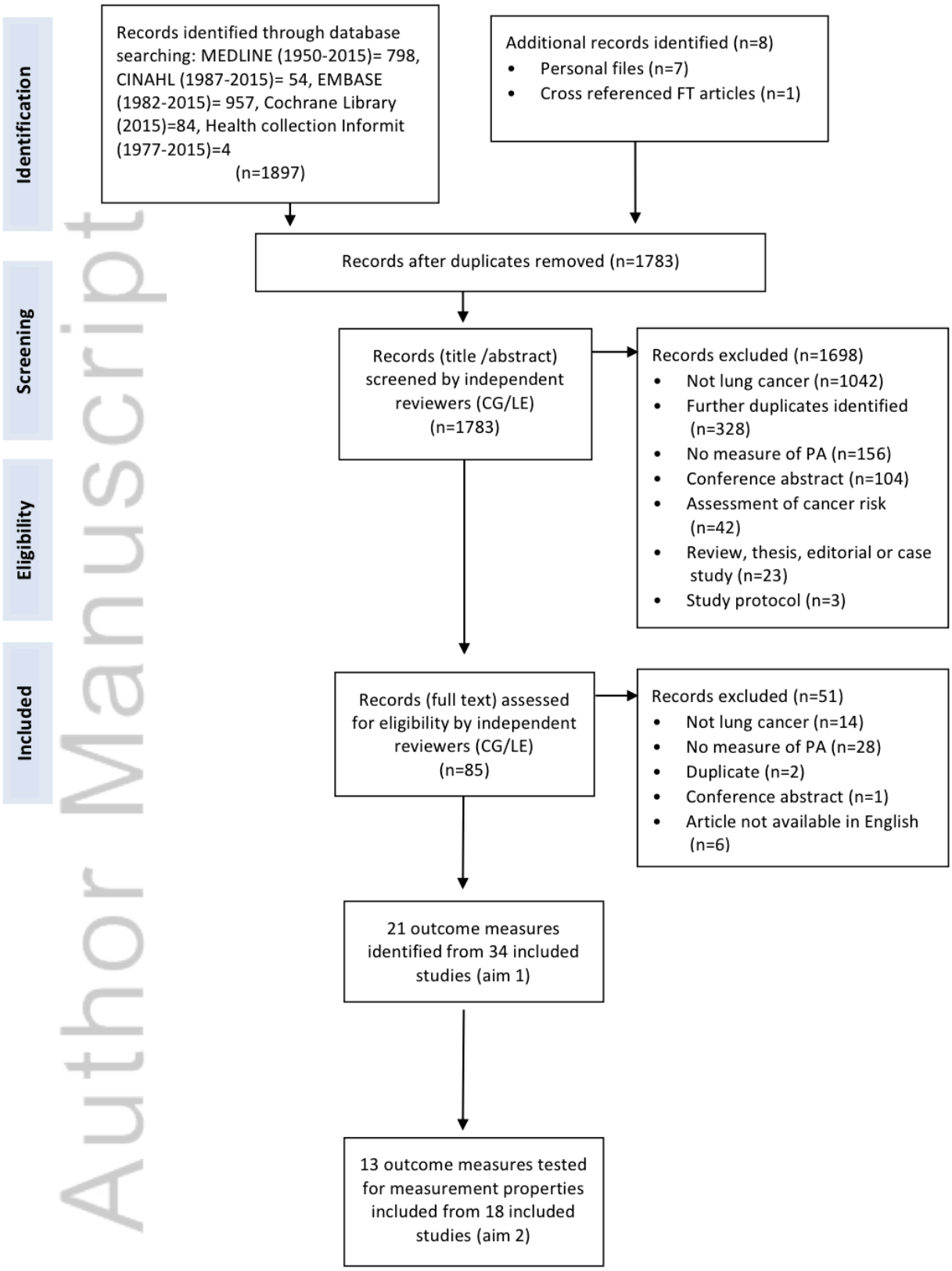
months of

treatment

Footnotes: [*]ASCM = American College of Sports Medicine; [†]Eastern Cooperative Oncology Group Performance Status; [‡]EORTC = European Organisation for the Research and Treatment of Cancer questionnaire; [§]GLTEQ = Godin Leisure Time Exercise Questionnaire; [**]LS-ES = limited stage-extensive stage; [††]MET = metabolic equivalent; [§§]MRC = Medical Research Council; [***]NSCLC = non-small cell lung cancer; [†††]PA = physical activity; [‡‡‡]PASE = Physical Activity Scale for the Elderly; [§§§]SCLC = small cell lung cancer; [****]WHO = World Health Organisation

Figure legend

Figure 1: Flow diagram of outcome measures selection process. [14]



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