



Physical inactivity in chronic airways disease: an important candidate in the treatable traits paradigm

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Physical inactivity is highly prevalent across chronic airways diseases and demonstrates the key features of a clinically relevant treatable trait. <https://bit.ly/3MyZOZB>

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Abstract

Background Physical inactivity is a common and potentially modifiable trait in individuals with chronic airways disease, yet disease-specific physical activity profiles and clinical determinants remain poorly defined.

Methods We conducted a systematic review and meta-analysis in accordance with PRISMA guidelines to characterise physical activity profiles across the spectrum of chronic airways disease. Studies reporting objectively measured physical activity in adults with COPD, asthma, noncystic fibrosis bronchiectasis, cystic fibrosis or primary ciliary dyskinesia were included. Primary outcomes were daily step count and time spent in moderate-to-vigorous physical activity (MVPA). Univariate and multivariate regression analysis was used to explore disease-specific determinants and associations with established clinical outcome measures.

Results 236 studies (353 cohorts, n=25 278 with chronic airways disease) met the eligibility criteria. The mean daily step count was 5494 (95% CI 5152–5636) and MVPA was 48.2 min·day⁻¹ (95% CI 33.8–62.6), with the lowest levels observed in COPD. Physical activity levels were consistently lower than matched healthy controls. Disease-specific determinants of physical activity remained elusive; body mass index and percent predicted forced expiratory volume in 1 s (FEV₁) were significant in COPD and asthma. Step count associated positively with FEV₁ % pred and 6-min walk distance, and negatively with modified Medical Research Council scores.

Conclusion Physical inactivity is highly prevalent across chronic airways diseases and is consistently associated with established clinical outcome measures. These findings highlight the clinical relevance of objective physical activity assessment and support its consideration within the treatable traits framework as part of routine disease evaluation and management.

Introduction

Physical activity is defined as any bodily movement produced by skeletal muscle that requires energy expenditure [1]. It is a complex and multidimensional behaviour influenced by social, behavioural, environmental and physiological factors [2]. The World Health Organization (WHO) currently recommend that adults should undertake at least 150 min of moderate or 75 min of vigorous-intensity physical activity per week (alongside muscle-strengthening activities on two or more days) to enhance health and well-being, optimise physiological function and prevent the development and progression of disease across the lifespan [3, 4]. The benefits of leading an active lifestyle extend across all age groups and include maintaining and promoting cardiovascular health, musculoskeletal integrity, metabolic homeostasis and neurocognitive function [5–7].



In older adults, regular physical activity preserves functional independence, reduces the risk of falls and enhances health-related quality of life [8, 9], whereas in the context of disease, physical inactivity (assessed *via* daily steps) is considered a significant risk factor associated with increased morbidity and mortality [10, 11]. This is particularly apparent in individuals with chronic airways disease; whereby heightened perception of breathlessness and increased work of breathing often leads to activity avoidance in an effort to prevent the onset of symptoms [12]. This self-perpetuating cycle of inactivity, paralleled by chronic disease progression, is referred to as the “vicious cycle of physical inactivity” [13, 14]. It can cause a progressive decline in physical function, which increases the risk of early mortality and hospitalisation in people with COPD [15] and is associated with worse lung function and disease control in people with asthma [16–18].

The impact and clinical relevance of physical inactivity in other forms of chronic airways disease such as cystic fibrosis (CF), noncystic fibrosis bronchiectasis (NCFB) and primary ciliary dyskinesia (PCD) remain less well defined, although there is growing literature on the benefits of active living as an adjunct to routine therapy [19]. In the current era of precision medicine, there is an increased focus on identifying “treatable traits” in people with chronic airways disease to individualise management and personalise treatment programmes [20]. The treatable traits framework is categorised into three domains, namely pulmonary, extrapulmonary and behavioural/lifestyle factors, which permits a tailored, multidimensional approach to disease management through the identification of clinically relevant modifiable characteristics that can be targeted with specific therapeutic interventions to improve outcomes. For a trait to be included within this framework, it should fulfil three core criteria, it must be clinically relevant, measurable and treatable, ensuring that it can be reliably identified and modified to influence patient outcomes [21].

In recent years, a number of novel and potentially important treatable traits have been proposed for the management of chronic airways disease, with physical inactivity emerging as a key potential target [20]. We have previously demonstrated, *via* a meta-analysis of interventional trials, that programmes designed to promote physical activity, particularly those utilising wearable activity monitors, produce significant and clinically meaningful increases in activity levels in people with chronic airways disease [22]. Building on these findings, the present meta-analysis sought to 1) systematically characterise physical activity profiles across the spectrum of chronic airways disease, including comparison of COPD with rarer non-COPD conditions, and 2) examine disease-specific determinants of physical activity and their associations with established clinical outcome measures. Together, these objectives were intended to evaluate whether physical activity satisfies the core criteria of a treatable trait.

Methods

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23]. The review was prospectively registered with PROSPERO (registration number: CRD42024505997).

Study selection and eligibility criteria

Electronic databases (PubMed, PubMed Central, CINAHL and EBSCO) were used to search for published articles between January 2014 and September 2024. The search strategy comprised broad terms including: “chronic obstructive pulmonary disease” OR “COPD” OR “cystic fibrosis” OR “bronchiectasis” OR “asthma” OR “primary ciliary dyskinesia” AND “physical activity” OR “activity” OR “step count” OR “steps” AND “accelerometer” OR “pedometer”. The results were combined and duplicate articles were removed. Any additional relevant articles identified by the authors or sourced from the reference list of identified studies were also included.

Inclusion and exclusion criteria

Studies were required to meet the following PECOS criteria: (P) population: adults (≥ 18 years) with chronic airways disease; (E) exposure: chronic airways disease (COPD, asthma, CF, NCFB and PCD); (C) comparison: healthy controls free from chronic disease; (O) outcomes: daily step count or time spent ($\text{min}\cdot\text{day}^{-1}$) in moderate-to-vigorous physical activity (MVPA) objectively assessed *via* accelerometry or pedometry; (S) study: peer-reviewed full-text articles including cross-sectional, cohort, interventional or randomised control trials. Baseline (pre-intervention) physical activity data was extracted and reported. Studies including individuals post solid organ transplant or those having undergone either surgical or endoscopic lung volume reduction interventions, mixed adult and paediatric population, secondary analysis, or any other confounding factors that may impact physical activity status (*e.g.* comorbid musculoskeletal disease), or data that were only presented graphically were excluded.

Data extraction

Two reviewers (B. Griffiths and R. Alajmi) independently screened titles and abstracts, followed by full-text review. Any disparity was resolved by mutual agreement or following consultation with a third reviewer (O.J. Price). Data from accepted articles were extracted using a standardised data extraction template developed specifically for this review. Information concerning title, author(s), year of publication, study design, population, sample size, participant characteristics (*i.e.* sex, age, body mass index (BMI)), objectively measured physical activity (*i.e.* daily step count and MVPA) and available clinical and patient-reported outcome measures (*i.e.* lung function, functional capacity, symptom scores) were extracted by B. Griffiths. Means and standard deviation for each variable were recorded and if values were reported as median (interquartile range or range), or mean (confidence intervals) an estimated conversion tool was employed [24, 25].

Quality assessment

B. Griffiths and R. Alajmi evaluated eligible studies independently using the Joanna Briggs Institute (JBI) Critical Appraisal Tool (eight-item) which was specifically designed to evaluate bias in cross-sectional studies [26]. Any disparity between the two reviewers was resolved by mutual agreement or following consultation with a third reviewer (O.J. Price).

Data synthesis and analysis

Physical activity data (daily step count and MVPA) are presented in forest plots according to disease sub-type and, where available, compared with matched healthy controls. Study heterogeneity was assessed using χ^2 test of Cochran's Q statistic. I^2 values $>75\%$ were considered to be heterogeneous [27]. Univariate and multivariate regression analysis were performed to explore potential sources of heterogeneity using the following variables: age, percentage male, BMI, risk of bias, sample size and percent predicted FEV₁ (FEV₁ % pred). These variables reflect commonly reported and clinically relevant outcome measures in chronic airways disease. All significant results in univariate models were used for multivariate analysis. The relationship between step-based physical activity and clinical outcome measures was assessed *via* univariate modelling. Data analysis was conducted using Stata v.18 (Stata LLC, Texas, USA). $p < 0.05$ was considered statistically significant.

Results

Study characteristics and quality assessment

In total, $k=6681$ studies were identified (6037 after duplicates removed). Of these, 236 studies included an objective measure of physical activity and were eligible for inclusion in the systematic review and meta-analysis (figure 1). The study design breakdown included: 164 observational studies (69.5%), 53 randomised controlled trials (22.5%) and 19 nonrandomised controlled trials (8%). In total, 353 unique cohorts were extracted from eligible studies. The combined study population included 26 832 participants (chronic airways disease: 25 278 and healthy controls 1554). The cohort breakdown of studies and participant numbers, according to diagnostic categories, included $n=253$ COPD ($n=21\ 370$, 85%), $n=34$ asthma ($n=2393$, 9%), $n=19$ NCFB ($n=1066$, 4%), $n=13$ CF ($n=449$ (2%) and $n=0$ PCD respectively. Overall, 34 studies (14.4%) included a matched healthy control group. Study characteristics and JBI assessment checklist scores are summarised for reference in tables S1–4. Quality and risk of bias scores ranged from one to eight, with over half (55.5%) considered good quality (score ≥ 7). The remaining studies were considered poor quality (score range 1–6).

Step count and time spent in MVPA

Step-based physical activity was reported in 290 cohorts (91%) ($n=23\ 316$) with an average step count of 5494 (95% CI 5152–5636) across all forms of chronic airways disease. Step count was lower in people with COPD (4594, 95% CI 4377–4812) when compared to asthma (7201, 95% CI 6546–7856), NCFB (6836, 95% CI 6127–7546) and CF (8688, 95% CI 8192–9183) (figures 2–5). High heterogeneity was observed for daily step count between studies for COPD ($I^2=98.8\%$), asthma ($I^2=97.4\%$) and NCFB ($I^2=88.4\%$), whereas between-study variation for CF was more consistent ($I^2=31.5\%$). In studies with matched healthy controls ($n=28$), average step count was consistently lower in disease categories *versus* controls: COPD ($n=17$) (4474, 95% CI 3881–5078 *versus* 6969, 95% CI 6245–7694), asthma ($n=8$) (7184, 95% CI 6033–8335 *versus* 8677, 95% CI 7560–794), NCFB ($n=4$) (8288, 95% CI 7108–9469 *versus* 10 534, 95% CI 9050–12 019). Only one study reported comparative step count for individuals with CF and matched healthy controls, therefore comparisons were not conducted due to insufficient statistical power.

Time ($\text{min}\cdot\text{day}^{-1}$) spent in MVPA was reported in 115 cohorts (33%) ($n=9115$) with a combined total of 48.2 min (95% CI 33.8–62.6) across all forms of chronic airways disease. Time spent in the MVPA domain was lower in COPD (39.9, 95% CI 32.9–46.9) compared to asthma (61.6, 95% CI 41.2–82.0),

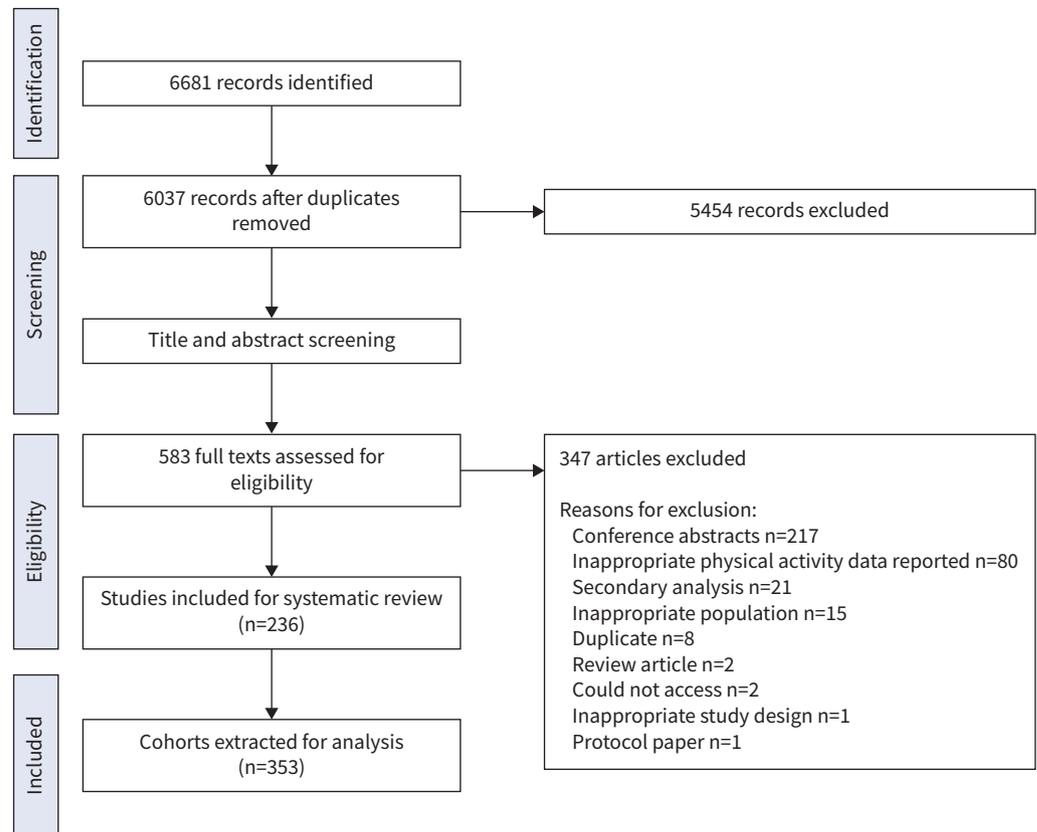


FIGURE 1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart representing search results.

NCFB (63.9, 95% CI 22.9–104.9) and CF (46.1, 95% CI 18.4–73.8) (figures S1–S4). High heterogeneity was observed for MVPA between studies for COPD ($I^2=99.9\%$), asthma ($I^2=99.6\%$), NCFB ($I^2=99.4\%$) and CF ($I^2=98.3\%$). In cohorts with comparative data, time spent in MVPA was lower for disease categories *versus* healthy controls: COPD ($n=11$) (35.6, 95% CI 8.4–68.8 *versus* 62.0, 95% CI 24.7–99.3) and asthma ($n=8$) (74.1, 95% CI 42.8–105.5 *versus* 94.4, 95% CI 57.7–131.0). Time spent in MVPA with matched healthy control groups were limited to two studies in both NCFB and CF, therefore no comparisons were conducted due to insufficient statistical power.

Disease-specific determinants of step-based physical activity

In COPD, step count was positively associated with BMI (coefficient 128.9, 95% CI 53.0–204.8, $p<0.01$), FEV₁ % pred (coefficient 39.1, 95% CI 18.6–59.7, $p<0.01$) and sample size (coefficient 3.7, 95% CI 1.8–5.7, $p<0.01$). All variables remained significant in multivariate models (adjustment reduced heterogeneity from I^2 98.8% to 96.9%). In asthma, step count was negatively associated with age (coefficient –80.7, 95% CI –153.8–7.5, $p=0.03$) and BMI (coefficient –236.0, 95% CI –411.1–60.9, $p=0.01$). No other factors were associated with step count. In the multivariate regression model, both factors remained significant (adjustment reduced heterogeneity from I^2 97.5% to 92.8%).

In NCFB, step count correlated with age (coefficient –88.3, 95% CI –164.0–12.6, $p=0.03$) and BMI (coefficient –499.6, 95% CI –957.5–41.7, $p=0.04$), FEV₁ % pred (coefficient –74.4, 95% CI –142.2–6.5, $p=0.03$) and sample size (coefficient 26.5, 95% CI 14.5–38.5, $p<0.01$). In the multivariate regression, only sample size remained significant ($p=0.03$) (adjustment reduced heterogeneity from I^2 86.2% to 71.2%). In CF, no factors correlated with step-based physical activity.

Disease-specific determinants of MVPA

In asthma, time spent in MVPA was associated with BMI (coefficient –6.9, 95% CI –12.6––1.1, $p=0.02$) and FEV₁ % pred (coefficient 2.7, 95% CI 0.5–4.9, $p=0.02$) (*i.e.* individuals with higher BMI and lower

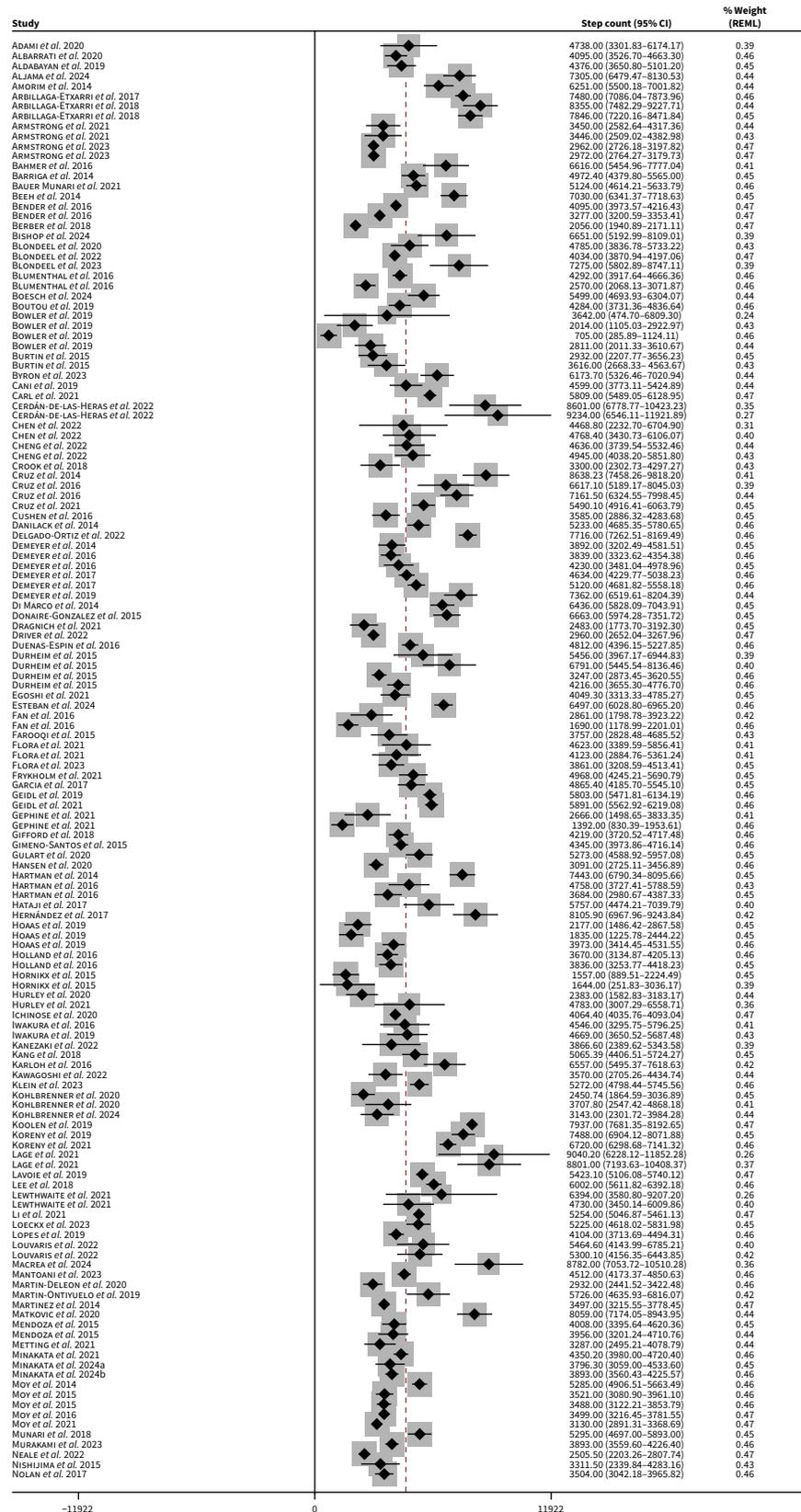


FIGURE 2 Daily step-based physical activity in COPD. Dashed vertical line denotes overall pooled estimate: 4594, 95% CI 4378–4810. For details regarding the studies, see the supplemental material. REML: restricted maximum likelihood.

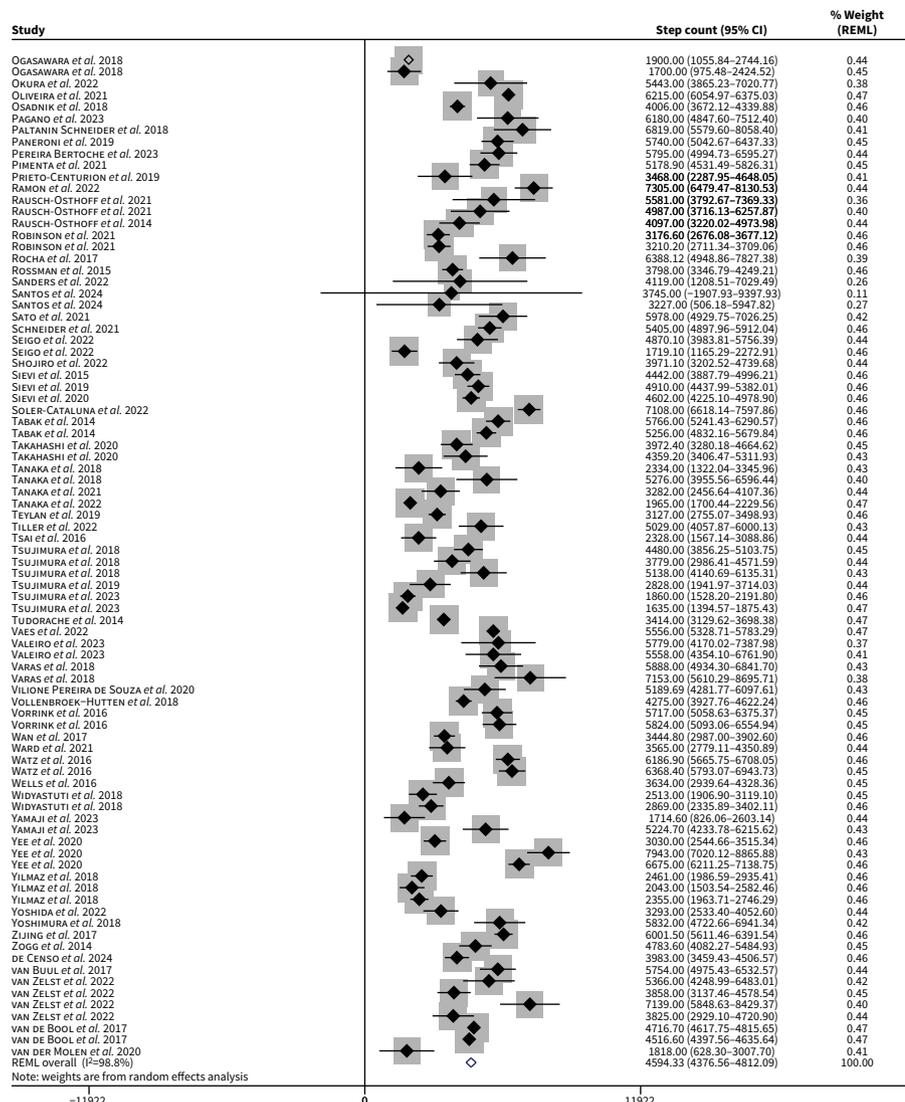


FIGURE 2 Continued.

FEV₁ % pred spend less time in moderate-to-vigorous intensity domains); however, neither factor remained significant in the multivariate models (p>0.05). In NCFB, FEV₁ % pred was the only variable negatively associated with time spent in MVPA (coefficient =-13.9, 95% CI -26.0--1.8, p=0.04). None of the variables were significantly associated with time spent in MVPA for COPD and CF (p>0.05).

Physical activity and key clinical associations

The most commonly reported clinical outcome measures were lung function (FEV₁ % pred) (n=207, 88%), 6-min walking distance (6MWD) (n=120, 51%) and perceived disability associated with breathlessness assessed via modified Medical Research Council (mMRC) score (n=85, 36%). The association between physical activity (daily steps and time spent in MVPA) and clinical outcomes stratified according to disease could not be calculated due to insufficient statistical power. Step-based physical activity was therefore combined for all forms of chronic airways disease. Lung function (FEV₁ % pred) and functional capacity (6MWD) had strong positive associations with increased daily step count (coefficient 56.8, 95% CI 45.4-68.2, p<0.001, and coefficient 15.2, 95% CI 12.6-17.8, p<0.001, respectively). Patient-reported breathlessness, reflected by higher mMRC scores (n=85), was also strongly associated with a reduction in daily steps (coefficient -1229.3, 95% CI -1702.9--755.7, p<0.001). High heterogeneity was observed across studies for all variables (I²>96%).

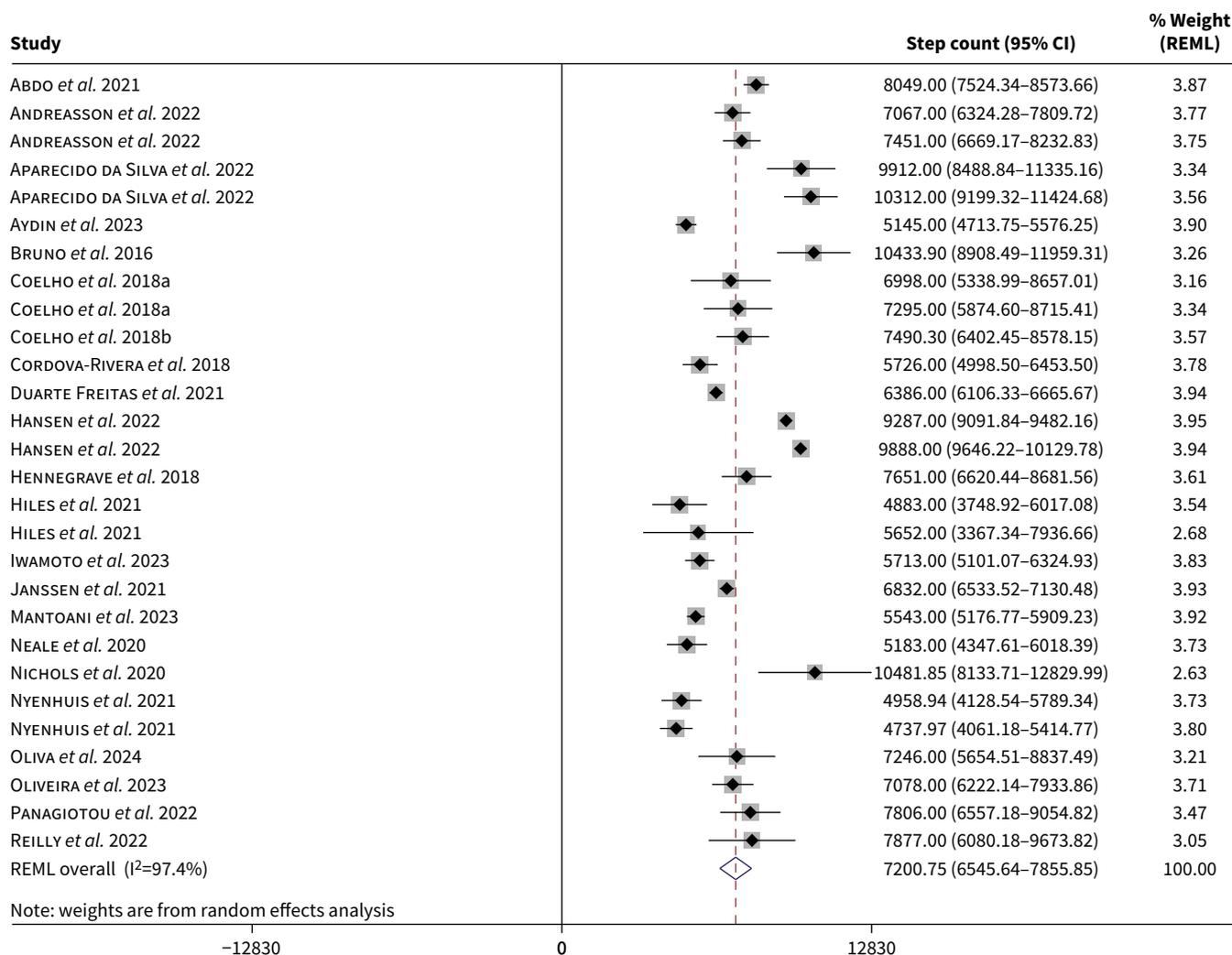


FIGURE 3 Daily step-based physical activity in asthma. Dashed vertical line denotes overall pooled estimate: 7201, 95% CI 6546–7856. For details regarding the studies, see the supplemental material. REML: restricted maximum likelihood.

Discussion

Physical activity is a fundamental component of daily living that significantly influences overall quality of life in both health and disease [28, 29]. For that reason, disease-related impact on an individual’s ability to engage in physical activity is a key domain captured by many of the most widely employed quality of life assessment tools in respiratory medicine [30–32]. In this comprehensive systematic review and meta-analysis, the largest to date incorporating objective physical activity data from more than 25 000 individuals with chronic airways disease, we confirm that physical inactivity is highly prevalent and closely associated with established clinical outcome measures, including FEV₁ % pred, 6MWD and perceived breathlessness. Whilst disease-specific determinants of physical activity status remain elusive, these associations emphasise the clinical relevance of physical activity as an important modifiable behaviour, supporting its routine consideration as a target within management and rehabilitation pathways. Although not the focus of the current analysis, we have previously shown that physical activity is responsive to intervention, with targeted programmes producing significant improvements in daily step count [22]. When considered alongside this interventional evidence, the present findings support the classification of physical inactivity as a clinically relevant treatable trait.

The main aim of this systematic review and meta-analysis was to characterise physical activity profiles across the spectrum of chronic airways disease. To achieve this objective, we identified recent studies that utilised accelerometers or pedometers, with daily step count and time spent in MVPA extracted and pooled

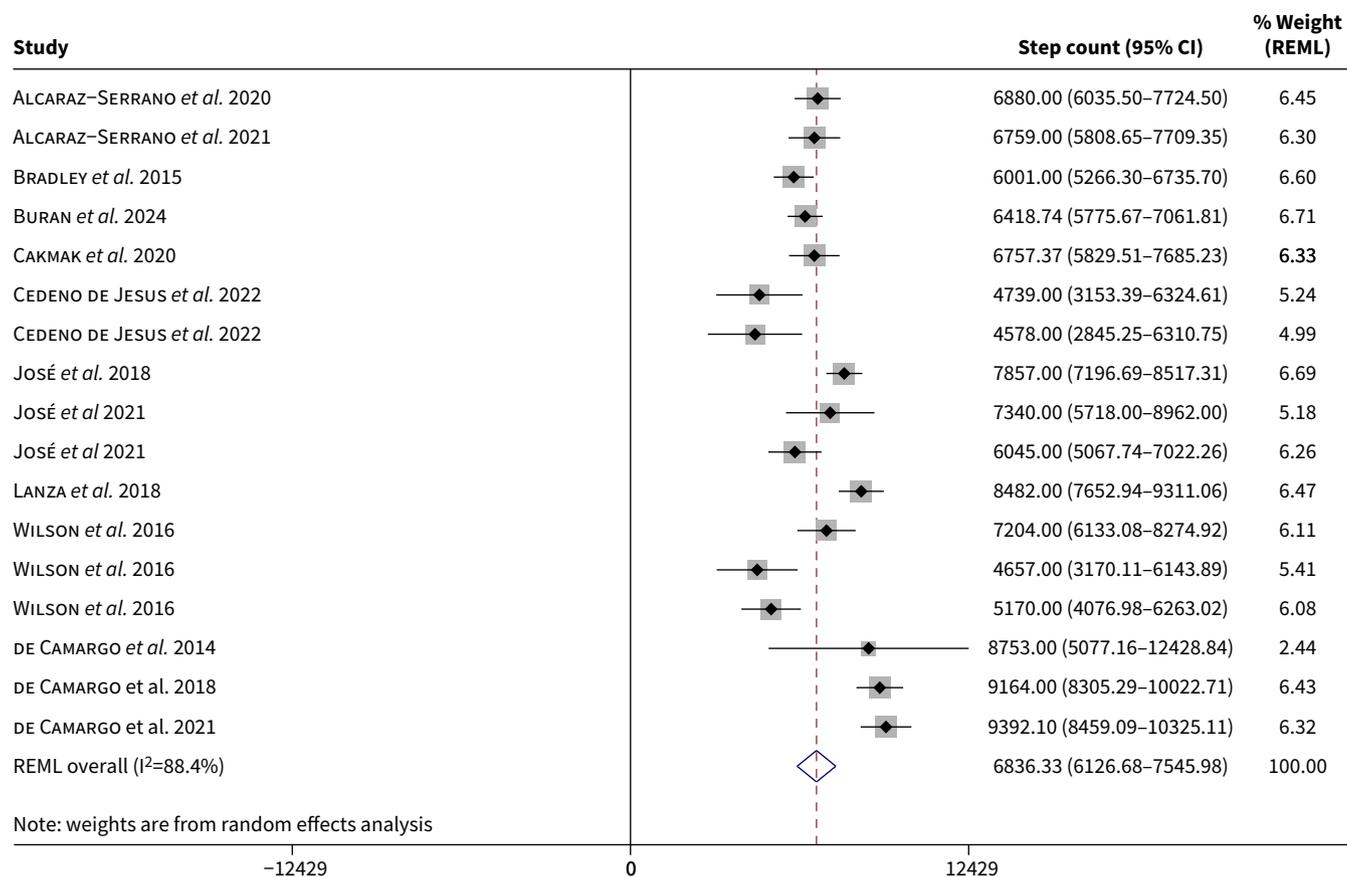


FIGURE 4 Daily step-based physical activity in noncystic fibrosis bronchiectasis (NCFB). Dashed vertical line denotes overall pooled estimate: 6836, 95% CI 6127–7546. For details regarding the studies, see the supplemental material. REML: restricted maximum likelihood.

to establish disease-specific reference values and permit between-group comparisons. The first notable finding was that the vast majority of studies meeting the inclusion criteria focused on COPD (85%) followed by asthma (9%). There was limited evidence for people with rarer conditions such as NCFB (4%), CF (2%) and PCD (0%). The preponderance of COPD is likely to reflect the high disease burden and earlier adoption of formal pulmonary rehabilitation as an integral intervention to reducing symptoms and improving exercise tolerance in this population.

The meta-analysis revealed that the average daily step count across all forms of chronic airways disease was 5494 steps·day⁻¹ (95% CI 5152–5636), which is markedly below the widely promoted public health target of 10 000 steps·day⁻¹ [33]. Whilst daily step count is a common and widely accepted metric to quantify physical activity, universally accepted recommendations for step-based physical activity have yet to be established. An alternative approach is to utilise a graduated step index, which is an intuitive and widely adopted approach to classifying physical activity status using the following framework: “basal activity” (<2500 steps·day⁻¹); “limited activity” (2500–4999 steps·day⁻¹); “low active” (5000–7499 steps·day⁻¹); “somewhat active” (7500–9000 steps·day⁻¹); “active” (10 000–12 499 steps·day⁻¹); and “highly active” (≥12 500 steps·day⁻¹) [34–36]. For healthy adults, accumulating 7000–11 000 daily steps typically meets recommended levels of MVPA, whereas fewer than 5000 steps·day⁻¹ indicates a sedentary lifestyle [35]. For older adults and those with chronic conditions, 7000–8000 steps·day⁻¹ is considered a more realistic target, reflecting habitual activity plus 30-min of MVPA [37]. When applying this criterion to the findings of our meta-analysis, individuals with COPD exhibit the lowest step-based physical activity (4594 steps·day⁻¹, 95% CI 4378–4810) and are therefore classified within the “limited activity” domain. In contrast, people with asthma (7201 steps·day⁻¹, 95% CI 6546–7856) and those with NCFB (6836 steps·day⁻¹, 95% CI 6127–7546) achieved step counts consistent with the “low active” category. Importantly, individuals with CF recorded the highest daily step count (8688 steps·day⁻¹, 95% CI 8192–9183), aligning with the “somewhat active” classification.

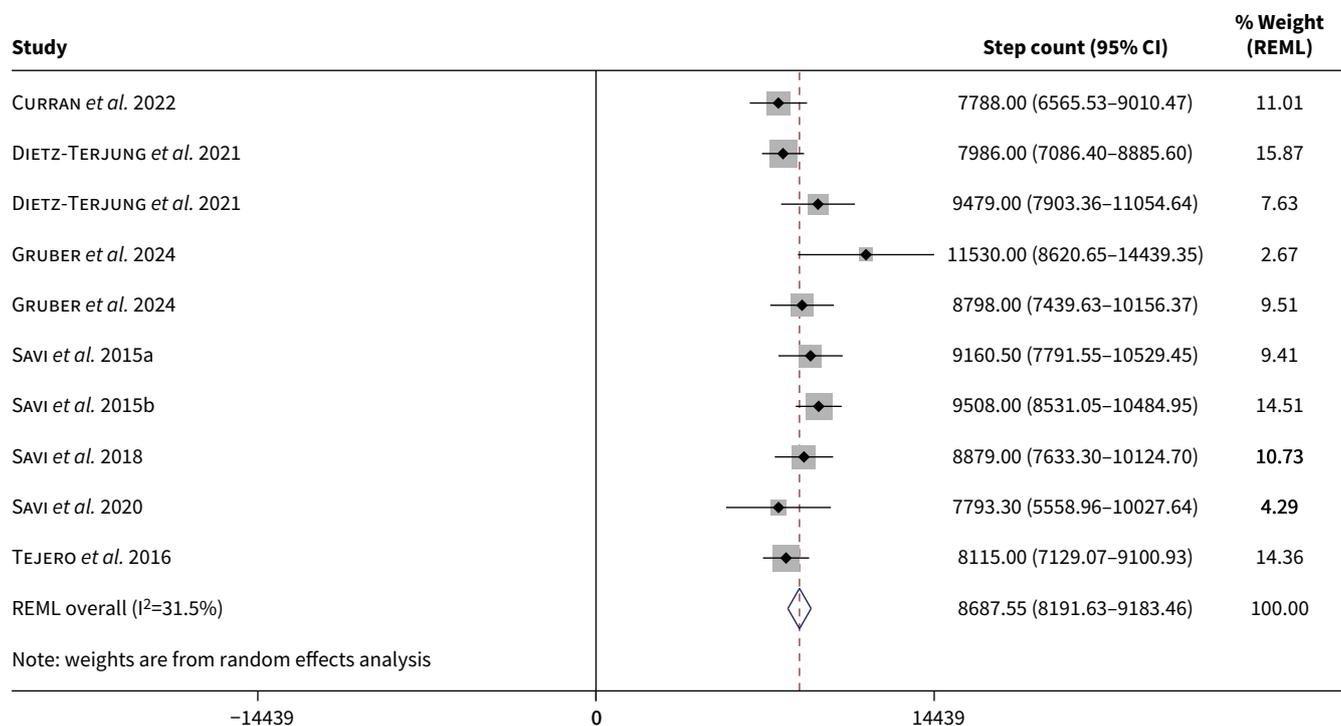


FIGURE 5 Daily step-based physical activity in cystic fibrosis (CF). Dashed vertical line denotes overall pooled estimate: 8688, 95% CI 8192–9183. For details regarding the studies, see the supplemental material. REML: restricted maximum likelihood.

Despite daily steps providing an intuitive and accessible measure of physical activity, the WHO currently recommend the use of MVPA as the primary metric to quantify physical activity as it captures both the volume and intensity of activity required to elicit physiological adaptation and confer clinically meaningful health benefits [38]. In the current meta-analysis, the average MVPA across all forms of chronic airways disease was $48.2 \text{ min}\cdot\text{day}^{-1}$ (95% CI 33.8–62.6). When benchmarked against WHO recommendations (*i.e.* 150 min of moderate or 75 min of vigorous-intensity physical activity per week) [4], individuals with COPD demonstrated the lowest MVPA levels ($39.9 \text{ min}\cdot\text{day}^{-1}$, 95% CI 32.9–46.9). In contrast, participants with asthma ($61.6 \text{ min}\cdot\text{day}^{-1}$, 95% CI 41.2–82.0) and NCFB ($63.9 \text{ min}\cdot\text{day}^{-1}$, 95% CI 22.9–104.9) exceeded the recommended target, albeit with considerable between-study variability. Despite recording the highest daily step counts, individuals with CF accumulated only slightly more MVPA ($46.1 \text{ min}\cdot\text{day}^{-1}$, 95% CI 18.4–73.8) than COPD, which may, in part, explain the lower functional exercise capacity that is commonly observed in this population [39, 40].

A secondary aim of our meta-analysis was to explore disease-specific determinants of physical activity. Despite exploring a broad range of potential influencing factors, the variance in physical activity was only partly explained by BMI and FEV₁ % pred, supporting the concept that physical activity is a complex behaviour influenced by physiological, psychological, social and environmental determinants [2]. Treatment side-effects can also influence physical activity, particularly in relation to the use of oral corticosteroids, which are associated with weight gain and myopathy [41–43]. Although BMI is routinely used as a standard measurement of health, it does not accurately quantify body composition and muscle mass. This may partially explain why BMI positively associates with step count in people with COPD and negatively associates with step count in asthma and NCFB. BMI also negatively associates with MVPA in people with asthma.

Pulmonary cachexia in COPD is relatively common and is associated with increased mortality [44] and deterioration of both peripheral and respiratory muscle function [45–47]. The positive association between BMI and step count in COPD may therefore reflect the preservation of skeletal muscle mass. This is supported by studies demonstrating a positive correlation between BMI, fat-free mass index [48–50] and reduced activity status in those with evidence of sarcopenia [51]. Conversely, BMI was negatively associated with physical activity in asthma and NCFB. In asthma, this may relate to the recognised T-helper 2 (Th2)-low asthma phenotype, which is associated with obesity and high symptom burden [52, 53].

Obesity has also been recognised as a barrier to remission for people with Th2-high asthma receiving anti-interleukin-5 biological therapy [54]. In NCFB, BMI is typically reduced in comparison to healthy controls as a consequence of reduced muscle mass and disproportionately increased fat mass [55, 56]. Decreased peripheral muscle strength is also related to reduced physical activity and functional capacity in this disease cohort [57].

As might be expected, higher lung function in people with COPD was independently associated with greater daily step count. This is likely to reflect the link between disease severity and exercise tolerance as well as the concept of the self-perpetuating cycle of physical inactivity and progressive clinical deterioration [13, 58]. In people with asthma, FEV₁ % pred was positively associated with MVPA in univariate analysis, suggesting that the degree of airflow limitation may influence participation in more vigorous-intensity domains due to fear of provoking worsening symptoms or an exacerbation [59–61]; however, this association did not remain after adjustment, indicating other potential confounding factors. In NCFB, an inverse association was observed between FEV₁ % pred and MVPA; however, this was not maintained in multivariate models. No significant associations were identified in CF.

Methodological considerations and future research

Several methodological limitations should be acknowledged. Due to the imbalance in the number of studies focusing on COPD, the pooled physical activity estimates (daily steps and MVPA) in the current analysis are likely to be disproportionately influenced by COPD as well as potential comorbidities such as cardiovascular disease. The findings from this analysis should therefore be interpreted at a population level as stratification according to disease severity (*e.g.* Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage in COPD or Global Initiative for Asthma (GINA) classification in asthma), sub-type or sex was not possible due to substantial between-study heterogeneity, primarily arising from nonstandardised reporting and inconsistent definitions. It is also important to note that reduced exercise capacity is commonly observed in people with chronic airways diseases, which will inevitably influence the MVPA values reported. Indeed, accelerometer intensity thresholds are based on absolute cut-points, meaning that a given ambulatory speed or movement pattern represents a higher relative intensity in individuals with lower physical fitness. Consequently, activities that would be classified as low intensity in healthy adults may be registered as MVPA in these populations, potentially inflating MVPA estimates across disease groups.

Our pooled physical activity estimates also includes early stage and mild disease, where physical activity levels are typically within the normal range [39, 62, 63]. It is therefore likely that daily steps and time spent in MVPA is substantially lower in sub-groups with more established or severe disease. This concept is supported by studies which demonstrate a significant reduction in physical activity levels in people with COPD with advanced disease (*i.e.* progressing from stage III and IV GOLD classification) [58, 63, 64]. Similarly, data from over 200 unique cohorts in the current analysis indicate a significant positive relationship between FEV₁ % pred and step-based physical activity, with matched healthy controls consistently leading more active lifestyles. In the general population and in COPD, females tend to undertake less physical activity than males [65–67], thus underscoring the requirement to explore whether similar sex-based disparities exist among individuals with other forms of chronic airways disease.

It is important to acknowledge that significant variation in the range of wearable activity monitors employed across the included studies was observed, many of which incorporated device-specific algorithms and data filtering processes, potentially introducing inter-device variability [68]. Future research should therefore prioritise standardisation of device selection, data-processing algorithms and reporting procedures to improve comparability across studies. In terms of quality assessment, only half of the included studies were rated as “good quality” based on the JBI score; therefore, a significant proportion did not meet all quality criteria. The directionality of associations should therefore be interpreted with a degree of caution; for example, it remains unclear whether greater physical activity leads to preserved lung function, or whether higher FEV₁ % pred facilitates greater activity. Finally, whilst our analysis indicates that BMI is a key determinant of physical activity in people with chronic airways disease, further studies are needed to clarify the association between body composition and physical activity status using gold-standard techniques such as dual-energy X-ray absorptiometry.

Clinical implications and practical application

The clinical implications and practical application of our findings can be considered two-fold. First, we provide contemporary population-level reference values that characterise typical physical activity profiles across the spectrum of chronic airways disease. These normative values offer a useful benchmark to help identify individuals who may benefit most from referral pulmonary rehabilitation and/or physical activity promotion interventions, as previous studies have shown that those who are the least active derive the

greatest benefit from targeted intervention [69, 70]. Second, physical activity is a well-established marker of physical frailty [71], loss of independent living [72] and all-cause mortality [3]. In the general population, a modest increase of 1000 steps·day⁻¹ has been associated with a 12% reduction in mortality risk [73]. In the context of chronic airways disease, increased physical activity is associated with improved clinical outcomes [74], reduced symptom burden [75] and a lower risk of exacerbation [12]. Step count represents a simple, valid and cost-effective method of objectively assessing and promoting physical activity [76, 77], particularly given the widespread use of smartphones and wearable devices [78]. Potentially, there are opportunities to support people with increasing physical activity by jointly reviewing step count where available and using this to guide interventions. Our findings confirm that physical activity, assessed *via* daily steps, is strongly associated with validated outcome measures including FEV₁ % pred, 6MWD and perceived breathlessness (mMRC). This supports the concept that objective measurement of physical activity (particularly *via* step count) could be integrated into routine clinical monitoring and may offer enhanced insights to either acute or chronic changes in health status over time.

Conclusion

In summary, physical inactivity is highly prevalent across chronic airways diseases and is consistently associated with established clinical outcome measures, including lung function, exercise capacity and symptom burden. These findings highlight the clinical relevance of objective physical activity assessment and support its consideration within the treatable traits framework as part of routine disease evaluation and management. In line with the treatable traits paradigm, which emphasises a shift from disease-based classifications toward precision medicine approaches centred on modifiable behaviours, our results reinforce the importance of routinely identifying and targeting physical inactivity in clinical practice. Targeting this trait may offer a pathway to improved long-term outcomes across the spectrum of chronic airways disease.

Points for clinical practice

- Routine assessment of physical activity is warranted: daily step count and MVPA are consistently lower in individuals with chronic airways disease compared to healthy controls. Objective measurement (*e.g. via* pedometers or accelerometers) can help identify inactivity and support clinical decision-making.
- Physical inactivity demonstrates key features of a treatable trait: inactivity is prevalent, objectively measurable, and associated with impaired lung function, reduced exercise capacity, and greater symptom burden. Evidence from interventional studies indicates that physical activity can be improved through rehabilitation and behaviour-change strategies.
- Step count is a practical clinical tool: step count correlates strongly with FEV₁ % pred, 6MWD and breathlessness (mMRC), and represents a feasible metric for monitoring functional status and evaluating response to intervention in routine care.

Provenance: Submitted article, peer reviewed.

The systematic review protocol was registered with PROSPERO (<https://www.crd.york.ac.uk/prospero/>) with identifier: CRD42024505997.

Author contributions: B. Griffiths: conception and design of the study, data acquisition: preparing and validation of search strategy, searching bibliographic databases, title and abstract screening, full-text screening, drafting the manuscript. R. Alajmi: data acquisition: preparing and validation of search strategy, searching bibliographic databases, title and abstract screening, full-text screening, data analysis, drafting the manuscript. R.J. Birch: data analysis, drafting the manuscript and critical revision. I.J. Clifton: conception and design of the study, data acquisition: preparing and validation of search strategy, drafting the manuscript, critical revision and project supervision. D. Peckham: conception and design of the study, data acquisition: preparing and validation of search strategy, drafting the manuscript, critical revision and project supervision. O.J. Price: conception and design of the study, data acquisition: preparing and validation of search strategy, drafting the manuscript, critical revision and project supervision. All authors provided approval of the final version of this manuscript to be published.

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