Absolute and relative intensity of physical activity after lung cancer surgery

Received: 19 Nov 2025
Accepted: 25 Jan 2026

To the Editor:

Physical activity (PA) benefits functional recovery, overall health, and prognosis following treatment for nonsmall cell lung cancer (NSCLC) [1, 2]. Guidelines recommend ⩾150 min of moderate intensity PA per week, ⩾75 min of vigorous intensity PA per week, or an equivalent combination [3]. However, many patients with NSCLC remain inactive after curative-intent surgery [2, 4]. PA intensity is commonly reported using absolute accelerometer cut-off points [4], which ignore inter-individual differences in physical capacity and may therefore misclassify physiological effort. Clinically, such misclassification may affect monitoring of recovery and the tailoring of PA prescriptions. Expressing PA intensity relative to individual capacity may better reflect effort and show different associations with health outcomes [5, 6].

Therefore, we aimed to characterise daily PA after surgery for patients with resectable NSCLC using both absolute thresholds and relative thresholds anchored to an instrumented field test.

This cross-sectional analysis was embedded in the baseline assessment of an ongoing randomised controlled trial (ClinicalTrials.gov: NCT06057766) evaluating post-operative PA tele-coaching in patients with resectable NSCLC. Patients were recruited from University Hospital Ghent, Hospital ZOL Genk, General Hospital Sint-Jan Brugge-Oostende and General Hospital Delta Roeselare in Belgium between 1 and 12 months after surgical resection (stage I–IIIA), or 1–12 months after adjuvant therapy, when applicable. Adults (⩾18 years) able to provide informed consent and ambulate independently were eligible. Exclusion criteria included disease recurrence/progression, other malignancies within the past 2 years, conditions precluding participation, or insufficient Dutch language proficiency.

Participants completed: 1) two 6-min walk tests (6MWTs) (as a pragmatic proxy for physical capacity) according to European Respiratory Society/American Thoracic Society guidelines [7], while wearing a waist-mounted tri-axial Actigraph GT3X accelerometer (Ametris, Pensacola, FL, USA); and 2) continuous PA monitoring with the same device for seven consecutive days (24-h protocol). Valid continuous-monitoring data required ⩾3 days of ⩾8 $h \cdot day^{-1}$ wear time [8]. Minute-by-minute accelerometer vector magnitude units (VMU), reflecting the combined intensity of movement across three axes, were exported from both 6MWT and continuous-monitoring; analyses of continuous monitoring used data between 07:00 and 22:00 [8].

From the continuous-monitoring data, daily minutes were calculated in absolute low-intensity PA (LIPA) (100–1951 VMU) and absolute moderate-to-vigorous intensity PA (MVPA) (⩾1951 VMU) using conventional absolute thresholds [9]. The movement intensity achieved during the 6MWT (referred to in this study as "instrumented intensity") was calculated as the average VMU of the three highest minutes during the best-performing 6MWT, to reduce the start-up and end-of-test artefacts inherent to 1-min epochs. Relative MVPA was predefined as VMU ⩾50% of instrumented intensity. Time in absolute and relative MVPA were compared using a paired T-test. Agreement in MVPA minutes per day between both methods was quantified using Bland–Altman analysis (bias, 95% limits of agreement) and the intraclass correlation coefficient (ICC) (two-way, absolute-agreement, average-measures). The absolute MVPA cut-off point (1951 VMU) was expressed as a percentage of instrumented intensity. Subsequently, continuous monitoring time was summarised across relative-intensity bands expressed as % of instrumented intensity

Shareable abstract (@ERSpublications)
After NSCLC surgery, patients spend the most time at a very low relative intensity of PA. Absolute and relative measures align at group level but individual agreement is limited. Capacity-anchored metrics are needed for personalised PA assessment. https://bit.ly/4qWZnYm

Cite this article as: Arents E, Haesevoets S, Van Hulle F, *et al*. Absolute and relative intensity of physical activity after lung cancer surgery. *ERJ Open Res* 2026; 12: 01596-2025 [DOI: 10.1183/23120541.01596-2025].

(<20%, 20–30%, 30–40%, 40–50%, 50–60%, 60–70%, 70–80%, 80–90%, 90–100%, ⩾100%). Analyses were performed in R 4.3.1 (R Foundation, Vienna, Austria).

49 patients (26 males; mean age 66±10 years; 6MWT distance 83±15% pred; 5475±3427 steps·day^{-1}) were included; 18 had received (neo-)adjuvant therapy. Using absolute cut-off points, patients accumulated 231±74 min·day^{-1} of LIPA and 19±25 min·day^{-1} of MVPA. Time spent in relative MVPA was comparable (20±25 min·day^{-1}; p=0.57). At the individual level, Bland–Altman showed a small mean bias of −1.39 min·day^{-1} between absolute and relative MVPA, with wide 95% limits of agreement (–34.47 to 31.68 min·day^{-1}) (figure 1a); the ICC was 0.88 (95% CI 0.79–0.93). The absolute MVPA threshold corresponded to 60±25% of instrumented intensity (range 31–179%). Participants spent 915±155 min·day^{-1} (97% of monitored time (median 98%, interquartile rage 97–99%)) below 40% of instrumented intensity (figure 1b).

Although group-level MVPA estimates were similar across both metrics, individual-level agreement was limited, with wide limits of agreement (±33 min·day^{-1}). This discrepancy exceeds the daily MVPA target implied by current PA guidelines (∼20–25 min·day^{-1}) [3] and reflects the broad range of relative loads corresponding to a single absolute MVPA threshold. The absolute MVPA cut-off point mapped on average to 60±25% of instrumented intensity, with large inter-individual spread, underestimating effort for some and exceeding instrumented intensity in others. Consequently, absolute and relative intensity metrics are not interchangeable at the individual level. Patients spent 97% of monitored time at very low relative intensity. This finding may reflect a combination of symptom burden and cautious activity behaviour, consistent with previously reported barriers to PA in this population, such as dyspnoea, fatigue, fear of symptom exacerbation, and reduced self-efficacy [10]. Together, these barriers may contribute to persistently low activity levels and may further limit functional recovery.

These findings have important clinical implications. Where absolute PA intensity is associated with a reduced risk of mortality [11], this association may differ for people with the same absolute PA intensity but different relative intensities, which may better capture physiological effort and thus plausibly show different associations with clinical outcomes.

Our findings align with recent work by Rowlands *et al*. [12], who emphasised (based on conceptual and methodological considerations in the general population) that absolute PA thresholds may misrepresent true physiological effort, and advocated for individualised intensity assessment. Similarly, Orme *et al*. [13] demonstrated in patients with COPD that relative intensity derived from the incremental shuttle walk test (ISWT), revealed substantially different activity profiles compared to absolute cut-off points.

This study has several strengths. It provides novel insights into the PA profile of patients with NSCLC by combining standardised field testing and real-world PA assessment using validated accelerometery. This approach offers a clinically feasible method. In clinical practice, relative-intensity assessment could complement absolute thresholds to support individualised monitoring and PA intervention planning, using an instrumented 6MWT that is already routinely performed and therefore represents a low-burden extension of standard care. The multicentre design further supports external validity across care settings.

Nonetheless, some limitations should be acknowledged. First, our sample size was modest and drawn from a larger ongoing trial, limiting statistical power to explore subgroup differences by recovery phase or surgical procedure, although these factors may influence capacity and should be considered in future studies. Second, although VMU data reflect tri-axial movement, no physiological parameters such as heart rate or perceived exertion were retrieved, which may have further enhanced intensity classification. Moreover, maximal oxygen uptake from cardiopulmonary exercise testing is considered the gold standard for determining capacity, and the use of the 6MWT as a proxy may therefore be questioned. However, previous studies have shown that maximal oxygen uptake achieved during a 6MWT approximates that of a cardiopulmonary exercise test in patients with COPD [14]. In the present study, the 6MWT is used as an individualised, standardised reference to anchor movement intensity, aligning with the pragmatic goal of relative intensity classification rather than maximal performance assessment. Furthermore, Orme *et al*. [13] reported comparable results using a more maximal field test (the ISWT), also shown to correspond well with maximal oxygen uptake [14], further supporting our approach. Third, while we used 50% of instrumented intensity as a relative cut-off point, this threshold remains arbitrary and may not fully align with metabolic equivalents or ventilatory markers. Orme *et al*. [13] applied a lower relative threshold (40%), derived from the ISWT. In contrast, the 6MWT is self-paced and inherently submaximal, meaning that relative percentages of instrumented intensity cannot be directly equated across tests. The selected 50% threshold should therefore be interpreted as a pragmatic reference to illustrate capacity-anchored intensity

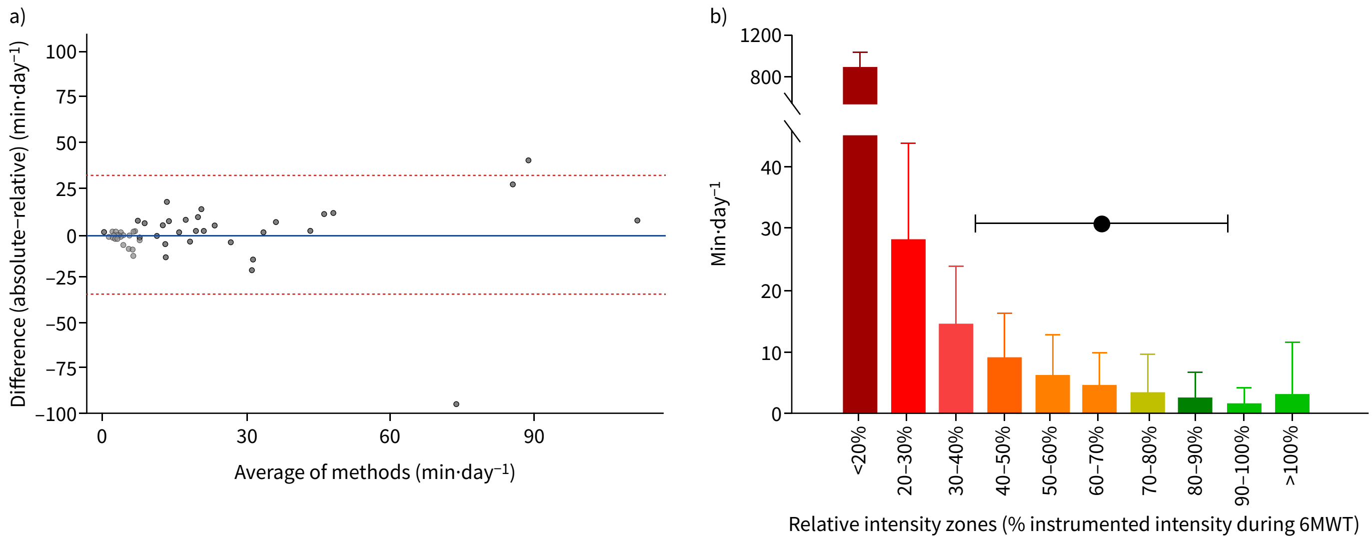

FIGURE 1 a) Bland–Altman plot of moderate-to-vigorous physical activity (MVPA) minutes per day. Each dot represents one participant. X-axis: average of methods; y-axis: absolute minus relative MVPA. The blue line shows the mean difference (−1.39 min·day^{-1}), and the red dashed lines indicate 95% limits of agreement (−34.47 to 31.68 min·day^{-1}). Positive values indicate more MVPA with the absolute method, negative with the relative method. Averages are computed across valid days (07:00–22:00). b) Distribution of relative intensity zones. The bars represent the distribution of the time (mean±SD) patients spent in different relative physical activity intensity zones. The black dot represents the percentage (mean±SD) of the cut-off point for moderate-to-vigorous intense MVPA (1951 vector magnitude units) relative to a person's instrumented intensity measured during a 6-min walk test (6MWT).

rather than as a physiological equivalent of thresholds derived from maximal tests. Future work should validate this approach against physiological markers and test associations with clinically important outcomes like fatigue, quality of life and recovery. Finally, the use of device-specific accelerometer metrics (such as VMU) may limit direct comparability across studies, underscoring the need for future work to adopt raw-acceleration-based approaches.

After NSCLC surgery, most monitored time occurs at very low relative intensity, and the absolute MVPA cut-off point corresponds to a broad range of relative loads across individuals. While group means are similar across methods, individual-level agreement is limited, arguing against interchangeable use. These findings support individualised, capacity-anchored intensity metrics for PA assessment and rehabilitation in NSCLC care.

Eva Arents[1], Sarah Haesevoets[2,3], Francesca Van Hulle[1], Maarten Criel[4,5], Dieter Stevens[6], Veerle Surmont[7], Eric Derom[8], Bihiyga Salhi[8], Lander Van Acker[9], Ingel Demedts[10], Chris Burtin[2,3,11] and Heleen Demeyer[1,11]

[1]Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium. [2]REVAL Rehabilitation Research Center, Hasselt University, Hasselt, Belgium. [3]BIOMED Biomedical Research Institute, Faculty of Rehabilitation Sciences, Hasselt University, Hasselt, Belgium. [4]Department of Respiratory Diseases, Ziekenhuis Oost-Limburg, Hasselt University, Genk, Belgium. [5]Faculty of Medicine and Life Sciences, Hasselt University, Genk, Belgium. [6]Department of Respiratory Medicine and Thoracic Oncology, Ghent University Hospital, Ghent, Belgium. [7]Department of Internal Medicine and Paediatrics, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium. [8]Department of Respiratory Medicine, Ghent University Hospital, Ghent, Belgium. [9]Department of Pulmonary Diseases, AZ Sint-Jan, Bruges, Belgium. [10]Department of Pulmonary Diseases, AZ Delta, Roeselare, Belgium. [11]These authors contributed equally.

Corresponding author: Heleen Demeyer (h.demeyer@ugent.be)

Acknowledgement: Generative artificial intelligence (ChatGPT, version 5.2; OpenAI) was used as a basic writing assistant for language editing and text reduction. The authors take full responsibility for the final manuscript.

Provenance: Submitted article, peer reviewed.

Ethics statement: Lung cancer patients were recruited for this study, which was approved by the ethics committees of University Hospital Ghent, Hospital ZOL Genk, General Hospital Sint-Jan Brugge-Oostende and General Hospital Delta Roeselare in Belgium.

Conflict of interest: All authors report no conflicts of interest.

Support statement: This study was supported by Fonds Wetenschappelijk Onderzoek grant G0A0125N and Bijzonder Onderzoeksfonds UGent grant BOF.STG.2021.0013.01 and BOF21KP15. Funding information for this article has been deposited with the Open Funder Registry.

References

1 Avancini A, Sartori G, Gkountakos A, *et al.* Physical activity and exercise in lung cancer care: will promises be fulfilled? *Oncologist* 2020; 25: e555–e69.

2 Timmerman JG, Dekker-van Weering MGH, Wouters MWJM, *et al.* Physical behavior and associations with health outcomes in operable NSCLC patients: a prospective study. *Lung Cancer* 2018; 119: 91–98.

3 Campbell KL, Winters-Stone KM, Wiskemann J, *et al.* Exercise guidelines for cancer survivors: consensus statement from international multidisciplinary roundtable. *Med Sci Sports Exerc* 2019; 51: 2375–2390.

4 Zhou W, Webster KE, Smith EL, *et al.* Physical activity in surgical lung cancer patients: a systematic review. *Support Care Cancer* 2022; 30: 6473–6482.

5 Siddique J, Aaby D, Montag SE, *et al.* Individualized relative-intensity physical activity accelerometer cut points. *Med Sci Sports Exerc* 2020; 52: 398–407.

6 Fridolfsson J, Arvidsson D, Ekblom-Bak E, *et al.* Accelerometer-measured absolute *versus* relative physical activity intensity: cross-sectional associations with cardiometabolic health in midlife. *BMC Public Health* 2023; 23: 2322.

7 Holland AE, Spruit MA, Troosters T, *et al.* An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J* 2014; 44: 1428–1446.

8 Demeyer H, Mohan D, Burtin C, *et al.* Objectively measured physical activity in patients with COPD: recommendations from an international task force on physical activity. *Chronic Obstr Pulm Dis* 2021; 8: 528–550.

9 Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc* 1998; 30: 777–781.

10 Granger CL, Connolly B, Denehy L, *et al.* Understanding factors influencing physical activity and exercise in lung cancer: a systematic review. *Support Care Cancer* 2017; 25: 983–999.

11 Wang Y, Nie J, Ferrari G, *et al.* Association of physical activity intensity with mortality: a national cohort study of 403 681 US adults. *JAMA Intern Med* 2021; 181: 203–211.

12 Rowlands AV, Orme MW, Maylor BD, *et al.* Quantifying the relative intensity of free-living physical activity: differences across age, association with mortality and clinical interpretation—an observational study. *Br J Sports Med* 2025; 59: 830–838.

13 Orme MW, Lloyd-Evans PHI, Jayamaha AR, *et al.* A case for unifying accelerometry-derived movement behaviors and tests of exercise capacity for the assessment of relative physical activity intensity. *J Phys Act Health* 2023; 20: 303–310.

14 Chae G, Ko EJ, Lee SW, *et al.* Stronger correlation of peak oxygen uptake with distance of incremental shuttle walk test than 6-min walk test in patients with COPD: a systematic review and meta-analysis. *BMC Pulm Med* 2022; 22: 102.