

Critical outcomes in pulmonary rehabilitation: Assessment and evaluation of dyspnea and fatigue

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Abstract—Dyspnea and fatigue, the two most common symptoms experienced by patients with chronic obstructive pulmonary disease, are believed to result in decreased activity levels and poor quality of life. The primary measurable benefits of pulmonary rehabilitation to date have been a decrease in symptoms (mainly dyspnea and fatigue) and an increase in exercise endurance. The precise means by which pulmonary rehabilitation improves these symptoms is not clear. The use of standardized questionnaires to measure the changes associated with pulmonary rehabilitation is important if we are to understand the magnitude of improvement with the intervention and determine those who will benefit. This article reviews the mechanisms believed to contribute to these symptoms and the methods available for their measurement.

Key words: symptoms; dyspnea; fatigue; chronic obstructive pulmonary disease (COPD); pulmonary rehabilitation, measurement, and assessment.

INTRODUCTION

Dyspnea and fatigue are the two most common symptoms experienced by patients with chronic obstructive pulmonary disease (COPD) [1,2]. While dyspnea has traditionally been considered the primary symptom limiting COPD patients, recent attention to measures of fatigue have shown both dyspnea and fatigue to be important symptoms in this population [3–5]. COPD patients often report decreases in activity levels because

of dyspnea, fatigue, or both. When these symptoms affect the performance of daily activities, the potential exists for overall quality of life to be decreased. Further, if these symptoms continue to limit daily activities and the intensity of the symptom increases (despite decreasing the magnitude of the daily activities), then the potential is great for patients to become deconditioned. This results in an interrelationship of symptoms affecting activities, and vice versa, often referred to as the “dyspnea spiral” or

Abbreviations: ATS = American Thoracic Society, BDI = baseline dyspnea index, COPD = chronic obstructive pulmonary disease, CRQ = chronic respiratory questionnaire, MAFS = multidimensional assessment of fatigue, MFI = multidimensional fatigue inventory, MRC = Medical Research Council, OCD = oxygen cost diagram, PFSDQ = pulmonary functional status and dyspnea questionnaire, PFSDQ-M = pulmonary functional status and dyspnea questionnaire—modified version, PFSS = pulmonary functional status scale, POMS = profile of moods state, POMS-F = profile of moods state fatigue, SGRQ = Saint George respiratory questionnaire, SOBQ = shortness of breath questionnaire, TDI = transitional dyspnea index, VAS = visual analog scale.

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cycle of deconditioning. Symptom intensity may play a role in this cycle, in that the greater the severity of symptoms experienced by patients, the more the interplay between psychosocial issues, mood changes, and reduction in daily activities [6]. Pulmonary rehabilitation is one of the few interventions believed to break this cycle/relationship of progressive symptoms limiting activities [7].

Pulmonary rehabilitation uses a multidisciplinary approach and combines education and exercise to affect activity levels and symptoms. The primary measurable benefits of pulmonary rehabilitation to date have been a decrease in symptoms (mainly dyspnea and, to a lesser degree, fatigue), and an increase in exercise endurance [8]. The precise means by which pulmonary rehabilitation improves these symptoms, however, is not clear. It has been proposed that exercise alone, or exercise combined with desensitization to symptoms [9], contributes to improved outcomes in patients undergoing pulmonary rehabilitation. While desensitization is a plausible explanation for improving dyspnea associated with activities, this relationship has not been established [10]. Nonetheless, it is important to assess symptoms and evaluate activity levels as a part of an outcome assessment of any pulmonary rehabilitation program [7,11]. By doing so, one not only measures the effect of pulmonary rehabilitation but also can help evaluate the impact of the program's elements (e.g., exercise, education, etc.). To appropriately assess and evaluate dyspnea and fatigue, it is important to understand how they are defined and to review their known mechanisms and the methods available to measure them.

DYSPNEA

Definition

Dyspnea, like all symptoms, is a subjective experience, and as such, is only fully known to the individual experiencing the symptom. This is reflected in the definition of dyspnea published by the American Thoracic Society (ATS) [12]:

“Dyspnea is a term used to characterize a subjective experience of breathing discomfort that is comprised of qualitatively distinct sensations that vary in intensity. The experience derives from interactions among multiple physiological, psychological, social, and environmental

factors, and may induce secondary physiological and behavioral responses.”

This definition fits well with the dyspnea experienced with COPD and by other patients commonly seen in pulmonary rehabilitation programs. It is in pulmonary rehabilitation programs that many of the secondary physiological (deconditioning) and behavioral (anxiety) responses are addressed [7].

Mechanisms

The pathophysiology believed to contribute to dyspnea in individuals with COPD can be summarized as a primary disparity between central respiratory motor activity and incoming information from receptors in the airways, lungs, and chest wall structures. For example, heightened ventilatory demand and impedance, as well as reduced respiratory muscle function, are common pathophysiological alterations that can contribute to dyspnea in individuals with COPD.

Many of the components of pulmonary rehabilitation address the mechanisms that contribute to the sensations associated with dyspnea. **Table 1** identifies those mechanisms believed to be targeted by pulmonary rehabilitation. Some evidence exists that pulmonary rehabilitation improves dyspnea by increasing the condition of the muscles, thus decreasing metabolic demands and improving overall muscle performance [7]. Furthermore, desensitizing patients to symptoms of dyspnea through controlled exposure to exertional dyspnea potentially helps alter the perception of dyspnea [9]. Reinforcing the need for bronchodilators either routinely or before exercise helps reduce the resistive loads and potentially improves ventilatory mechanics. Probably, pulmonary rehabilitation improves symptoms of dyspnea through a combination of mechanisms, many of which are still unclear.

Assessment and Evaluation

Assessment and evaluation of any subjective experience is difficult and typically relies on self-reports. Because dyspnea is a subjective symptom, it is assessed through the use of standardized symptom reports or questionnaires. One useful way to group self-report questionnaires is to determine if they are to be used to evaluate change or discriminate between groups of individuals. It is beyond the scope of this article to review in detail the specifics of these groupings; other good discussions of groupings have been published [13,14]. For the most part,

Table 1.
Interventions in pulmonary rehabilitation that target dyspnea mechanisms.*

Mechanism to Reduce Dyspnea	Interventions	Targeted by Rehabilitation
Reduce Ventilatory Demand		
Reduce metabolic load	Exercise training	X
	O ₂ therapy	X
Decrease central drive	O ₂ therapy	X
	Medications (opiates)	—
	Altered afferent signal	—
Improve muscle function	Nutrition	X
	Inspiratory muscle training	X
	Positioning	X
	Partial ventilatory support	—
Reduce Ventilatory Impedance		
Reduce/counterbalance hyperinflation	Surgery	—
	Continuous positive airway pressure	—
Reduce resistive load	Medications (bronchodilators)	X
Alter Central Perception		
	Education	X
	Cognitive-behavioral approaches	X
	Desensitization	X
	Medications (opiates)	—

*Modified from the American Thoracic Society dyspnea statement [12].

questionnaires used to measure dyspnea as an outcome of pulmonary rehabilitation are evaluative instruments. Therefore, in addition to demonstrating traditional psychometric properties of reliability and validity, these questionnaires must demonstrate the ability to measure change. Formal studies of an instrument's ability to measure change, usually referred to as assessments of responsiveness, may include such complex and controversial determinations as clinically/minimally important differences or such a simple and established one as a paired *t*-test of differences. The methods used to determine the value of clinically or minimally important differences are debatable, and a complete discussion of the issues is beyond the scope of this review. Consequently, we recommend reviewing two important examinations of these issues [15,16]. For the purpose of this review, values found in the literature will be reported here, but a careful assessment should be made of the issues involved in relation to use of the instrument. In many cases, a simple paired *t*-test or determinations of effect size are ample to evaluate the instrument's responsiveness. The important point here is that, regardless of the instrument used, it is essential to ensure that the instrument can capture change before and after rehabilitation. For example, does the dys-

pnea questionnaire measure improvement following pulmonary rehabilitation? If not, is there a valid explanation for improvement not to occur, such as the questionnaire being very stable and not sensitive to change?

It is useful, conceptually, to group measures of dyspnea used in pulmonary rehabilitation into three main categories, outlined in **Table 2**: standard measures (standardized reports of symptoms associated with activities); exertional measures (symptoms associated with exercise); and broader measures (symptoms measured in the context of quality of life or functional status). Some measures may overlap among categories, because they may have properties of more than one category. While most dyspnea questionnaires ask patients to rate the current intensity of their dyspnea, some, such as the standard measures, evaluate only dyspnea related to activities and are thus not "pure" assessments of current intensity levels of dyspnea. For example, the Medical Research Council (MRC) dyspnea scale categorizes patients based on whether their dyspnea is associated with specific tasks.

Standard Measures

The MRC is a grading system indicating dyspnea associated with walking that produces a single score

Table 2.

Reliability, validity, and responsiveness of dyspnea and fatigue measures.

Type and Name of Measure	Dyspnea	Fatigue	Reliable	Valid	Responsive
Standard					
MRC	X	—	Yes [20,21]	Yes [23]	NR
OCD	X	—	Yes [26]	Yes [25]	NR
BDI	X	—	Yes [27,28]	Yes [25]	Yes [28,30]
SOBQ	X	—	Yes [33]	Yes [32]	Yes [34]
Exertional					
Borg	X	X	Yes [37–39]	Yes [37,39]	Yes [40]
VAS	X	X	Yes [42,44]	Yes [43]	Yes [28,30]
Broad					
CRQ	X	X	Yes [46,51,52]	Yes [51,52]	Yes [48,50,53–56]
PFSS	X	—	Yes [57–58]	Yes [57,59]	Yes [60]
PFSDQ	X	—	Yes [61–62]	Yes [4,61]	NR
PFSDQ-M	X	X	Yes [62–63]	Yes [62]	Yes [65]
SGRQ	X*	—	Yes [66]	Yes [66]	Yes [66–70]
Fatigue Measures					
POMS	—	X	Yes [78,85–86]	Yes [78,85–86]	NR
MAF	—	X	Yes [87–88]†	Yes [73,87–88]	NR
MFI	—	X	Yes [89–90]†	Yes [4,89–90]	NR

Notes: Bracketed numbers represent references cited in the main text; these references further explain the psychometric properties reported in the table.

NR = no available reports

*Dyspnea measured as part of a total symptom subscale.

†Reports available only in a non-COPD population.

[17,18]. Patients are assigned to one of five grades, based on their difficulty with mobility, from Grade 1, “never troubled by breathlessness except on strenuous activity,” to Grade 5, “too breathless to leave the house or breathless after undressing.” The MRC does not uniquely measure dyspnea, since the level of dyspnea is evaluated related to activities. The MRC could thus be considered a functional status evaluation. This questionnaire, however, is easy to administer and is useful for general screening and categorizing of patients. Its use in pulmonary rehabilitation programs to evaluate dyspnea is limited. No testing of responsiveness or clinically important differences in rehabilitation setting is available. It has been used, however, to categorize patients for pulmonary rehabilitation [19]. Test-retest [20], inter-rater reliability [21] and content [22], and concurrent validity have been reported [23]. The MRC has not shown responsiveness. This may be difficult to establish because of the lack of clear differences between grades [12]. Another questionnaire that uses a similar grading system is the ATS Division of Lung Disease dyspnea evaluation [24]. The ATS

dyspnea measure was developed for epidemiologic studies and has similar indications to the MRC.

The oxygen cost diagram (OCD) is a vertically oriented, one-item scale, usually 100 mm long, with a list of daily activities placed on both sides of the line [25]. Activities are listed by name, from those requiring low energy expenditure (e.g., sleeping or sitting) on the bottom to those activities likely to cause the most energy expenditure (e.g., brisk walking uphill) at the top of the scale. Patients indicate on the 100 mm line the activity during which the dyspnea was severe enough to not allow them to go further [25]. The point selected on the line is then expressed in millimeters. The OCD is easy for the patient to complete. The reliability is reported from an intraclass correlation of 0.68 [26], and concurrent validity in COPD and population with pulmonary infiltrates without airway obstruction [25]. It is unclear how responsive the OCD is following rehabilitation, as there are no published reports of clinically important differences. However, because it correlates moderately well with the 12 min walk ($r = 0.60$) [25], it is likely to show improvement in those who

improve their walking distance following pulmonary rehabilitation; but this remains to be tested.

The baseline dyspnea index (BDI) is a rater evaluation of dyspnea associated with activities [27]. The rating includes the magnitude of the task and the effort required to perform the task. Each category is rated on a 0 to 4 grade and summated for a total score. The BDI also has a transitional score, the transitional dyspnea index (TDI), that measures the change in dyspnea associated with activities following an intervention. The BDI and TDI rely on raters to evaluate and assign patient levels of dyspnea with activities. The BDI has good interobserver reliability (weighted Kappa) of 0.65 [28] to 0.72 [27] and validity [29] correlating with the 12 min walked distance ($r = 0.60$) [28]. The TDI has been shown to be responsive to rehabilitation [28,30].

The University of San Diego shortness of breath questionnaire (SOBQ) is a 24-item, self-completion questionnaire listing 21 activities [31,32]. Patients are asked to rate their dyspnea associated with the activity, from 0 = "not at all" to 5 = "maximally or unable to do because of breathlessness." Additionally, patients rate three additional items related to dyspnea in their daily lives. Patients are asked to rate any activity they have never performed with an estimate of their dyspnea if they were to perform the activity. The SOBQ has shown good reliability taken over 2 days (test-retest, $r = 0.94$), good internal consistency ($\alpha = 0.91$), and good correlation with the 6 min walked distance ($r = -0.47$) and percentage of predicted forced expiratory volume in 1 s ($r = -0.28$) [33]; it has also been shown to be responsive postrehabilitation [34].

These standard measures of dyspnea, with the exception of the MRC and OCD, have been widely used in pulmonary rehabilitation. One of their limitations is the rating or assignment of dyspnea associated with activities. When evaluating dyspnea following pulmonary rehabilitation, researchers must consider that this linkage of dyspnea with activities makes it difficult to know whether patients are rating their activity level or the dyspnea they experience associated with the activity.

Exertional Measures

Exertional measures of dyspnea are used to evaluate dyspnea before, during, and after exercise. Given that increased exertion results in an increase in metabolic demands, it is normal to expect dyspnea to increase with exertion. Two scales have proven particularly useful in evaluating this progressive increase in symptoms during

exercise: the Borg scale and the visual analog scale (VAS).

The Borg scale [35,36], a category-ratio scale, is commonly used to evaluate the effects of exercise on dyspnea. The original and modified scales have ratio properties ranging from 0 = nothing at all to 10 = very, very severe, with descriptors from 0 to 10. (A number greater than 10 can be selected.) Descriptors have been modified by others so that 10 has been labeled "extremely severe," or "the worst possible dyspnea imaginable." Reliability and validity have been reported in a general population [37] and in COPD patients [38,39]. The Borg scale has been used in pulmonary rehabilitation programs to evaluate dyspnea before, during, and after progressive exercise [30]. While its usefulness and responsiveness in measuring dyspnea during the period of exercise [40] (e.g., treadmill) has been demonstrated, the Borg scale may not be responsive longitudinally. One investigator used the Borg scale at maximum exercise, baseline, 6 months, and 1 year and found no significant differences in patient ratings of dyspnea over time; however, patients in this study did improve their distance walked [41].

The VAS [42] is usually a 100 mm line anchored at either end with descriptors, such as "none" to "very severe." When used to measure dyspnea, these anchors are qualified to read "no shortness of breath" to "maximum shortness of breath," or some similar variation. The VAS has been shown to be equally valid when the scale is oriented not only the traditional horizontally, but also vertically [43]. The VAS can be used to quantify a number of aspects of symptoms besides the sensation of dyspnea, such as effort and distress with dyspnea. Test-retest reliability [44,45] and construct validity [43] have been demonstrated. Evaluations of dyspnea with exercise using the VAS support its responsiveness, showing dyspnea to decrease following pulmonary rehabilitation [28,30].

Exertional questionnaires are excellent measures of dyspnea with exercise in a laboratory setting. Less is known about their responsiveness to change following intervention. Test-retest correlations have been low (VAS, $r = 0.54$; Borg, $r = 0.45$) [32]. The Borg is particularly suited for the laboratory evaluation of dyspnea under controlled exercise conditions. The VAS, on the other hand, is a well standardized test to measure multiple sensations associated with dyspnea. Its measurement of a

single dimension, however, limits its evaluation of outcomes in rehabilitation programs to dyspnea in general.

Broad Measures of Dyspnea

With the burgeoning interest over the past 20 years in measuring the various effects of chronic respiratory disease on patients, a number of questionnaires have been developed that evaluate symptoms directly or indirectly. Some questionnaires have items specific to dyspnea; others measure the various symptoms of interest in pulmonary patients; and still others, the impact of more general activities and symptoms on quality of life. The use of these instruments to measure dyspnea may not be appropriate, depending on the particular program, and researchers should consider that they are generally less specific to the symptom and more complex to administer. For the purposes of this article, our review has been restricted to those instruments with published reports of use in pulmonary rehabilitation.

The chronic respiratory questionnaire (CRQ), a 20-item, disease-specific, quality-of-life questionnaire [46], has been used extensively in pulmonary rehabilitation settings. While the CRQ is normally interviewer-administered, a new self-administered version has been reported in the literature [47]. The CRQ consists of four domains (dyspnea, fatigue, emotional function, and mastery), rated on a seven-point scale. The dyspnea component of the CRQ asks patients to identify five activities of importance to them. These same activities are rated with 1 = most dyspnea and 7 = least dyspnea, before and after a pulmonary rehabilitation program. Because the activities are unique to the patient, a comparison of dyspnea scores between studies, and therefore groups, is tenuous. The clinically important difference on the CRQ has been reported as an average of 0.5 per item within a domain [48,49]. The CRQ has been criticized as not clinically useful, both because of the difficulty and time involved in its administration and because of the great variance in activities selected. Recently, the CRQ did demonstrate its ability to be reliable in the new, self-completion format [47]. The CRQ has been widely tested [50] as a measure of dyspnea in pulmonary rehabilitation. One ongoing concern has been the potential for the association of dyspnea with individually selected activities to limit the researcher's ability to make precise comparisons within or across groups. The CRQ has acceptable reliability (test-retest, $r = 0.73$), but low internal consistency for dyspnea ($\alpha = 0.53$) [51]. The CRQ dyspnea component correlates

with the VAS, $r = 0.66$ [52], and it has been shown to be responsive following pulmonary rehabilitation [53–56].

The pulmonary functional status scale (PFSS) is a 53-item, self-administered questionnaire measuring physical, mental, and social function [57]. The dyspnea subscale evaluates dyspnea related to activities, as well as dyspnea independent of activities. The PFSS has acceptable test-retest reliability ($r = 0.67$) and internal consistency ($\alpha = 0.81$) [58]. The PFSS has reports of construct validity [59], including good correlation with the 12 MWD [57]. The PFSS has been successfully used as an outcome measure following pulmonary rehabilitation [60].

The pulmonary functional status and dyspnea questionnaire (PFSDQ) is a 164-item, self-administered questionnaire that evaluates dyspnea and activity levels [61]. The shorter version, the pulmonary functional status and dyspnea questionnaire—modified version (PFSDQ-M), consists of 40 items measuring dyspnea, fatigue, and activity levels [62]. The PFSDQ measures dyspnea associated with 79 activities, while the PFSDQ-M measures dyspnea associated with 10 activities. Both questionnaires also evaluate dyspnea independent of activities with five items that evaluate dyspnea. The PFSDQ has good test-retest reliability on the dyspnea scale (test-retest, $r = 0.94$) [63] and internal consistency of $\alpha = 0.88$ to 0.94 [61]. The PFSDQ-M has also had good test-retest reliability on the dyspnea scale (test retest, $r = 0.83$), and internal consistency of $\alpha = 0.94$ [63]. The PFSDQ has been shown to be responsive over time [64], and the PFSDQ-M responsive to change following pulmonary rehabilitation [65].

Finally, the Saint George respiratory questionnaire (SGRQ) is a 76-item, self-administered, disease-specific, quality-of-life questionnaire [66]. Three domains are measured: symptoms, activities, and impact on daily life. The symptoms domain evaluates dyspnea, as well as cough, sputum, and wheezing. Scoring does not allow for differentiating dyspnea from other symptoms. The clinically important difference in the SGRQ is reported as 4 [66,67]. The SGRQ has been demonstrated to be reliable (intraclass correlation = 0.92) and valid [66]. The SGRQ has been used in pulmonary rehabilitation programs, but has not been consistently responsive to rehabilitation [67–70].

The measures of dyspnea described here vary in their ability to evaluate dyspnea following pulmonary rehabilitation. In some instances, questionnaires are designed to evaluate multiple symptoms (e.g., SGRQ), and dyspnea cannot be separated out, while others evaluate dyspnea

exclusively. It is safe to say that all evaluations of dyspnea are not the same.

Many questionnaires evaluate the dyspnea experienced with activities (e.g., BDI and SOBQ), while others evaluate several dimensions of dyspnea, both associated with and independent of activities (e.g., PFSDQ and PFSDQ-M). Selection of the instrument to measure improvements in dyspnea associated with pulmonary rehabilitation must be carefully matched to the particular program and the ways in which dyspnea is managed.

FATIGUE

Definition

Fatigue can be described as a pure physiological phenomenon or a subjective experience. Physiologically, muscle fatigue can be evaluated in response to increasing resistance or stress. In pulmonary patients, fatigue has been examined both from a physiological perspective, as in respiratory muscle performance [71] or leg fatigue [72], and as a subjective experience or symptom [4,73]. The symptom of fatigue, like dyspnea, is subjective and commonly measured by self-reports of the patient. Fatigue can occur acutely in association with a self-limiting event or chronically. For the purpose of this article, fatigue will be defined as a general sensation of tiredness, lack of energy, or exhaustion; and the discussion will be limited to its presentation as a general symptom. General fatigue, as defined here, encompasses physiological and psychological origins and is not limited to peripheral or skeletal muscle fatigue. Fatigue in patients with COPD usually presents in response to exercise or activity and resolves with rest, and it is generally reported by the patient with such terms as “exhausted” or “bushed.” However, the relationship between dyspnea and fatigue is so close that they are sometimes difficult for patients to distinguish between, which adds to the difficulty in assessment.

Mechanisms of Fatigue

While both fatigue and dyspnea are common in COPD patients [46,74], dyspnea sometimes appears to be confused with fatigue [75]. Potentially, this confusion may result because the mechanisms of dyspnea and fatigue in COPD patients are not completely clear and likely overlap. For example, it is entirely possible that due to deconditioning, a general sensation of both fatigue

and dyspnea might accompany many daily activities [76]. Oxygen use is increased in deconditioned patients and improves with exercise. Coinciding with these developments are reports of improvements in both dyspnea and fatigue. Consequently, it is of little surprise that, when measured, both symptoms correlate strongly in COPD patients. The common association between dyspnea and fatigue is supported by the strong relationships found between dyspnea and fatigue, regardless of the instrument used to measure fatigue. For example, in one study of subjects with different pulmonary conditions, 8 percent of the variance in usual dyspnea scores was attributable to fatigue measured by the profile of moods state fatigue (POMS-F)/inertia subscale [77]. On the other hand, in a study of only COPD patients, dyspnea measured by VAS was found to explain approximately 26 percent of the variance in fatigue [78]. Additionally, if individuals with COPD are asked to assess their level of fatigue and dyspnea daily, each symptom follows a similar but distinct pattern [5]. The association between these symptoms, while not clear at this point, is strong. Besides the apparent interrelated nature of fatigue and dyspnea in COPD, the improvement in this symptom following pulmonary rehabilitation [8] suggests that it is an important outcome variable.

A key concern for researchers assessing fatigue in individuals with COPD is that depression is moderately prevalent (7% to 42%) in this population [79], and it can be confused with the fatigue associated with various disease states [80,81]. In fact, the diagnostic criteria for depression includes the presence of fatigue or low energy nearly every day [82]. A major depressive episode requires that a depressed mood or other associated symptoms, such as insomnia, diminished interest or pleasure in activities, or fatigue, be present for most days for a period of at least 2 weeks. If a patient reports a depressive mood or other symptoms of depression in combination with fatigue, then a full assessment should be performed, using screening questionnaires for depression or a clinical interview by trained personnel. Further details on the assessment of or screening tools for depression is beyond the scope of this article; several excellent sources have been published [83,84]. The difficulty in measuring fatigue is determining the severity, chronicity, and persistence of the symptom and its association with other symptoms of depression.

Assessment of Fatigue

Assessment of fatigue as a general symptom requires a self-report measure or questionnaire. As mentioned earlier, the psychometric properties of the questionnaire must be evaluated before it is used as an outcome measure. With the categorization of the measures outlined in the dyspnea section, the majority of questionnaires used to measure fatigue can be labeled broader measures. Exertional measures such as the VAS and Borg have been modified to measure leg fatigue in association with exercise, but will not be elaborated on here. Many broader measures have been used with individuals with COPD, but few—with the exception of the CRQ [8]—have been used in pulmonary rehabilitation as an outcome measure.

The CRQ has a fatigue subscale consisting of five items, scored on a 7-point scale. The CRQ fatigue domain is reliable, valid with the same clinically important differences as the other components. Results of multiple randomized controlled trials of rehabilitation report a 1.5- to 5-point improvement in fatigue postintervention [8]. Consequently, to determine the outcomes of pulmonary rehabilitation, it is safe to say that the CRQ is the most widely used and tested instrument that measures both dyspnea and fatigue.

The PFSDQ-M also has been used to measure fatigue in COPD patients [5] and its psychometric properties have been discussed above. The reliability ($\alpha = 0.94$) and validity have been established for the fatigue subscale of this instrument, and these could be used separately or in conjunction with other instruments. While the PFSDQ-M has more limited testing in pulmonary rehabilitation than the CRQ, it is a useful alternative if there are concerns about dyspnea comparisons or self-administration.

The profile of mood states (POMS) is another broader measure that has been used in investigations of individuals with COPD [77,78]. The POMS is a 30-item questionnaire composed of 6 subscales (tension/anxiety, depression/dejection, anger/hostility, vigor/activity, confusion/bewilderment, and fatigue/inertia); the POMS-F subscale consists of 7 items [85]. Subjects are asked to indicate the degree or intensity of feelings in the past few days on a 5-point Likert scale (0 = not at all to 4 = extremely). Reports of the POMS-F used in the general population report good reliability (internal consistency, $\alpha = 0.93$, and test-retest, $r = 0.74$) [85,86]. Reliability estimates of the POMS-F in the COPD population ($\alpha = 0.80$) are also good, and there is evidence of construct validity [78]. However, as with the PFSDQ-M,

no reports of responsiveness to pulmonary rehabilitation or clinically important differences are available. Nevertheless, the POMS-F presents another possible way to measure fatigue in the COPD population, which could be useful, particularly in conjunction with the other subscales available on the POMS that are not found with other questionnaires.

The multidimensional fatigue inventory (MFI) was developed in the Netherlands and has undergone extensive testing in various patient populations, including cancer [87], chronic fatigue syndrome [88], and COPD [73]. The MFI contains 20 items that reportedly measure the following components of fatigue: general, physical, mental, reduced motivation, and reduced activity. A 5-point Likert scale is used, ranging from 1 = “yes, that is true for me,” to 5 = “no, that is not true for me.” The MFI has been shown to have good validity in the COPD population, but no reliability in this sample was reported [73]. Although this instrument has not been used in pulmonary rehabilitation and no clinically important differences are reported, it presents a unique aspect to measuring fatigue not seen in any other measure. Specifically, the MFI is able to tap multiple aspects of fatigue, including reduced activity and motivation, that are not measured by other instruments.

The multidimensional assessment of fatigue (MAF) (16 items) was originally designed for arthritis patients [89,90], but it has also been used in cancer patients [87] and those with chronic pulmonary disease [4]. The MAF surveys four dimensions: severity, measured by items 1 and 2; distress, item 3; degree of interference in activities of daily living, items 4 through 14; and, finally, timing (frequency of occurrence and changeability), items 15 and 16. The scoring for the MAF, not simply summative as with most instruments, requires attention to details. Reports of reliability ($\alpha > 0.80$) and validity of the MAF in other populations are good [89,90]. However, recent reports of its use in COPD have not included reliability estimates [4], and there are no reports of clinically important differences with this tool.

In summary, all the instruments used to measure fatigue in individuals with COPD present a slightly different assessment of the symptom. The CRQ has undergone comprehensive testing and use, but is only one-dimensional in its approach. Nonetheless, if used wisely, each of the other instruments could provide a slightly different and potentially broader picture of fatigue in relation to pulmonary rehabilitations.

CONCLUSIONS

Dyspnea and fatigue are important symptoms associated with COPD that improve with pulmonary rehabilitation. The use of a standardized questionnaire to measure the changes associated with this intervention is critically important if we are to understand the magnitude of improvement with the intervention and determine those who will benefit. A general guideline to follow when selecting an instrument is to carefully appraise the rehabilitation program's strengths and weaknesses and target the questionnaires to capture the maximum impact of the program. For example, if dyspnea management and energy conservation are strengths of a particular program, then a separate dyspnea and fatigue questionnaire with known responsiveness to pulmonary rehabilitation programs will help capture the impact of that program. Additionally, if a program is designed to evaluate dyspnea or fatigue in relation to specific activities, then a more specific instrument may be needed. A program that excels in improving exercise performance may want to focus on measuring improvements in these symptoms with exercise. Whatever the strength of the program, there are several instruments available that use both dyspnea and fatigue as useful outcome measures for pulmonary rehabilitation.

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