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What kind of non-pharmacological strategy for reducing sedentary behavior in COPD? Data from a scoping review

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ABSTRACT

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is usually associated with sedentary behavior (SB). Literature reports a harmful impact of SB on the physical, mental, and social health of individuals with COPD. However, Pulmonary Rehabilitation (PR) programs seem to have no clear effect on changing SB. Therefore, our study aimed to identify the strategies used in the literature to reduce SB among individuals with COPD.

Method: A scoping review was conducted to summarize the current literature regarding the proposed strategies to reduce SB in individuals with COPD. Searches were conducted in PUBMED; SCOPUS and COCHRANE LIBRARY for studies published from 2010 to march 2024.

Results: Twenty four articles were retained for our review. Most of the identified strategies in the literature (21/24 articles) are based on behavioral approaches, with various forms: promoting self-efficacy, self-management and self-regulation of one's own behavior (12 articles), goal setting (10 articles), constant feedback (11 articles), therapeutic education (8 articles), motivational strategies (6 articles), re-engagement in meaningful activities (4 articles), promoting light intensity physical activity (LPA) (6 articles) and social support (6 articles). In association with the behavioral strategies, wearable connected technologies have been used in 4 articles, alone or combined with physical exercise programs included or not in a PR program. The home is associated with 83 % of interventions as a place for initial and continuous implementation of behavioral strategies.

Conclusion: It would seem appropriate to focus on combined strategies to reduce SB in individuals with COPD (improvement of physical abilities and behavioral strategies). Further research is needed to only target the reduction of SB and to evaluate the effects of various interventions.

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is defined as a heterogeneous lung condition characterized by chronic respiratory symptoms due to abnormalities of the airways that cause persistent, often progressive, airflow obstruction, resulting from an interaction of gene and environment of a person over her lifetime [1]. According to the World Health Organization, over 3 million people die every year of COPD [2]. Moreover, it causes a significant and highly important economic and social burden (mortality and disability) which is projected to increase over the decades [1].

One of the cardinal symptoms of COPD is dyspnea, which represents a major complaint from individuals with COPD [1]. Dyspnea could be defined as a subjective feeling of respiratory discomfort including

sensory and affective components [3–5]. It is due essentially to a thoracic distention secondary to bronchial obstruction and hyperventilation disrupting the normal mechanisms between the neural respiratory drive and the response (limited) of the respiratory system [4,6,7]. This dyspnea induces, over time, profound changes in the daily Physical Activity (PA) Level of individuals with COPD, corresponding to a behavioral adaptation/response to the discomfort described above [4,6,7]. Indeed, the arduousness of PA leads to their gradual decrease which will result in an intolerance to exercise disproportionate compared to real alterations in the respiratory and peripheral muscular system. It represents a morbid psychodynamic process, that affects the desire of the individual with COPD to engage in daily PA. This notion of a downward spiral of disengagement puts more emphasis on the behavioral dimension, than the physiological ones described in the literature

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[8]. This may explain why individuals with COPD are less engaged in PA and progressively adopt sedentary behavior (SB) [4,6,9].

Until now, the “*Sedentary Behavior Research Network*” defines SB as any waking behavior characterized by an energy expenditure less than or equal to 1.5 metabolic equivalents tasks, while in a sitting, reclining, or lying posture [10]. Concerning individuals with COPD, the literature shows that they are highly marked by SB [11–13]. In fact, most of people living with COPD spend a considerable and unhealthy proportion of their daily lives in SB [14]. The degree of SB in individuals with COPD is further illustrated, in the study of Pitta et al. by the fact that they spent 12 % of the time during the day in the lying position, as compared with 4 % in healthy elderly subjects [15].

There is increasing evidence that SB negatively affects the health status of individuals with COPD [16–19]. In fact, like PA level, SB is associated with an increased risk of developing comorbidities such as diabetes and cardiovascular diseases and then an increased risk of mortality [16,19]. SB increases episodes of exacerbations, decreases exercise capacity, and significantly impairs the quality of life [15,17, 20–23]. According to Furlanetto et al. (2017), it would be an independent predictor of mortality in individuals with COPD even if they are engaged in moderate to vigorous intensity physical activities (MVPA) [18]. Thus, there is a real and high importance to focus on interventions that address SB in individuals with COPD, as an independent therapeutic target, to reduce the decline of health status and improve quality of life [19,20].

On top of the interventions to break the spiral of deconditioning appear Pulmonary Rehabilitation (PR) programs, particularly indicated for individuals with dyspnea or intolerance to exercise and who have reduced their amount of daily PA [24]. The PR programs are often based on the optimization of the pharmacological treatment and the education of patients for a better therapeutic observance. But non-pharmacological approaches are also offered, being now a cornerstone of COPD management. The benefits of PR are well established in terms of improvement of psycho/pathophysiology: reduction of dyspnea, significant improvements in exercise tolerance, muscle strength and quality of life [25–27]. In addition, PR has potential effects on reducing healthcare costs by reducing exacerbation episodes, emergency admissions and length of hospital stays [27,28]. However, PR programs seem to have no clear effect on changing SB [29] and most of the PR participants failed to transfer these achievements into long-term health promotion behavior [30]. Indeed, the exercise training offered by PR programs is mainly aimed at developing the physical abilities of the person and thus acts on their ability to perform in daily life PA. However, the lack of a behavioral response targeting the desire to engage in daily PA makes the effectiveness of these PR programs in changing behavior itself “controversial” [31–33]. Thus, a non-negligible proportion of individuals with COPD will gradually return to a sedentary lifestyle after completing the PR program, losing many of the benefits achieved during the program in terms of improvements in physical capacities and psychological state [29]. According to Mesquita et al. (2017), 30 % of individuals with COPD, corresponding to poor responders to PR programs, will increase their sedentary time by an average of 32 min/day once their PR program ended [29]. Therefore, it could be also interesting to investigate the adequate timing for offering SB reduction approaches, by adding SB specifically oriented intervention in PR or by realizing specifically oriented interventions outside the PR [31]. As mentioned by Blondeel et al. (2018) for strategies focusing on PA level enhancement in individuals with COPD, this aspect of strategies developed outside PR could facilitate the translation of SB reduction strategies in daily life [31].

Thus, we conducted a scoping review to explore the different strategies proposed so far in the scientific literature, that focus on the reduction of SB among individuals with COPD. Given these objectives, a scoping review seems to be the most appropriate approach to summarize and describe the research progress and to provide more information for future guidelines.

2. Methods

This scoping review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Scoping Review guidelines [34]. The PRISMA-ScR checklist is provided in Supplementary file 1.

A literature search was conducted to identify relevant articles to include in this scoping review.

To clearly formulate a research equation, a list of keywords was established using the Population (or participants)/Concept/Context (PCC) framework, as recommended by JBI as a guide to establish “clear and meaningful” search strategy with eligibility criteria for a scoping review [35].

The PCC framework is described in Table 1.

We conducted a search using the terms ‘chronic obstructive pulmonary disease’, ‘sedentary behavior’, and ‘strategies’, as well as their appropriate synonyms and combinations.

Boolean logic operators “AND, OR, NOT” were used. Therefore, our complete research equation was: (“COPD” OR “Chronic Obstructive Pulmonary Disease” OR “Chronic Bronchitis” OR “Emphysema”) AND (“Strateg*” OR “Intervention*” OR “Recommendation*” OR “Guideline*”) AND (“Sedentary Behavior*” OR “Sedentary Behavior*” OR “Sedentarism” OR “Sedentary Lifestyle” OR “Sedentary Time” OR “Reclining” OR “Lying” OR “sitting” OR “Screen time” OR “Television viewing” OR “Daily life activit*” OR “Activit* of daily living” OR “Occupation*” OR “Stand*” OR “Number of step*” OR “Walk*”).

This research equation was submitted to the following databases: PUBMED; SCOPUS and COCHRANE LIBRARY with a final search on **march 2024**. The detailed search strategy for each database is reported in supplementary file 2.

Articles were retained if they meet the following inclusion criteria: (1) Individuals with COPD, regardless of the degree of severity, age, sex, origin, and without motor, cognitive, or psychological disabilities that prevent PA; (2) use or description of any other non-pharmacological approach that aim to decrease SB and/or sedentary time or any recommendations or guidelines that aim to decrease SB (3) studies with a quantitative and/or qualitative measure and/or appreciation of SB as a major dependent or independent variables; (4) articles must be published in the English language; (5) articles must be published since 2010; (6) articles must be available in full and original text.

The proposed time period (2010–2024) was decided by the authors, based on subjective criteria for identifying recent and non-exceeded literature.

The Zotero® software was used to record, manage, analyze, classify, and edit the references of the articles collected from the different databases.

Table 1
PCC framework.

Population	Individuals with COPD regardless of the degree of severity, age, sex, origin; and without motor, cognitive, or psychological disabilities that prevent PA.
Concept	<ul style="list-style-type: none"> • Description, proposal, or implementation of strategies to reduce SB/ sedentary time. • Recommendations or guidelines to reduce SB. Studies with a quantitative and/or qualitative measure and/or appreciation of: <ul style="list-style-type: none"> • SB • Sedentary time • Time spent performing sedentary activities such as television/ screens viewing time. • Time spent in a sitting or reclining or lying position. • The level of engagement in daily life PA. • Number of steps • Time spent standing or walking.
Context	Only articles available in full text, in the English language, and published since 2010.

After removing duplicates, the articles were analyzed by title by two independent researchers.

Once this stage was completed, the articles were analyzed on the basis of the full text and retained if they met the inclusion criteria mentioned above.

The studies included in this review were quantitatively and qualitatively described, and the findings were extracted, summarized, and analyzed in a combined and objective way using a **descriptive method**. As this is a scoping review, assessing the risk of bias is not mandatory.

3. Results

3.1. Selection of articles

After querying databases and selecting articles according to the previously reported criteria, 24 articles were retained for our review. A PRISMA flow diagram, available on Fig. 1, provides detailed information about the screening process.

Out of the 24 articles, 12 are randomized controlled trials (RCT) [36–47], while the remaining 12 present various study designs,

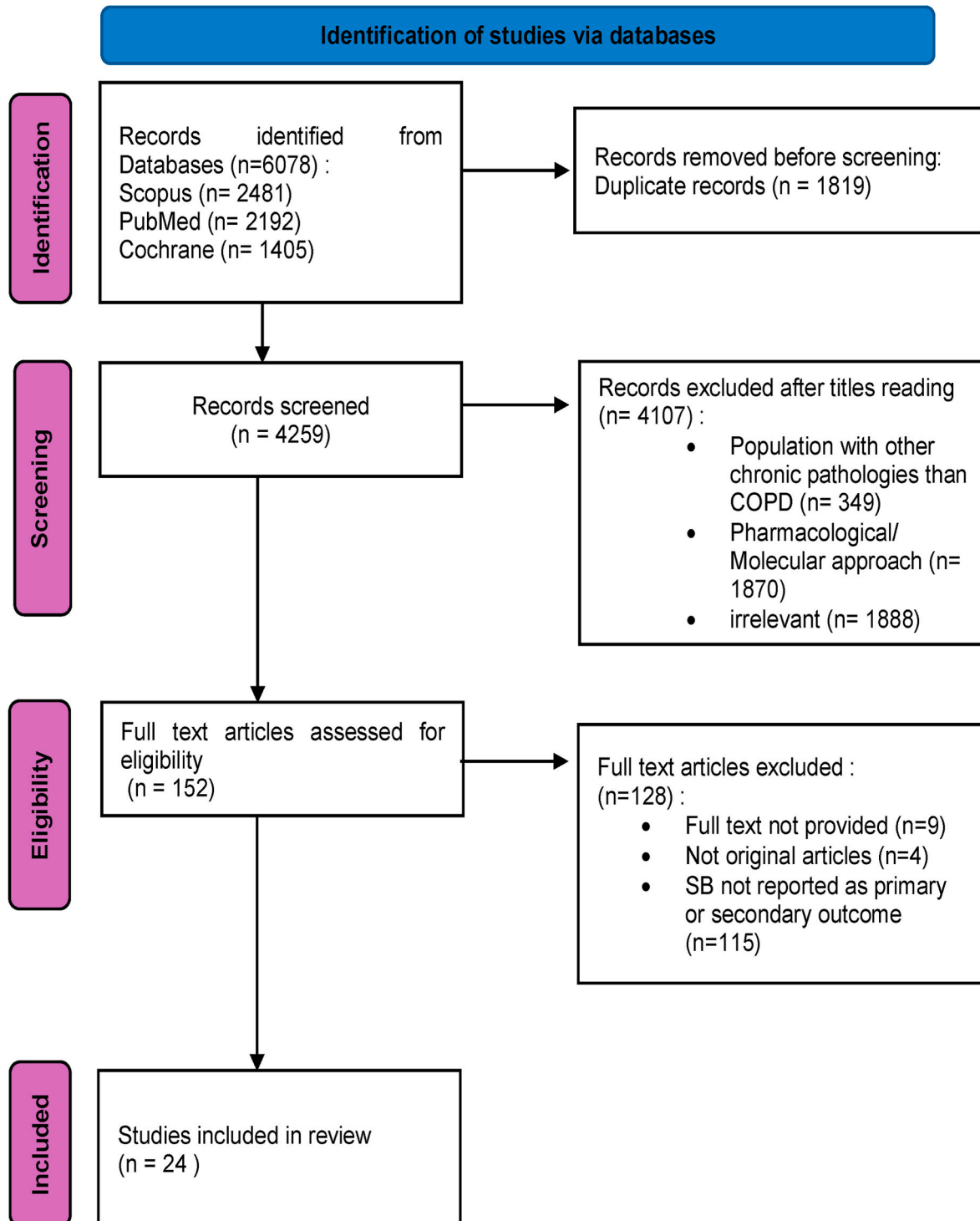


Fig. 1. Flow chart diagram of the scoping review.

including 2 retrospective study [29,48], 1 literature review [17], 1 preliminary study [49], 1 cross-sectional analysis [50], 3 qualitative semi-structured interviews [21,22,51], 3 mixed-method studies [52–54] and 1 non randomized study [55].

The selected articles, two published between 2010 and 2013, nine between 2014 and 2017, and thirteen between 2018 and 2023, reflect recent literature on reducing SB in individuals with COPD.

3.2. Context of the proposed strategies

To identify the context in which these strategies are implemented/described, we focused on the spatio-temporal characteristics of the identified strategies. As a result, Table 2 summarizes, for each article, the moment, and the place of the proposed strategies.

Most of the selected studies proposed an approach based on SB reduction at home with 16 out of 24 included studies [17,29,36,38,39,41,43–47,49,51,52,54,55]. The others proposed places for implementing SB reduction interventions are reported in Table 2.

The moment when the strategies were implemented/described was pretty different in the identified articles, either associated with a PR program (before, during or after PR), for 11 studies out of 24 [17,21,22,29,36,37,39,40,46,48,53] or without being attached to a reported PR program (unless this information has not been reported by the authors) for the remaining 13 studies [38,41–45,47,49–52,54,55].

For all the studies included in this review that implement an intervention (n = 17; Table 3), the average duration of interventions was 10.9 weeks ± 7.4. In addition, the average follow-up duration of individuals after the completion of the intervention program was 10.3 weeks ± 16.6.

3.3. Contents of the proposed strategies

The strategies for reducing SB proposed in each study were extracted and compiled. Therefore, Tables 3 and 4 present the following information:

- Table 3 focuses on the 17 articles implementing strategies to change SB within their interventions and evaluating their effects on behavior change [36–49,52,53,55].
- Table 4 covers 7 articles aiming, in a descriptive or an exploratory way, to highlight the causes of SB, without implementing interventions [17,21,22,29,50,51,54]. The interest here is to be able to identify and collect proposed solutions and intervention strategies to reduce SB.

After analyzing the reported strategies, we can note that behavioral strategies alone are proposed in 4 studies [21,45,50,51]. Combined strategies have also been proposed, with behavioral interventions associated with the use of connected technologies in 4 other studies [38,39,41,47] or combined with physical exercise programs in order to improve physical abilities via training sessions (included or not in a PR program) in 13 studies [17,22,29,36,40,43,44,46,49,52–55]. Overall, behavioral strategies represent most of interventions/proposals aiming to reduce SB in individuals with COPD, with 21 of the 24 articles selected [17,21,22,29,36,38–41,43–47,49–55] (87 % of all identified strategies) using this approach. Table 5 details the different behavioral strategies proposed in the screened articles.

The last 3 studies identified are based on different strategies to address SB:

- Breyer et al. (2010) set up an outdoor walking program (Nordic walking) to break SB and promote an active lifestyle [42].
- Liacos et al. (2019) propose an assessment tool (PRAISE) with a predictive validity to identify, in a predictive way, the COPD patient with high or low self-efficacy to reduce SB and therefore to implement early strategies following PR [48].

Table 2
Moment and Place of the proposed strategies.

Authors (Year of publication)	Cruz et al. (2016)	Liacos et al. (2019)	Cheng et al. (2021)	Hartman et al. (2013)	Larson et al. (2014)	Wshah et al. (2021)	Hill et al. (2015)	Breyer et al. (2010)	Tabak et al. (2014)	Gaidl et al. (2021)	Larson et al. (2017)	Orme et al. (2018)	Larson et al. (2020)	Park et al. (2020)	Wshah et al. (2020)	Mesquita et al. (2017)	Mesquita et al. (2017)	Bender et al. (2016)	Guan et al. (2020)	Hill et al. (2020)	Cruz et al. (2014)	Valeiro et al. (2023)	Michaelchuk et al. (2023)	Xiang et al. (2023)	
Place of the proposed strategies																									
At hospital																									
At home	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
In the laboratory																									
PR center	X																								
Outdoors								X																	
Moment of the proposed strategies																									
Before PR program			X																						
During PR program	X					X	X																		
After PR program	X						X																		
No PR program (not mentioned or contraindicated)				X	X			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 3

Articles implementing strategies to change SB within their interventions and evaluating their effects on behavior change.

Articles	Proposed strategies
Xiang et al. (2023) [55]	Motivational interview: customized health education manuals/One-on-one motivational interview to assess the patients' current behavior change stage. Goal setting: Short-term goal: start with LPA (for example, walking at a leisurely pace, riding a bike on flat ground and lifting light weights) and gradually increase the intensity of exercise; Long-term goal: All patients' daily walking time increased, sedentary time decreased, dyspnea improved, and cardiopulmonary function and quality of life improved. Implement exercise prescription from 1 week after discharge to 12 weeks. Exercise monitoring: WeChat pedometer for self-monitoring of daily steps; use an activity log to record daily activity. Regular follow-up: "After discharge, the patients were followed up by telephone or WeChat (that is a smartphone application) every week for 15–20 min for 12 weeks"
Cruz et al. (2016) [46]	Behavioral intervention based on social cognitive theory that aims to promote the role of self-efficacy, goal setting and performance feedback as essential elements of behavior change: the physiotherapist, during individual therapeutic education sessions, helps to: <ul style="list-style-type: none"> • Formulate objectives in terms of the number of steps according to abilities (short, medium and long-term objectives) regarding the reference to international recommendations on PA (7000–10,000 steps per day). These objectives are set out in a health contract drawn up by the patient and the physiotherapist. • Feedback and goal-adjustment. • Identify facilitators (involvement of family/friends, make a schedule every day). During the 3 months PR and 3 months follow-up.
Liacos et al. (2019) [48]	This is not an intervention in itself, but rather an assessment tool with a predictive validity in order to identify, in a predictive way, the COPD individual with high or low self-efficacy to reduce SB and therefore to implement early strategies following PR.
Cheng et al. (2021) [45]	Therapeutic education, guided goal setting and real-time feedback on SB in order to achieve two objectives: <ul style="list-style-type: none"> • Replace sitting or lying position with LPA. • Get up and move for 2 min after 30 min of continuous SB. Establish a behavioral diagnosis: identify the component of the behavior to target (capability, opportunity, motivation) according to the COM-B model. Depending on the diagnosis, from COM-B, appropriate behavioral techniques will be used: <ul style="list-style-type: none"> • Information about the deleterious effects of SB. • Weekly goal setting. • Feedback on SB using wearable measure instrument. Duration: for 6 weeks including 3 telephone exchanges and 3 face-to-face exchanges.
Larson et al. (2014) [44]	Increasing the level of self-efficacy (motivational videos of people doing PA, helping patients interpret their emotional and physiological status during exercises) + resistance exercises targeting the upper body. Rhythm: 16 sessions, one session per week over 4 months. 3 booster sessions (therapeutic education) at 3, 6 and 9 months about: general principles of PA, adjust PA to improve respiratory function, overcome barriers to exercise, promote an active lifestyle.
Breyer et al. (2010) [42]	3 months of Nordic walking performed outdoors, 3 times a week (guided by PA-recommendations). The duration of a session is 1 h and goes at 75 % of the initial maximum heart rate of subjects. Groups are formed according to their physical abilities and walking speed. The walk is done with a Nordic walking instructor for 2 h.
Tabak et al. (2014) [41]	Telerehabilitation via a connected Smartphone and a sensor (worn at the belt of patient) that allow: <ul style="list-style-type: none"> • Continuous visual feedback: the smartphone displays the level of accumulated PA instantaneously and the level that the patient must achieve. Graphed display.

Table 3 (continued)

Articles	Proposed strategies
Geidl et al. (2021) [40]	<ul style="list-style-type: none"> • The COPD individual to receive a motivational message every 2 h in order to increase the level of consciousness and give him even more motivation. Duration: 4 times a week over a period of 4 weeks. Besides a 3-week PR program, patients receive a pedometer in addition to two 45-min PA promotion sessions. Behavior change techniques are based on: <ul style="list-style-type: none"> • Setting objectives • Planning • Feedback (use of pedometer) • PA diary • Circuit- training exercises • Walking • Behavioral strategies based on self-efficacy, self-regulation and self-management of his own behavior. • Therapeutic education that explains the potential benefits of increasing LPA and decreasing SB.
Larson et al. (2017) [49]	Educational component (therapeutic education): Delivery of a booklet "sit less, move more, live healthier" with 7 areas of suggestions to break with SB: leave the house every day, stand, step during queues, be active during commercial breaks, increase the number of steps, get up and sit without using hands, reduce the time spent sitting or lying down. Feedback component (use of wearable measuring instruments connected to a smartphone application): Real-time feedback on the time spent sitting, standing and the number of steps at home via a watch (inclinometer) worn on the wrist which is connected to a smartphone application. The inclinometer also sends vibrations to encourage patient movement. (Vibration after 30 min in sedentary postures). The intervention last 2 weeks post hospital-discharge.
Orme et al. (2018) [39]	Increase the overall level of PA by 60 min/day with particular attention to increasing LPA-level via: Behavioral strategies: <ul style="list-style-type: none"> • Re-engagement in meaningful activities "subjects choose their own enjoyable activities and adjust their intensity and duration." These activities are at least LPA and must be performed in a standing position. • Increase self-efficacy in activities. • Set SMART goals and track the progress on activities over a week. • Social support provided by creating groups (between COPD patients). • Therapeutic education: the principles of PA, physical benefits of LPA and the deleterious effects of a sedentary lifestyle, management of relapses in SB and exacerbations. Structured exercises: Rhythm: 2 sessions in the laboratory and one at home per week over 4–8 weeks. Followed by 2 weeks of transition at home including a laboratory session and 2 home sessions per week. Program of a lab session: 20 min of walking, 30 min of educational/behavioral activities, 1 h of functional training circuit and 10 min of stretching.
Larson et al. (2020) [52]	- Therapeutic education + educational material installed on the Smartphone application. - Group/individual exercises + pedometer + app exercises (videos) - Self-management (recording of parameters over a day from the pedometer to the Smartphone application, recording of symptoms and episodes of exacerbations). - Social support: participants were encouraged to communicate with each other and with the research team by calling or texting via the smartphone application. 6 months of intervention
Bender et al. (2016) [36]	Intervention delivered by a wellness coach via face-to-face and telephone interviews with the COPD individual aimed at:

(continued on next page)

Table 3 (continued)

Articles	Proposed strategies
	<ul style="list-style-type: none"> Increasing the time spent in a meaningful activity such as shopping, taking care of grandchildren. Motivational interviewing and assistance in setting goals to re-engage in meaningful activities. Explaining the benefit of increasing the number of daily steps to re-engage in meaningful activities and thus achieve the set goals. (Each patient has a pedometer and records the number of daily steps taken on a calendar). Set goals in terms of increasing the number of daily steps (by 15 % per month, adjusted for each patient). Discuss the patient's perception of achieving their goals and set new ones in terms of meaningful activities.
Hill et al. (2020) [37]	<p>Rhythm: 12 weeks of intervention:</p> <ul style="list-style-type: none"> An initial visit at the beginning of the intervention (face to face) A telephone interview every two weeks over 10 weeks. <p>Intervention of 10 weeks using a Wheeled Walker. 2 supervised exercise classes each week during the 8-week PRP and an individually prescribed home exercise program to complete on an additional 2 or 3 days a week. At home, standardized instructions to use WW were given to assist COPD individuals in daily activities that involved walking, including the walking component of their home exercise program.</p>
Cruz et al. (2014) [53]	<p>Providing feedback on PA levels to patients to enhance PA time during a 12 week-PR program. Feedback was given at the end of the exercise training session of the following week and lasted 15–20 min.</p> <p>Feedback component:</p> <ul style="list-style-type: none"> Written (graphical) and verbal information about time spent standing, sitting, and lying on each day of the week and a weekly average of the number of daily steps and of time engaged in sedentary activities, LPA and MVPA. Information about the recommended values of PA for healthy people. Individualized recommendations to improve or maintain PA levels regarding the time spent in MVPA and number of steps per day, based on the results of the previous week. Participants also received general recommendations to improve daily PA and a leaflet with exercises similar to those of the exercise training component.
Valeiro et al. (2023) [43]	<p>Behavioral intervention to increase PA and reduce SB in post hospital discharge for exacerbation.</p> <p>A 12-Week program with:</p> <ul style="list-style-type: none"> A motivational interview to explore the patient's feeling towards being more active and to assist them taking the decision in favor of change in SB. Personalized PA program with a pedometer and a printed calendar to engage the subject in an individualized, 12-week, progressive and steps-targeted intervention. Weekly telephone calls with the participants to assess their progress, discuss possible barriers and set new weekly PA goals.
Michaelchuk et al. (2023) [47]	<p>Wearable technology providing vibration movement prompts "FITBITm" for one week.</p>

- Hill et al. (2020) propose a wheeled walker to use at home after finishing PR program to increase PA level and reduce SB [37].

4. Discussion

To the best of our knowledge, this scoping review is the first one to identify and summarize the current literature regarding the strategies to reduce SB in individuals with COPD. 24 articles have been selected from databases from 2010 to march 2024.

The main results of our study illustrated that behavioral strategies are the most widely used approach in the literature, often implemented in a home-based context.

Table 4

Recommendations in terms of strategies proposed by articles that do not implement and do not evaluate the impact of these strategies.

Articles	Strategies
Hartman et al. (2013) [54]	<ul style="list-style-type: none"> Adapt activities to be less sedentary. Increase individual's understanding of their symptoms and the beneficial effect of decreasing SB. Increase self-efficacy. Reduce barriers to PA.
Wshah et al. (2021) [22]	<p>Add a therapeutic component targeting SB to a PR program that includes:</p> <ul style="list-style-type: none"> Information on health issues and risks of SB. Social support: include and influence the patient's environment as a motivational lever to reduce SB. Goal setting. Feedback.
Hill et al. (2015) [17]	<p>Behavioral intervention combined with physical exercise.</p> <p>Behavioral strategies include:</p> <ul style="list-style-type: none"> Setting objectives. Self-management. Feedback. Promotion of LPA. Break with any time spent sitting or lying down via technological aids (system that automatically turns off the television after a timed-viewing period).
Wshah et al. (2020) [21]	<ul style="list-style-type: none"> Information on SB and its harmful effects on health. Replace SB with LPA (such as standing). Take short breaks in order to engage in more meaningful activities. Encouragement and support from health professionals. Environmental restructuring (adaptation of the living environment as a resource to reduce SB). Improve COPD individuals' self-congratulation in order to move more and sit less. Involve the family environment as a support and lever to engage in more activity.
Mesquita et al. (2017) [29]	<p>Promoting LPA to lead a less sedentary lifestyle. This can be done through a re-engagement in meaningful activities.</p>
Mesquita et al. (2017) [50]	<p>Involve the human environment (family, friends) to address SB.</p>
Guan et al. (2020) [51]	<ul style="list-style-type: none"> Education component to increase awareness of SB and afford self-management strategies. Guided goal setting.

4.1. Context of SB-focusing interventions

About the context of implementation/description of the strategies, almost half of the interventions targeting SB are delivered or proposed in a context of a PR program, whether before, during, or after [17,21,22,29,36,37,39,40,46,48,53]. Indeed, PR programs usually induce an improvement of the physical abilities of individuals with COPD, in terms of exercise tolerance and reduction of dyspnea [24–28]. However, it appears that an intervention only targeting the individual's physical abilities does not act directly on his behavior, which is the result of a behavioral adaptation (response) to the chronic limitations imposed by COPD [29,31,32]. On the opposite side, acting on SB without focusing on an improvement of the functional abilities of the patient will not lead to any benefits on his health issues generally and SB itself specifically [17]. This may explain the negative results of the intervention performed by the article of Cheng et al. [45]. Indeed, this study recruited participants on the waitlists of PR programs and implemented behavioral strategies to reduce SB without any intervention to improve physical abilities. Associated with a short intervention period proposed in the study (6 weeks with one session per week of education, guided goals setting, and real-time feedback on SB), this intervention did not reduce SB among stable moderate-to-severe COPD prior to PR compared to sham intervention.

Conversely, the article of Cruz et al. (2016) implemented behavioral strategies during the PR program (3 months) and offered a follow-up support period (3 months), which had a positive impact on the decrease in SB (a significant decrease in time spent in sedentary activity

Table 5

Focus on the proposed behavioral strategies: identification and detailed description of each strategy.

Behavioral strategy	Description	References
Promoting self-efficacy, self-management and self-regulation of one's own behavior.	This involves understanding by the COPD individual of the different dimensions of his pathology and SB and then empowering by making him actor of his everyday care process. He will engage by himself in more PA to be less sedentary.	[17,21,38,40,44,46,48,49,51,54,55]
Goal setting	SMART, guided by a professional, progressive, contract ... as well as the monitoring of the effective achievement of these objectives.	[17,22,36,40,43,45,46,51,52,55]
Constant feedback	By an application or a health-care professional on performance, sedentary time and achievement of planned objectives over the day (graphed subjects' progress).	[17,22,36,39-41,43,45,46,53,55]
Health education	Information about PA and its benefits, the deleterious effects of a sedentary lifestyle, the management of relapses in SB. Delivery and explanation of booklets containing suggestions to break with SB: leave the house every day, stand up, step during queues, be active during commercial breaks on TV ...	[22,38,39,45,49,51,52,55]
Motivational strategies	Receiving encouraging messages to reduce SB. Showing and valorizing subjects' progress.	[21,36,39,41,47,55]
Re-engagement in meaningful occupational activities	Spend more time in activities that make sense to the person. If these activities are sedentary ones, encourage the subjects to perform them standing, adjust their durations and intensities to be less sedentary.	[21,29,36,52]
Focusing on Light-intensity Physical Activity (LPA) rather than moderate to vigorous ones.	More realistic and effective way to reduce SB. Strong correlation found between changes in SB and LPA.	[17,21,29,45,49,52]
Social support	Between COPD individuals: group activities and peer-to-peer exchanges. Between COPD individuals and healthcare professionals Involvement of the nearby human environment (Family and friends) as a motivational lever.	[21,22,36,38,50,52]

($p = 0.018$) at 3 months of intervention) [46]. Indeed, once the PR program is completed and physical abilities are improved, the follow-up and continuity of the behavioral intervention (initially implemented during the PR program) allow the maintenance of gains at home and therefore are associated with better results. In addition, this post-PR follow-up allows the individuals with COPD to stay in contact with healthcare professionals avoiding a home-return context, associated with a total break with any support, which can negatively influence their behavior. Indeed, frequent contact with healthcare professional(s) is part of the patient's human resources in terms of motivational levers to reduce SB [21]. Cruz et al. (2016) also explained the positive results of their study by the duration of their intervention and its patient-centered follow-up. The authors concluded that differences in results between

their study and another previous one with the same goals may be explained by the different duration of the PR program (9 weeks vs. 12 weeks) and professional support (five 30-min individual sessions vs. weekly 20–30-min group sessions). The results were maintained over 6 months without significant differences from the control group ($p = 0.781$). An important limitation is that the primary goal of the study of Cruz et al. (2016) was to increase the level of PA and not directly focus on SB. It can be assumed that a similar intervention focusing on SB could have significant effects over time (after 6 months) compared to a control group.

More than half of the identified studies do not provide guidance with any PR program [41,42,44,47,54,55] or, on the opposite side, define as an exclusion criterion, the patient's participation in a PR program in the year preceding the study [38,43,49,52]. These studies offer, instead, combined interventions as proposed in several identified studies: exercise-specific self-efficacy enhancing intervention with upper body resistance training [44], walking, functional circuit training, behavioral and educational strategies [49,52], PA program based on the behavior change wheel theory [55]. These interventions take place both in the laboratory/hospital and at home, followed by a transition and follow-up that takes place only at home.

This first analysis reflects the understanding that a sedentary lifestyle is a problem that combines as determining factors the behavior and physical abilities of an individual affecting both the desire and ability to engage in daily PA [6]. Thus, it would seem appropriate to focus on combined strategies to reduce SB in individuals with COPD [56–58]. The intervention sites follow this logic of combined strategies (improvement of physical abilities and behavioral strategies to reduce SB) with an important part of studies offering interventions in a home-based setting. This could have several forms, with only home-based interventions or through the association home-PR centers [37,40,46]; home-research laboratory [44,49,52], or home hospital [39,43,55]. The home may also be the only place to implement strategies to reduce SB, as in the articles of Tabak et al. [41] and Park et al. [38] which offered full telerehabilitation care via smartphone applications as support (exercise videos, monitoring of the achievement of set objectives; feedback, motivational messages, etc.). The home can be considered as the preferred environment for expressing SB. It is not only a place for monitoring SB but also a place for the initial and continuous implementation of behavioral strategies.

4.2. Characteristics of behavioral strategies

The analysis of the different studies included in this review highlights that behavioral strategies are widely used for focusing on SB and it appeared a wide range of behavioral strategies implemented in the interventions.

Some of the articles proposing behavioral interventions are based on behavior change models, such as the Social Cognitive Theory (SCT) [59] model for the article of Cruz et al.(2016) [46]. The 'capability', 'opportunity', 'motivation' and 'behavior' (COM-B) and the Behavior Change Wheel [60] for the article of Cheng et al.(2021) [45]. Self-efficacy theory [61] for the article of Larson et al.(2014) [44]. The Theoretical Domains Framework (TDF) [62] for the article of Wshah et al. (2020) [21]. Both social cognitive theory (SCT) [59] and self-efficacy theory [61] were used in the article of Park et al.(2020) [38].

The multitude of models for the classification and the intervention in the different behavioral components of SB meant that we chose not to refer to these theoretical models to classify the different proposed strategies. This would either be too restrictive or would not respect the indications of a particular theoretical model.

We therefore assume the classification we made of behavioral strategies on the basis of a detailed and cross-cutting analysis of the proposals in each article.

Among these various strategies, the place occupied by measurement

instruments appears very important. These instruments (including inclinometer, pedometer, and accelerometer) worn by the patient are, for part of the interventions, connected to an application on a Smartphone, or integrated into a smartwatch [38,39,41,47]. Therefore, it allows to go beyond their primary role of measurement and data collection for therapists/researchers. These instruments could be used by the subjects, as a mean of action by involving them in the daily self-management of their pathology. Indeed, concrete objectives could be defined through the application (according to the individual's abilities) and real-time follow-up/feedback on his level of achievement could be proposed, like information on the time spent being sedentary on a day or during a week [39,41]. All these options could make the individual with COPD highly involved in the daily self-management of his behavior (Empowerment strategy) [38]. Therefore, it can be concluded that these measurement tools may play an important role in promoting self-regulation and self-management of the individual with COPD of his own behavior by maximizing his self-efficacy in reducing SB [38]. Positive results on the change in SB are reported for this type of intervention:

- According to Orme et al. [39], patients responded to approximately one-third of the vibration prompts provided by the inclinometer resulting in approximately 1.5 additional min standing, 0.5 min of walking, and 21 extra steps per response.
- An increase in the level of self-efficacy to reduce the daily time spent in sedentary activities according to Park et al. [38].

Another strategy concerns the promotion of light-intensity physical activity (LPA) level as an important part to reduce SB. Mesquita et al. (2017) demonstrate a strongest correlation between changes in SB and increased level of LPA ($r = -0.89$), compared to the correlation between change in SB and increased level of MVPA ($r = -0.74$) [29]. Besides, promoting LPA (standing, walking at low intensity, stepping) would be a more realistic and achievable goal [49] to reduce SB in the long term [52] rather than focusing on MVPA. But for this to be achieved prior (or at least at the same time), improvements of functional capacity seem to be required [29]. Positive results are also reported for these strategies during and after an intervention: decrease of 55min/day of sedentary time with 72 % of re-engagement in LPA for the article of Larson et al. [49] with a maintenance over 86 % of results after 2 months of follow-up. One other study of Larson et al. [52] reported an increase in time spent standing or stepping by 36 min per day ($p > 0.05$) and 21 min per day ($p > 0.05$) 2 months later. This strategy can be associated with another behavioral approach, described in Table 5, that involves a re-engagement of meaningful activities. Sedentary activities collected from the individual's daily life activities would be more easily transformed into LPA by modifying their way of realization, intensity, and duration [17,52].

Breyer et al. (2010) presented one of the only interventions that does not offer behavioral strategies [42]. Instead, they described an outdoor supervised Nordic walking program for 3 months as a "simple, safe, and effective physical training modality for individuals with COPD." This study demonstrates an increase in time spent standing ($+129 \pm 26$ min/day) and a decrease in time spent sitting (-128 ± 15 min/day) with benefits maintained up to 6 and 9 months following the intervention. These results may be explained by the cheapest and easiest accessibility and training modalities of Nordic walking compared to PR programs. Besides, training modalities of Nordic walking, which "imitate everyday life movements" enable the participants to transfer their achievement (improvement in functional exercise capacity) in daily PA to be less sedentary [42]. In fact, "63 % of the individuals with COPD have adopted Nordic Walking as regular physical exercise", which explains the long-term lasting benefits after an un-coached (non-supervised) period of six months. However, these results "might be biased by the selection of very motivated patients" who probably wouldn't need a behavioral intervention [42].

5. Limitations and perspectives

The current scoping review was designed to map the scientific evidence about how to reduce SB in COPD context. But we are aware that the current work has some limits. The first limit could be linked to the identification of articles. Despite our efforts, it may be possible that some articles and grey literature was not identified and included within the bibliography. In order to limit this aspect, we applied a robust methodology, based on the current guidelines for scoping reviews. This approach helps the authors to identify the current evidence on the mentioned topic and to improve the evidence level, that is an important strength of the current work. Secondly, it appears that reducing SB in individuals with COPD as an independent therapeutic goal has mainly been reported in recent scientific literature, as shown by the small number of articles reporting interventions targeting SB as a main outcome. This is why we decided to only include articles published since 2010, that could be another potential risk that not all the literature on this topic has been reviewed.

Then, it is noteworthy that the strategies suggested in most of the selected articles have broader objectives beyond the reduction of SB. In fact, this objective of SB reduction is usually not considered as a primary study objective and/or a primary outcome. The assessment of SB level (time spent standing, LPA, time spent sitting or lying) often appears in a "melting pot" of parameters/outcomes such as the measure of PA levels (MVPA, number of steps, time spent walking), sleep, reduction of symptoms (such as dyspnea and exacerbations), exercise capacity, muscle strength and health reported quality of life and self-reported behavior changes (such as self-efficacy). Moreover, strategies to reduce SB are still proposed as part of an intervention to increase global PA time. SB appears, in most studies, at best, among the primary outcomes with the improvement of the level of PA or in the secondary outcomes.

By reviewing the literature on proposed strategies for decreasing SB, our work can establish a foundation for future research. The perspective will be to select and combine these strategies to evaluate their long-term impact in reducing SB. The aim is then to identify the most effective combinations of strategies for reducing SB and how to implement them in a long-term observation.

Conclusion

The current scoping review reports that the strategies used to address SB are mainly centered around behavioral interventions often associated with physical exercise for improving upstream or in parallel the physical capacities of individuals with COPD. Some of these strategies focus on LPA promotion or are associated with the use of wearable technologies connected to a smartphone application that could play a major role in the implication of individuals with COPD in the self-management of SB.

Our work, which aimed to list the strategies to address SB, could be continued by evaluating the effectiveness of these strategies, proposed so far in the literature. Besides, future-specific research could focus on finding the most effective combinations of these strategies and their delivery modalities to reduce SB in a more sustainable way. This could help researchers and clinicians to identify individualized approaches to further enhance the benefits of interventions offered for COPD management.

CRediT authorship contribution statement

A. Younes: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **S. Mandigout:** Writing – review & editing. **L. Robin:** Writing – review & editing. **B. Borel:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

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Appendix A. Supplementary data

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