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Title page

Review Article

The Montafon proposal: New insights and emerging concepts in pulmonary rehabilitation

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Short Title: New insights in pulmonary rehabilitation

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Keywords: pulmonary rehabilitation, outcome measure, PROMs, CROMs, performance score, critical success criteria

Abstract

Background

Pulmonary rehabilitation (PR) is beneficial, yet outcome assessment remains inconsistent. A multidisciplinary D-A-CH working group reviewed evidence, introduced new measures, and explored emerging PR concepts.

Summary

The meeting emphasized patient-reported (PROMs) and clinician-reported (CROMs) outcome measures. A key focus was the minimal clinically important difference (MCID), a widely used metric which is applied inconsistently and is highly dependent on the baseline value. The 'performance score' (T2D = T2 + (T2 – T1)) takes baseline status (T1) into account by combining the discharge value (T2) with the improvement (T2 – T1) before and after treatment, based on the distribution. This simple descriptive approach results in a baseline-adjusted MCID estimator, with a planned multicenter study to validate its use in COPD rehabilitation. Further discussions addressed epistemic trust, crucial for patient adherence and interdisciplinary collaboration, with a study planned to assess its impact. Dysfunctional breathing (DB), often overlooked in PR, was highlighted, emphasizing the need for standardized diagnostic tools. The role of artificial intelligence (AI) in PR, including large language models, was explored, with surveys planned to evaluate patient and provider perceptions.

Key Messages

The T2D performance score offers a dynamic approach to assessing PR progress, addressing MCID limitations. Standardized methods for epistemic trust and DB diagnosis are essential for better recognition and management. AI integration in PR presents opportunities for personalized rehabilitation but requires further evaluation. The D-A-CH working group remains committed to advancing PR through evidence-based strategies and international collaboration.

Introduction

Pulmonary rehabilitation including patient-tailored therapeutic interventions based on specific assessments is pivotal to the management of chronic respiratory disease. This medical field is characterized by its dynamism and the promotion of patient adherence to healthy behaviors. Its long-term efficacy in reducing dyspnea, increasing exercise capacity, and improving quality of life (QoL) has been demonstrated in patients with chronic obstructive pulmonary disease (COPD) 1].

It is crucial to promote the exchange of knowledge, facts and methods on a European level and to ensure the implementation of new therapies in pulmonary rehabilitation. In pursuit of this objective, a group of 16 German-speaking pulmonary rehabilitation experts from Germany, Austria and Switzerland ("D-A-CH" working group) convened for a scientific retreat mid-January 2025 in a place called "Montafon" in western Austria. This group met in person and virtually for two days, to participate in a comprehensive review of the current clinical evidence and new concepts in the field. The multidisciplinary team of pulmonary rehabilitation experts included twelve physicians, two physiotherapists, one exercise scientist and one psychologist from three European countries. The primary objective of the meeting was to discuss relevant scientific issues in pulmonary rehabilitation within a multinational D-A-CH framework. The meeting features presentations by experts, which highlighted current evidence and novel clinical concepts in the field (full-text research papers, meta-analyses and [systematic] reviews; papers written in English or German and published in the last five years).

Although there are discrepancies among structural organizations and social insurance requirements across countries, this D-A-CH working group has sustained a collaborative relationship for a long-standing period, characterized by the organization of joint seminars, training courses, D-A-CH congresses and joint publications. For instance, several members of this D-A-CH working group were involved in developing the S1-guideline post-COVID/long-COVID in 2021 [2] and the S2k-guideline on COVID-19 and (early) rehabilitation published in 2023 [3], as well as joint practical recommendations on the prescription and adjustment of exercise training in chronic respiratory diseases [4], and patients with long-COVID [5].

During several joint physical and online meetings throughout 2024, the primary focus of the D-A-CH science retreat was established as the investigation of outcomes (patient-reported outcome measures [PROMs] and

clinician-reported outcome measures [CROMs]) in pulmonary rehabilitation for a better assessment of rehabilitation improvements. The minimal clinically important difference (MCID) is defined as the smallest change in a measurement result that patients consider significant and that requires an adjustment in treatment, as long as no disturbing side effects or excessive costs occur [6]. The determination of the MCID has been proven to be a crucial parameter in defining the clinical relevance of the improvements in individual parameters observed in clinical studies [7]. Historically, rehabilitation progresses have been routinely determined using either statistical relevance (p-value<0.05) or the MCID [7-11]. It is well known that evaluating therapeutic success based on change values (differences) or a uniform minimal clinically important difference (MCID) for all patients presents a methodological challenge: regression towards the mean or dependence on the baseline value. Patients with better baseline values tend to show less improvement during rehabilitation than those with poorer baseline values, even if both groups benefit equally from the intervention. This phenomenon makes interpreting change scores much more difficult, as the same absolute changes must be evaluated differently depending on the individual's status at the start of treatment (T1). Commonly, MCIDs are being treated as fixed, “one-size-fits-all” thresholds for each outcome measure, but recent evidence suggests that MCIDs are context-dependent and strongly influenced by baseline status [12] which has the strongest moderating effect on outcome [13,14]. For example, in the 6-minute walk test (6MWT) for patients with COPD, a global MCID of about 26 m has been proposed [9]. A patient with mild disease improving from 550 m to 600 m (+50 m; ≈9% relative change; T2D = 650m) and a patient with severe disease improving from 250 m to 300 m (+50 m; 20% relative change; T2D =350m) would both exceed this threshold, and the percentage change would suggest a larger response in the more impaired patient. However, the first patient reaches a substantially higher functional level at discharge. This illustrates that “one-size-fits-all” MCIDs and percentage change scores can be misleading when baseline status varies widely, and that clinically meaningful change must be interpreted in relation to the individual's baseline value at admission. Therefore, baseline-dependent or “dynamic” MCIDs that adapt to the individual baseline value have been proposed [12]. The T2D 'performance score', defined as an additive combination of the discharge value (T2) and the absolute change (D = T2 - T1), may provide a simple estimator in a single numerical value (e.g., for T2D = 500m in the 6MWT for COPD patients) for such dynamic MCIDs, as it jointly accounts for baseline status and discharge performance in the original units of the outcome [13, 14]. The T2D performance score or a baseline-dependent MCID offers the novel opportunity to re-evaluate the impact of rehabilitation and may prove to be a valid criterion for evaluating critical success factors. Furthermore, the absence of predicted target values and MCIDs in clinical practice was discussed, as well as the potential of dysfunctional breathing and epistemic trust to improve clinical outcomes in pulmonary rehabilitation. Additionally, we are also presenting an upcoming project dealing with artificial intelligence (AI) including the use of large language models in pulmonary rehabilitation. Finally, we reflected on the future of the D-A-CH collaboration.

Main Text

Pulmonary rehabilitation outcome measures – the T2D performance score

In a multidisciplinary rehabilitation team**,** diverse healthcare professionals collaborate to provide comprehensive care tailored to individual patient needs. Although outcome management has been a central component so far, it is not routinely used in the field as the process is rarely standardized and digitalized – i.e. database-compatible. In addition to the standardized recording of relevant demographic and disease characteristics, as well as behavioural, environmental and therapy information for classifying factors that influence treatment success, patient-reported outcome measures (PROMs) and clinician-reported outcome measures (CROMs) are examples of outcome measures.

The quality of medical outcomes is defined as ‘…measurable changes in professionally assessed health status…’ and ‘…the quality of outcomes is the difference between the initial state and the final state…’ [12]. However, reference values for outcome measurements in pulmonary rehabilitation vary. The MCID is a widely used valuable measure for some, but not all outcomes, as it is intended for group analysis and does not adequately account for individual performance. The validity of change scores in pre-post designs is fraught with methodological problems (e.g. regression to the mean and mathematical coupling, dependence on baseline values or patient cohort). Furthermore, MCIDs are not yet available for all outcome measures and different diseases, or there are different approaches to their determination.

However, references values used for critical assessments performed in pulmonary rehabilitation are not homogenous among different centers and are more general in the D-A-CH setting (Tab. 1). In the DACH region, there are differences in terms of inpatient and outpatient rehabilitation programs. In germany, all (but 1 in Leverkusen) rehab centers are inpatient clinics performing rehabilitation 3-4 weeks whereas in Austria and Switzerland, there is the possibility for outpatient pulmonary rehabilitation up to 6 months in rural areas, which may influence outcomes and MCID`s. We might be able to find different MCID`s for different settings.

Similarly, the interpretation of MCID results in a clinical context can vary depending on the reference values used, the clinical cohort, and the rehabilitation setting. Some MCID commonly used are not relevant in the context of pulmonary rehabilitation. This raises several questions: The necessity of customized MCIDs depending on severity, age, inpatient or outpatient status; Are we using the most appropriate MCID for individual patients? Are the observed changes both perceptible and clinically meaningful to the patient? Recent work suggests that MCIDs are not fixed properties of an outcome measure, but depend on baseline status and other contextual factors. This implies that a “one-size-fits-all” MCID may be inadequate, especially in heterogeneous populations such as patients with COPD.

In order to more accurately reflect individual outcomes in quantifying patients' performance and their response to rehabilitation, a novel method of summarizing outcomes by relating changes to baseline values – the T2D performance score – has been developed [13, 14]. The T2D Score is a descriptive metric that integrates baseline status and improvement in a single value and can be used to classify patients into performance strata (e.g. good, moderate, or poor performers; T2D-tertiles) while implicitly accounting for baseline differences. It incorporates final status at discharge (T2) and absolute improvement (delta = T2 – T1). This is where the abbreviation T2D comes from (T2 = post-measurement and D = delta). The T2D Score allows for fairer comparisons despite baseline differences and minimizes regression-to-the-mean bias, eliminating the need for complex statistical modelling. Thus, the T2D Score provides a more valid comparison across heterogeneous patient populations. It takes the mathematical dependence of difference values (T2 - T1) into account to estimate treatment success between two timepoints in clinical practice. Furthermore, integrating a dynamic MCID with the T2D score (e.g. based on the median T2D value) can help to identify floor and ceiling effects [13]. This new integrated performance measure has been first established and validated in an Austrian retrospective monocentric analysis of the assessment of six-minute walking tests (6MWT) in 575 patients with COPD undergoing outpatient pulmonary rehabilitation, thereby accounting for the patient's current status, and for changes over time [13]. The T2D has also been shown to be a valuable tool in the clinical setting for assessing rehabilitation outcomes in patients with low back pain based on different PROM and CROM scores [14] or to identify critical success factors in Psychosomatic Rehabilitation [15]. At present, however, no MCID threshold has been formally established for the T2D score applied to the 6MWD in COPD; deriving such baseline-dependent T2D cut-offs is one of the aims of the planned prospective multicentric study described below.

Through our D-A-CH network, we plan to conduct a joint prospective multicentric study, whose objective will be to evaluate the T2D performance score on different PROMs and CROMs in patients with COPD in pulmonary rehabilitation settings. It is anticipated that the results of the study will benefit from a larger European sample. We intend to evaluate prospectively the validity of the results of the 2022 retrospective multicentric study. A key objective of this study is to ascertain whether the MCID should be defined uniformly across all COPD classes and stages or if it should be adapted to reflect them better. (See the current work of Jenkins et al., 2024 [12]: “Findings suggest that baseline presentation should be considered for people with COPD when assessing the efficacy of pulmonary rehabilitation. However, clinical significance of the variation underpinning MIDs is yet to be determined.”). Thus, the first step is to empirically examine in our cohort whether MCIDs are indeed baseline-dependent and to derive dynamic, baseline-stratified MCIDs using anchor-based methods. In practice, however, such dynamic MCIDs would either require individual calculation using formulas or consulting look-up tables for subgroups defined by baseline levels, which may be cumbersome and difficult to implement in routine clinical care. Therefore, we also aim to explore whether a single T2D threshold – as a performance score already adjusted for baseline status – could serve as a pragmatic estimator of these dynamic MCIDs. In such a framework, one global T2D cut-off could potentially capture different individual MCID requirements at different baseline levels, while remaining easy to calculate mentally in clinical practice. At present, this concept is hypothetical and will need to be empirically tested in the planned study. The ability to set different thresholds for different

baseline values is what makes an MCID “dynamic”; our approach will evaluate whether a T2D-based threshold can approximate such dynamic behaviour in a simple and clinically applicable way, in order to characterize which COPD patients respond to rehabilitation therapy and which do not.
To assess the clinical relevance of potential critical success factors in our study (e.g. gender, age, disease burden, epistemic confidence, ...), the MCID of PROMs and CROMs will be determined - for example, the 6-minute walk test or the BODE index as CROM and the EQ-5D-5L or the COPD Assessment Test (CAT) as PROM. As the MCID can vary widely depending on the assessment method used [16], we intend to rather use the global rating of change scale (GRS) scale, which is particularly suitable for capturing the perception of change from the individual patient's perspective [17, 18]. To include both the patient and clinician perspectives in the MCID assessment, the GRS is completed independently by both patients and clinicians of each other at the end of rehabilitation [19].
The health status at the start of the study plays a pivotal role in defining clinically relevant changes [20-22]. This raises the question of whether patients with more severe impairments require a greater change for it to be considered clinically important. In a study with patients suffering from back pain, Stratford et al. showed that patients with more severe initial pain required a greater change in the outcome measures to be considered clinically important compared to patients with less severe complaints [23]. Therefore, we intend to use the T2D performance score applied to the 6MWT (CROM and COPD Assessment Test (CAT, PROM) to evaluate the influence of baseline impairment on the MCID and determine cut-off points using both distribution-based and anchor-based methods to create a baseline-dependent MCID. In a subsequent step, we will examine whether a single T2D threshold can serve as a pragmatic estimator of these dynamic MCIDs in clinical practice. In doing so, we will address three key questions: (i) whether MCIDs in our COPD cohort are baseline-dependent; (ii) which dynamic, baseline-stratified MCID values can be derived for different levels of baseline impairment; and (iii) whether a T2D-based threshold can be used as an estimator of these dynamic MCIDs in clinical practice.

Epistemic trust

Epistemic trust is essential for learning in social relationships and for evaluating the credibility of information in a safe environment [24-27]. In medicine, it influences patient adherence, interdisciplinary collaboration, and health outcomes. Epistemic trust is defined as the openness to social learning and the ability to evaluate whether information from other individuals or sources is considered trustworthy, relevant to oneself and applicable to other situations [15]. Conversely, epistemic mistrust has been associated with resistance to perceived influence in the patient healthcare pathway, leading to skepticism toward health professionals, treatment discontinuation, and non-compliance, whereas epistemic gullibility – defined as a lack of vigilance and discernment – leads to susceptibility to misinformation and a risk of exploitation [28]. For patients, these disruptions complicate diagnosis and therapy acceptance, increase patient anxiety, and create challenges in healthcare pathways, leading to therapy discontinuation and non-compliance [29, 30]. For healthcare professionals (HCPs), it may lead to difficulties due to mistrust in standards and processes, to more conflicts and complaints or to difficulties in relation to prevention.
Epistemic trust has been identified as a critical success factor in several domains [31-33], including the acceptance of diagnoses and preventive measures, therapy adherence, the facilitation of interdisciplinary communication and collaboration between different medical specialties, and the enhancement of early detection, reduction of long-term complications, stress and anxiety [34, 35]. Building epistemic trust in HCPs can be facilitated through active listening, clear communication, and cultural sensitivity. Institutions can promote this trust by ensuring transparent decision-making and relying on credible information sources. Patients can be supported in this development through health literacy promotion and reliable information access.
In clinical research, the epistemic trust, mistrust, and credulity questionnaire (ETMCQ) has been developed and validated, also in German language [36]. This instrument is a self-report tool designed to assess an individual's capacity for epistemic trust [37]. The questionnaire consists of 17 items that are scored on a seven-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’. The ETMCQ allows for the calculation of three subscales: ‘epistemic trust’, ‘distrust’ and ‘gullibility’.
In psychiatric rehabilitation, the efficacy of epistemic trust in enhancing long-term therapy outcomes has been already well-documented [38]. Epistemic trust has been empirically validated as a tool within the field of psychiatric rehabilitation. A new study aims to analyze the impact of epistemic trust in pulmonary

rehabilitation through a prospective multicenter D-A-CH study, to potentially identify its influence on responders/non-responders. We hypothesize that patients with higher epistemic trust will achieve better rehabilitation outcomes, while simultaneously demonstrating an increase in epistemic trust and a decrease in epistemic mistrust. Conversely, patients with lower epistemic trust are more likely to be categorized as non-responders and exhibit significantly higher levels of epistemic mistrust or epistemic credulity at the conclusion of the rehabilitation process [15].

Dysfunctional Breathing

Dysfunctional breathing (DB) is defined as breathing disorders characterized by chronic changes in breathing patterns, resulting in shortness of breath and other symptoms, either in the absence of or secondary to respiratory or heart diseases [39]. DB can manifest with different respiratory patterns, such as the hyperventilation syndrome (often used as a synonym for dysfunctional breathing), periodic deep sigh, thoracic-dominant breathing, forced abdominal exhalation or thoracoabdominal asynchrony [42]. However, there is a lack of consensus regarding the definition of DB and its subtypes [43]. Widely accepted clinical diagnostic criteria include the Nijmengen Score and expert physiotherapy-based assessments. The etiological dimensions of DB are biochemical, biomechanical and psychophysiological [45].

The prevalence of DB is estimated at approximately 10% in the general population, with higher incidence observed in women compared to men [40]. Post-COVID syndrome appears to be associated with an increased prevalence of DB and has brought this breathing pattern disorder into focus [41], but altered breathing patterns are also common in obstructive respiratory diseases [46]. COPD in particular, which is a leading respiratory disease in rehabilitation, appears to be associated with DB in up to 50% of cases. Small study sizes and limited objective criteria highlight the importance of further research and standardization of examination criteria.

Regarding post-COVID a study of 51 patients living in the United Kingdom (UK) revealed that 30% of participants had symptoms consistent with DB [47]. This finding suggests that DB may be a contributing factor to the post-COVID condition [48]. Patients diagnosed with both post-COVID and postural orthostatic tachycardia syndrome (POTS) who also have DB have shown a significant increase in shortness of breath and a reduced QoL, particularly with regards to physical functioning, vitality, social functioning and emotional role [39, 47, 49, 50]. The symptoms associated with DB can be substantial and include shortness of breath, particularly during exertion, and a sensation of “air hunger”. Additional symptoms may include chest tightness, dizziness, palpitations and tingling, especially in the feet, hands or around the mouth, significant discomfort, anxiety and breathing irregularities [40].

We assumed that DB is likely not sufficiently addressed in clinical practice of doctors and physiotherapists, necessitating an interprofessional consensus on the sensitivity and specificity of diagnostic tools such as the Nijmegen Score > 23 or expert physiotherapy-based assessments [51, 49]. Under visual inspection, most subjects with DB present with larger sequential changes in ventilation ($\dot{V}E$) and breathing pattern (tidal volume and breathing frequency) at rest and/or on exertion. Currently, however, there are no objective criteria to indicate increased ventilatory variability in these subjects. The use of cardiopulmonary exercise testing (CPET) has provided first mathematically approaches to describe altered ventilatory response patterns to physical activity in dyspnoeic subjects. The „chaotic“ variance of tidal volume versus breathing frequency (periodic deep sighing) is an important and recordable finding, apart from hyperventilation [53]. Thus, we suggest further validation of CPET for DB compared to controls. In addition, for therapeutic purposes, the value of heart rate variability (HRV) as a progression parameter and as biofeedback modality for patient self-training purposes, as well as diaphragm function and respiratory muscle strength and respiratory muscle training in DB-suspected or diagnosed patients must be evaluated.

Thus, an increasing awareness for DB in the medical and therapeutic fields (interprofessional) is needed. Therefore, the objective of an upcoming D-A-CH consensus is to propose a standardized core set of assessments, with the aim of promoting the broader use of diagnostic tool for DB for physicians and physiotherapists, as well as pediatricians and psychosomatics. Additionally, a proof-of-concept study is planned to assess DB in the context of pulmonary rehabilitation. The creation of video content in collaboration with a respiratory physiotherapy team is also underway, with the objective of sharing it with relevant medical departments through our D-A-CH working group. This strategy has been shown to be beneficial for patients with asthma who have participated in a physiotherapy breathing retaining program [54].

Artificial intelligence (AI) in pulmonary rehabilitation

As AI has become an integral component of clinical practice, there is a growing interest in understanding patient and HCP perceptions of AI in the field of non-pharmaceutical therapies and rehabilitation. This initiative aims to assess the impact of AI on pulmonary rehabilitation. To this end, two distinct anonymous online dedicated questionnaires have been developed. The patient survey will be populated through patient support groups and during rehabilitation programs, while the second intended for HCPs will be disseminated via national respiratory societies within our D-A-CH working group. The primary objective is to reach a diverse sample of the population. The thematic content of the patient survey was designed to address a comprehensive array of patient-related issues. These included demographic characteristics, awareness of artificial intelligence (AI), use of AI-based wearable technology, extent of knowledge and its applications, the online platforms employed for information retrieval, acceptance of AI-assisted therapeutic interventions, specialized knowledge regarding AI-based instruments - particularly among elderly populations -, therapy requirements, and confidence – better trust? in AI. Additionally, the survey addressed issues of data security. The HCP survey will concentrate on their role, current AI implementation, and expertise in the field of rehabilitation. Digitalization and AI may offer opportunities to support specific components of pulmonary rehabilitation programs. For example, AI-based tools could enhance patient education through individualized, interactive modules, guide relaxation and breathing exercises via apps, and provide virtual assistance or chatbots that deliver information about physiotherapy, exercise prescriptions, and self-management strategies. Such tools may complement the therapist–patient interaction, particularly in the context of non-pharmacological interventions. To better understand the current use and needs for digital and AI-based options in the field of rehabilitation interventions, we are planning a survey among healthcare professionals and patients with chronic respiratory diseases. Additionally, the survey will address awareness, expectations, acceptance, concerns, and benefits. Through the analysis of the survey's outcomes, the objective is to obtain an overview of the thematic elements of AI within PR and maybe implement broader future possibilities of AI such as predicting the response to PR. Consequently, the analysis will provide insights on the optimization of pulmonary rehabilitation using AI-based technology

Conclusion

Several factors have been identified to influence the course of convalescence during pulmonary rehabilitation. Outcome measures and endpoints have been found to be systematically associated with influences other than treatment. This has resulted in a significant amount of variability, thereby distorting the observed results. Therefore, it is imperative to identify critical success (or influence) factors at the onset of rehabilitation to accurately describe the medical quality of the results in the context of pulmonary rehabilitation. Therefore, patient characteristics, preferably summarized in clusters, may be stratified and identified as more or less likely to benefit from rehabilitation, as well as those for which a more personalized approach is indicated. Furthermore, more specific reference values must be used for the homogeneous assessment and comparison of pulmonary rehabilitation outcomes across different centers and countries. The T2D performance score offers a promising alternative approach to the MCID, the metric typically used for measuring changes in rehabilitation. This score considers two factors: the current health status and the initial status, as well as the course of the rehabilitation process. We believe that the T2D concept enables better clinical differentiation and can serve as a selection and validation criterion for new treatment options and applications.

Interventions options encompass an educational component, such as understanding of respiratory physiotherapy and development of treatment strategies, as well as breathing exercises for breathing control. We also believe that epistemic trust is crucial in the rehabilitation for patient engagement, treatment success, and enhanced adherence. Further research is warranted to develop targeted interventions. In addition, an interprofessional standardization of the diagnostic and therapeutic approach to dysfunctional breathing is planned in a position paper, as is the validation of the periodic deep sighing subtype using CPET. In our daily life, we are confronted with new technological developments, such as AI. Assessing the awareness and acceptance of patients and HCPs in the pulmonary rehabilitation may facilitate the optimization of routinely delivered healthcare for these patients.

The strength of this interprofessional network was the extensive cumulative expertise of the medical team from three European countries, with great visibility. A potential weakness of this working group could involve distinct medical structures across three German-speaking countries, including different routine clinical practice or social insurance requirements.
In recent years, the importance and effectiveness of pulmonary rehabilitation for patients with chronic lung diseases has been increasingly demonstrated. The complexity of the various measures requires a broad range of expertise to guarantee a more holistic and personalized patient care at the highest level. Currently, this can only be implemented in multi- and interdisciplinary network initiatives promoting international exchange from a wide range of professional groups.

Statements

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

PA was involved in methodology and writing (review and editing).
SB was involved in methodology and writing (review and editing).
MJF was involved in methodology and writing (review and editing).
RG was involved in methodology and writing (review and editing).
VG was involved in conceptualization, methodology, writing (review and editing).
RK was was involved in methodology and writing (review and editing).
AL was involved in methodology and writing (review and editing).
JLR was involved in methodology and writing (review and editing).
AM was involved in methodology and writing (review and editing).
SS was involved in methodology and writing (review and editing).
Te. S was involved in methodology and writing (review and editing).
Th. S was involved in methodology and writing (review and editing).
MS was involved in methodology and writing (review and editing).
CV was involved in methodology and writing (review and editing).
FB was involved in writing (first draft, as well as review and editing).
KV was involved in conceptualization, methodology, writing (review and editing).
RZ was involved in conceptualization, supervision, project administration, funding acquisition methodology, writing (review and editing).
All authors have reviewed the final version of the manuscript and agree to its publication.

References

1. Rochester CL, Alison JA, Carlin B, Jenkins AR, Cox NS, Bauldoff G, et al. Pulmonary Rehabilitation for Adults with Chronic Respiratory Disease: An Official American Thoracic Society Clinical Practice Guideline. Am J Respir Crit Care Med. 2023 Aug 15;208(4):e7-e26.
2. Koczulla AR, Ankermann T, Behrends U, Berlit P, Böing S, Brinkmann F, et al. [S1 Guideline Post-COVID/Long-COVID]. Pneumologie. 2021;75(11):869-900.
3. Platz T, Berlit P, Dohle C, Fickenscher H, Guha M, Köllner V, et al. S2k-Guideline SARS-CoV-2, COVID-19 and (early) rehabilitation - a consensus-based guideline for Germany. GMS Hyg Infect Control. 2023;18:Doc12.
4. Gloeckl R, Zwick RH, Fürlinger U, Jarosch I, Schneeberger T, Leitl D, et al. Prescribing and adjusting exercise training in chronic respiratory diseases - Expert-based practical recommendations. Pulmonology. 2023;29(4):306-14.
5. Gloeckl R, Zwick RH, Fürlinger U, Schneeberger T, Leitl D, Jarosch I, et al. Practical Recommendations for Exercise Training in Patients with Long COVID with or without Post-exertional Malaise: A Best Practice Proposal. Sports Med Open. 2024;10(1):47.
6. Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Ascertaining the minimal clinically important difference. Control Clin Trials. 1989;10(4):407-15.
7. Smid DE, Franssen FM, Houben-Wilke S, Vanfleteren LE, Janssen DJ, Wouters EF, et al. Responsiveness and MCID Estimates for CAT, CCQ, and HADS in Patients With COPD Undergoing Pulmonary Rehabilitation: A Prospective Analysis. J Am Med Dir Assoc. 2017;18(1):53-58.
8. Kiley JP, Sri Ram J, Croxton TL, Weinmann GG. Challenges associated with estimating minimal clinically important differences in COPD-the NHLBI perspective. Copd. 2005;2(1):43-6.
9. Puhan MA, Chandra D, Mosenifar Z, Ries A, Make B, Hansel NN, et al. The minimal important difference of exercise tests in severe COPD. Eur Respir J. 2011;37(4):784-90.
10. Alma H, de Jong C, Tsiligianni I, Sanderman R, Kocks J, van der Molen T. Clinically relevant differences in COPD health status: systematic review and triangulation. Eur Respir J. 2018;52(3):1800412.
11. Bondarenko J, Dal Corso S, Dillon MP, Singh S, Miller BR, Kein C, et al. Clinically important changes and adverse events with centre-based or home-based pulmonary rehabilitation in chronic respiratory disease: A systematic review and meta-analysis. Chron Respir Dis. 2024;21:14799731241277808.
12. Jenkins AR, Groenen MTJ, Vaes AW, Janssen DJA, Wouters EFM, Franssen FME, et al. Baseline dependent minimally important differences for clinical outcomes of pulmonary rehabilitation in people with COPD. Pulmonology. 2024 Jan-Feb;30(1):24-33.
13. Wagner B, Zdravkovic A, Pirchl M, Puhan MA, Zwick RH, Grote V, et al. Performance Score (T2D)-A New Perspective in the Assessment of Six-Minute Walking Tests in Pulmonary Rehabilitation. Diagnostics (Basel). 2022;12(10):2402.
14. Zdravkovic A, Grote V, Pirchl M, Stockinger M, Crevenna R, Fischer MJ. Comparison of patient- and clinician-reported outcome measures in lower back rehabilitation: introducing a new integrated performance measure (t2D). Qual Life Res. 2022;31(1):303-15.
15. Riedl, D., Kampling, H., Kruse, J., Nolte, T., Labek, K., Kirchhoff, C., et al. (2024) Epistemic Trust Is a Critical Success Factor in Psychosomatic Rehabilitation-Results from a Naturalistic Multi-Center Observational Study, *Journal of Clinical Medicine*, 13(1), Article 177.
16. Kosinski M, Zhao SZ, Dedhiya S, Osterhaus JT, Ware JE, Jr. Determining minimally important changes in generic and disease-specific health-related quality of life questionnaires in clinical trials of rheumatoid arthritis. Arthritis Rheum. 2000;43(7):1478-87.
17. Norman GR, Stratford P, Regehr G. Methodological problems in the retrospective computation of responsiveness to change: the lesson of Cronbach. J Clin Epidemiol. 1997;50(8):869-79.
18. Crosby RD, Kolotkin RL, Williams GR. Defining clinically meaningful change in health-related quality of life. J Clin Epidemiol. 2003;56(5):395-407.
19. Wells G, Beaton D, Shea B, Boers M, Simon L, Strand V, et al. Minimal clinically important differences: review of methods. J Rheumatol. 2001;28(2):406-12.
20. Stucki G, Daltroy L, Katz JN, Johannesson M, Liang MH. Interpretation of change scores in ordinal clinical scales and health status measures: the whole may not equal the sum of the parts. J Clin Epidemiol. 1996;49(7):711-7.

21. Baker DW, Hays RD, Brook RH. Understanding changes in health status. Is the floor phenomenon merely the last step of the staircase? Med Care. 1997;35(1):1-15.
22. Hays RD, Woolley JM. The concept of clinically meaningful difference in health-related quality-of-life research. How meaningful is it? Pharmacoeconomics. 2000;18(5):419-23.
23. Stratford PW, Binkley JM, Riddle DL, Guyatt GH. Sensitivity to change of the Roland-Morris Back Pain Questionnaire: part 1. Phys Ther. 1998;78(11):1186-96.
24. Corriveau KH, Harris PL, Meins E, Fernyhough C, Arnott B, Elliott L, et al. Young children's trust in their mother's claims: longitudinal links with attachment security in infancy. Child Dev. 2009;80(3):750-61.
25. Fonagy P, Luyten P, Allison E. Epistemic Petrification and the Restoration of Epistemic Trust: A New Conceptualization of Borderline Personality Disorder and Its Psychosocial Treatment. J Pers Disord. 2015;29(5):575-609.
26. Fonagy P, Luyten P, Allison E, Campbell C. Mentalizing, Epistemic Trust and the Phenomenology of Psychotherapy. Psychopathology. 2019;52(2):94-103.
27. Fonagy P, Campbell C. Future directions in personality pathology. Curr Opin Psychol. 2021;37:145-51.
28. Fonagy P, Luyten P, Allison E, Campbell C. What we have changed our minds about: Part 2. Borderline personality disorder, epistemic trust and the developmental significance of social communication. Borderline Personal Disord Emot Dysregul. 2017;4:9.
29. Hayton C, Clark A, Olive S, Browne P, Galey P, Knights E, et al. Barriers to pulmonary rehabilitation: characteristics that predict patient attendance and adherence. Respir Med. 2013;107(3):401-7.
30. Oates GR, Hamby BW, Stepanikova I, Knight SJ, Bhatt SP, Hitchcock J, et al. Social Determinants of Adherence to Pulmonary Rehabilitation for Chronic Obstructive Pulmonary Disease. Copd. 2017;14(6):610-17.
31. Riedl D, Kampling H, Kruse J, Nolte T, Labek K, Kirchhoff C, et al. Epistemic Trust Is a Critical Success Factor in Psychosomatic Rehabilitation-Results from a Naturalistic Multi-Center Observational Study. J Clin Med. 2023;13(1):177.
32. Kampling H, Riedl D, Hettich N, Lampe A, Nolte T, Zara S, et al. To trust or not to trust in the thrall of the COVID-19 pandemic: Conspiracy endorsement and the role of adverse childhood experiences, epistemic trust, and personality functioning. Soc Sci Med. 2024;341:116526.
33. Riedl D, Kampling H, Nolte T, Kirchhoff C, Kruse J, Sachser C, et al. Utilization of Mental Health Provision, Epistemic Stance and Comorbid Psychopathology of Individuals with Complex Post-Traumatic Stress Disorders (CPTSD)-Results from a Representative German Observational Study. J Clin Med. 2024;13(10):2735.
34. Poletti V, Pagnini F, Banfi P, Volpato E. Illness Perceptions, Cognitions, and Beliefs on COPD Patients' Adherence to Treatment - A Systematic Review. Patient Prefer Adherence. 2023;17:1845-66.
35. Watson JS, Jordan RE, Gardiner L, Adab P, Jolly K. A Systematic Review of the Effectiveness of Interventions to Promote Referral; Adherence; and Uptake of Pulmonary Rehabilitation for Patients with Chronic Obstructive Pulmonary Disease. Int J Chron Obstruct Pulmon Dis. 2023;18:1637-54.
36. Weiland AM, Taubner S, Zettl M, Bartmann LC, Frohn N, Luginsland M, et al. Epistemic trust and associations with psychopathology: Validation of the German version of the Epistemic Trust, Mistrust and Credulity-Questionnaire (ETMCQ). PLoS One. 2024;19(11):e0312995.
37. Campbell C, Tanzer M, Saunders R, Booker T, Allison E, Li E, et al. Development and validation of a self-report measure of epistemic trust. PLoS One. 2021;16(4):e0250264.
38. Lampe A, Riedl D, Kampling H, Nolte T, Kirchhoff C, Grote V, et al. Improvements of complex post-traumatic stress disorder symptoms during a multimodal psychodynamic inpatient rehabilitation treatment - results of an observational single-centre pilot study. Eur J Psychotraumatol. 2024;15(1):2333221.
39. Vidotto LS, Carvalho CRF, Harvey A, Jones M. Dysfunctional breathing: what do we know? J Bras Pneumol. 2019;45(1):e20170347.
40. Reilly CC, Floyd SV, Lee K, Warwick G, James S, Gall N, et al. Breathlessness and dysfunctional breathing in patients with postural orthostatic tachycardia syndrome (POTS): The impact of a physiotherapy intervention. Auton Neurosci. 2020;223:102601.
41. Nugent K, Berdine G. Dyspnea and long COVID patients. Am J Med Sci. 2024;368(4):399-404.
42. Vlemincx E. Dysfunctional breathing: a dimensional, transdiagnostic perspective. Eur Respir J. 2023;61(6):2300629.

43. Depiazzi J, Everard ML. Dysfunctional breathing and reaching one's physiological limit as causes of exercise-induced dyspnoea. Breathe (Sheff). 2016;12(2):120-9.
44. Ruane LE, Denton E, Bardin PG, Leong P. Dysfunctional breathing or breathing pattern disorder: New perspectives on a common but clandestine cause of breathlessness. Respirology. 2024;29(10):863-66.
45. Severe asthma tollkit. Last accessed February 24, 2025: https://toolkit.severeasthma.org.au/co-morbidities/pulmonary-upper-airways/dysfunctional-breathing/
46. Freeman A, Abraham S, Kadalayil L, Varkonyi-Sepp J, Ainsworth B, Hudson-Colby JJ, et al. Associations of Breathing Pattern Disorder and Nijmegen Score With Clinical Outcomes in Difficult-to-Treat Asthma. J Allergy Clin Immunol Pract. 2024 Apr;12(4):938-947.e6.
47. Frésard I, Genecand L, Altarelli M, Gex G, Vremaroiu P, Vremaroiu-Coman A, et al. Dysfunctional breathing diagnosed by cardiopulmonary exercise testing in 'long COVID' patients with persistent dyspnoea. BMJ Open Respir Res. 2022;9(1):e001126.
48. Gaffney A. Dysfunctional breathing after COVID-19: recognition and ramifications. Eur Respir J. 2024;63(4):2400149.
49. Genecand L, Altarelli M, Binkova A, Loew S, Vaudan S, Gex G, et al. Dysfunctional breathing symptoms, functional impact and quality of life in patients with long COVID-19: a prospective case series. BMJ Open Respir Res. 2023;10(1):e001770.
50. Skornscheck R, Hüttenberger D, Sonnweber T, Löffler-Ragg J. The diagnosis of dysfunctional breathing with the help of cardiopulmonary exercice testing. 48 Jahrestagung der Österreichischen Gesellschaft für Pneumologie. Vienna, Austria2024.
51. Langewitz W, Schaefert R. Hyperventilationssyndrom und dysfunktionale Atmung. . Swiss Medical Forum – Schweizerisches Medizin Forum. 2019;19:749–52.
52. Bridevaux P, Altarelli M, Genecand L, Loew S, Binkova E, Gex G, et al. CPET ventilatory characteristics of dysfunctional breathing in long COVID patients with persistent dyspnea. European Respiratory Journal.60(suppl 66):734.
53. Samaranayake CB, Warren C, Rhamie S, Haji G, Wort SJ, Price LC, et al. Chaotic breathing in post-COVID-19 breathlessness: a key feature of dysfunctional breathing can be characterised objectively by approximate entropy. ERJ Open Res. 2023 Jul 17;9(4):00117-2023.
54. Bruton A, Lee A, Yardley L, Raftery J, Arden-Close E, Kirby S, et al. Physiotherapy breathing retraining for asthma: a randomised controlled trial. Lancet Respir Med. 2018;6(1):19-28.
54. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166(1):111-17.
55. Dodd JW, Hogg L, Nolan J, Jefford H, Grant A, Lord VM, et al. The COPD assessment test (CAT): response to pulmonary rehabilitation. A multicentre, prospective study. Thorax. 2011;66(5):425-9.
56. Bohannon RW, Crouch R. 1-Minute Sit-to-Stand Test: SYSTEMATIC REVIEW OF PROCEDURES, PERFORMANCE, AND CLINIMETRIC PROPERTIES. J Cardiopulm Rehabil Prev. 2019;39(1):2-8.

Tables

Table 1. MCID in D-A-CH comparison

Assessment tool	Germany	Austria	Switzerland
6MWT[1]	30	25-35	25-35
CAT[2]	2	2 ±10%	2
Wattmax[3]	4?	+4	-
1-MSTST[4]	3	3	3

[1]6MWT, six-minute walk test [52]; [2]CAT, COPD assessment test [53]; [3]Wattmax, [7, 10]; [4]1-MSTS, one-minute sit to stand test [54].

COPD, chronic obstructive pulmonary disease; D-A-CH, Germany-Austria-Switzerland; MCID, minimal clinically important difference.