Research Article

Development of the Chronic Obstructive Pulmonary Disease Activity Rating Scale: Reliability, validity and factorial structure

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Abstract

The purpose of the present study was to develop the Chronic Obstructive Pulmonary Disease (COPD) Activity Rating Scale (CARS) to measure life-related activity in patients with COPD, and to confirm its reliability and constructive validity in a factorial structure model. The subjects consisted of 114 patients with COPD. An 88-item life-related activity list, generated previously from a literature review, was administered. The secondary structural model consisted of four factors with 12 items. The results of the confirmatory factor analysis by structural equation modeling showed the fit criteria to be statistically significant. The internal consistency of the 12 items was highly reliable (Cronbach’s α = 0.924). The CARS score was correlated with pulmonary function tests, breathlessness, and the health-related quality of life (QOL) scales in Pearson correlation coefficient. The results suggest that the COPD Activity Rating Scale is a valid scale for the assessment of life-related activity in patients with COPD.

Key words activity rating scale, chronic obstructive pulmonary disease, structural equation modeling.

INTRODUCTION

As the average age of the Japanese population has increased, so too has the prevalence of chronic obstructive pulmonary disease (COPD) (World Health Organization, 1992–1994). Previous studies have reported that functional impairments, caused by the irreversible changes accompanying COPD, limits the daily activity of COPD patients (McSweeney et al., 1982; Prigatano et al., 1984). Limitations to activity restricts the daily life of COPD patients, disrupts their self-sufficiency (Lee et al., 1991; Prigatano et al., 1984), and may subsequently lead to depression and/or anxiety, and a decrease in the patient’s quality of life (QOL) (Hoang et al., 1997; Lee et al., 1991; Mahler et al., 1992; Light et al., 1985; Weaver & Naravage, 1992; Anderson, 1995).

The relationship between functional impairment and the daily activities of COPD patients has been assessed previously in regards to their physical function, dyspnea sensation or functional status (Jones et al., 1989; Weaver et al., 1998). Although previous researchers have assessed the physiological function of COPD patients with the use of 6 min or 12 min walking tests (Light et al., 1985; Engstrom et al., 1998), they have had difficulty assessing the activity level of COPD patients, and the validity of measures that have been used to evaluate the activities of these patients (Bergner et al., 1981; Garrod et al., 2000; Leidy, 1999; Weaver et al., 1998).

In the present study, activities were defined as the dimension that deals with all aspects of human life in accordance with the International Classification of Functioning and Disability (ICIDH-2) (ICIDH, 2000). The purpose of this study was to develop a standardized questionnaire that would provide an
assessment of the life-related activities of patients with COPD, and to confirm the construct validity and reliability of the questionnaire in factorial models.

METHODS

Subjects

In the present study, 114 individuals (97 males, 17 females) with COPD, who had been referred by a pulmonary clinic physician, from five general hospitals and two outpatient clinics in western Japan, consented to participate. All of the subjects suffered from either emphysema, chronic bronchitis or both (American Thoracic Society (ATS), 1995; Siafakas et al., 1995). Those with a motor dysfunction, a tracheotomy, low cognition, and/or psychological symptoms were excluded. Approximately 20% of the participants experienced asthma. The subjects ranged in age from 50 to 91 years (M = 71.2, SD = 7.9) (Table 1).

Measurements

Pulmonary function

Using a spirometer (spirosift SP310), the participant’s pulmonary function was measured for forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1.0), % FEV1.0 and % FEV1.0 predicted.

Breathlessness

Breathlessness was measured using the Fletcher Hugh-Jones criteria (Fletcher et al., 1959). Fletcher Hugh-Jones criteria are: class I: Are you ever troubled by breathlessness except on strenuous exertion?; class II: Are you short of breath when hurrying on level ground or walking up a slight hill?; class III: Do you have to walk slower than most people on the level? Do you have to stop after a mile or so (or after 1/4 h) on level ground at your own pace?; class IV: Do you have to stop for breath after walking about 100 yards on level ground?; class V: Are you too breathless to leave the house or breathless after undressing?

Activities

Assessed activities consisted of four subordinate dimensions: self-care, domestic, outdoor, and social interaction. An 88-item questionnaire was generated by means of a literature review of previous tools that assessed activities of daily life (ADL) (Katz et al., 1963), instrumental activities of daily living (IADL) (Fillenbaum, 1985), and social activity (Lawton &

Table 1. Characteristics of the sample used in the study to develop the Chronic Obstructive Pulmonary Disease Activity Rating Scale (n = 114)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Characteristic</th>
<th>No.</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>97</td>
<td>85.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>17</td>
<td>14.9</td>
</tr>
<tr>
<td>Age (years)</td>
<td>71.2 ± 7.9 (50–91)†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Pulmonary emphysema</td>
<td>74</td>
<td>64.9</td>
</tr>
<tr>
<td></td>
<td>Pulmonary emphysema/chronic bronchitis</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Pulmonary emphysema/asthma</td>
<td>22</td>
<td>19.3</td>
</tr>
<tr>
<td></td>
<td>Chronic bronchitis</td>
<td>16</td>
<td>14.0</td>
</tr>
<tr>
<td>Clinical grade‡</td>
<td>I (mild-moderate)</td>
<td>36</td>
<td>31.6</td>
</tr>
<tr>
<td></td>
<td>II (severe)</td>
<td>27</td>
<td>23.7</td>
</tr>
<tr>
<td></td>
<td>III (very severe)</td>
<td>38</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>13</td>
<td>11.4</td>
</tr>
<tr>
<td>Pulmonary function</td>
<td>FVC (L) 1.87 ± 0.72 (0.61–4.08)†</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FEV1.0 (L) 0.95 ± 0.37 (0.29–1.75)†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breathlessness:</td>
<td>(Fletcher Hugh-Jones criteria)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class I</td>
<td>12</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>Class II</td>
<td>35</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>Class III</td>
<td>39</td>
<td>34.3</td>
</tr>
<tr>
<td></td>
<td>Class IV</td>
<td>16</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>Class V</td>
<td>12</td>
<td>10.5</td>
</tr>
</tbody>
</table>

† Mean ± SD (range); ‡ class I 70 ≥ % FEV 1.0 predicted ≥ 50; class II 50 > % FEV 1.0 predicted > 35; class III 35 ≥ % FEV 1.0 predicted. FVC, forced vital capacity; FEV1.0, forced expiratory volume in 1 s.
Brody, 1969). It was assumed that the items were of similar weighting. The questionnaire items were scored using a scale of 0 (dependent), 1 (partially dependent), and 2 (completely independent).

Functional assessment

The Medical Outcomes Study Short-Form 12-Item Health Survey (SF-12) (Ware et al., 1998) was used for the assessment of participants’ functioning. This instrument is a questionnaire developed for the purpose of assessing physical functioning, mental health, role-physical, role-emotional, bodily pain, general health perception, vitality and social functioning. The SF-12 has demonstrated validity and reliability and was used as the external standard.

Procedure

A cross-sectional survey of patients with COPD was conducted. Participants received a set of materials which included the original 88-item questionnaire, the SF-12, a list of instructions for completing the questionnaire and the informed consent form. The self-reported questionnaires were collected by the investigators within 3 days.

Statistical analysis

Content validity was assessed according to the frequency distribution and the Corrected-Item Total Correlation (CITC). Items outside 90% of the frequency distribution and below 0.3 of the CITC were excluded. Items associated with one’s sex were excluded by means of the chi-squared test. Using the remaining items, principal component analysis was performed for each of the four factors (self-care activity, domestic activity, outdoor activity and social interaction activity) to select 3 items of high factor loading for every factor. The final instrument consisted of four factors with 12 items.

Confirmatory factor analysis

The confirmatory factor analysis was performed for the assessment of the established secondary structural model. A factorial structure model for the present study was analyzed using structural equation modeling (SEM) techniques with maximum likelihood estimation. There has been consensus, in the SEM literature, concerning the best index of overall fit for evaluating structural equation modeling (Hoyle & Panter, 1998). Based on Hoyle and Panter’s (1998) recommendations, several criteria were used to evaluate the fit of the model. These included omnibuses fit indices such as the chi-squared/degrees of freedom ratio ($\chi^2$/d.f.) (Joreskog & Sorbom, 1989), and incremental fit indices, such as the goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and the comparative fit index (CFI) (Bentler, 1988). In addition, the root mean square error of approximation (RMSEA), advocated by Browne and Cudeck (1989), was used.

The $\chi^2$ is interpreted as the test of the difference between the hypothesized model and the just-identified version model. Low, insignificant values are desired (Kline, 1978). The generally agreed upon critical value for the GFI, AGFI, and CFI is 0.90 or higher. The root mean square error of approximation (RMSEA) is the standardized summary of the average covariance residuals and is thus a measure of the lack of fit between the data and the model. A low value (between 0 and 0.06) indicates a good fitting model (Hu & Bentler, 1989). The statistical significance of the standardized coefficient (path coefficient) was assessed by the critical ratio (CR). For the SEM techniques, the Analysis of Moment Structures (AMOS) Version 4.0, was used.

Analysis of reliability and validity

Reliability was obtained from the correlation coefficient scores between the second-order factor score and the total score of items. The coefficient of determination was obtained by squaring the correlation coefficient. Also, reliability was expressed by means of Cronbach’s alpha, which is a measure of the internal consistency of a scale. The generally agreed upon critical value for the Cronbach’s alpha is 0.70 or higher.

For assessment of concurrent validity, the pulmonary function tests, breathlessness measures, and the SF-12 (PCS) scores were used as the external standard. Pearson correlation coefficients between the external standards and the CARS scores were calculated.

Assessment of responsiveness

The degree of limitation to participants’ daily life activities in the present study was divided into four clinical classes of patients. These were: class I: completely dependent because of limitations to daily life activities; class II: partially dependent, because of restrictions to life-related activities and social interactions; class III: partially independent because of limitations to social interaction; class IV: completely independent with no limitations to daily life activities.
The responsiveness of the CARS was assessed using the relationship of the score distribution between the total score of the CARS and the degree of limitation of daily life in the clinical setting.

RESULTS
Table 1 shows the characteristics of the 114 patients that participated in the present study. The mean age of the participants was 71.2 years (SD = 7.9) and the majority were male (n = 97, 85.1%). The pulmonary function data revealed a mean FVC of 1.87 (SD = 0.72) liters and a mean FEV1.0 of 0.95 (SD = 0.37) liters. Regarding their clinical grade, 36 patients were in class I (31.6%), 27 in class II (23.7%), 38 in class III (33.3%) and 13 were not graded (11.4%). Five classes were identified using the Fletcher Hugh-Jones criteria for the breathlessness.

Development of the COPD Activities Rating Scale
The 12 items that were loaded onto the four factors (self-care activity, domestic activity, outdoor activity and social interaction activity) are listed in Table 2. Using these 12 items, the secondary factorial structure model (Fig. 1) was constructed. This secondary factorial structure model was named the COPD Activity Rating Scale; CARS. Figure 1 presents a proposed structural model of CARS by means of confirmatory factor analysis using SEM techniques. This model consists of four first-order factors (η1–4) including 12 items, and one second-order factor (ξ1), the life-related activity. Regarding the index of goodness-of-fit, the χ²/d.f. ratio, GFI, AGFI, CFI, and RMSEA were 1.034 (P = 0.407), 0.929, 0.889, 0.998, and 0.017 (PCLOSE = 0.841), respectively. The standardized coefficient (path coefficient) was positive to the dependent variable from the independent variable (0.592–0.934). The CR of path coefficient was 1.96 (P ≥ 0.05).

Reliability
The correlation coefficient between the second-order factor score (as the independent variable) and the total score of 12 items (as the dependent variable) was 0.94, with a coefficient of determination of 0.888. Reliability was estimated on the observed correlation of the items with each other and expressed by means of Cronbach’s alpha. The four subscale internal consistency levels ranged from 0.724 (‘domestic activity’ factor) to 0.946 (‘social interaction activity’ factor), with a total CARS scale alpha of 0.924.

Validity
Pearson’s correlation coefficients between the external standards and the CARS are shown in Table 3. Life-related activity was measured by the total score on the CARS. The coefficient correlation of the SF-12 (PCS) was 0.578, which is statistically significant

| Table 2. Chronic Obstructive Pulmonary Disease Activity Rating Scale factor structure and loadings |
|-----------------|-----------------|-------|-------|
| **Factor**     | **Item No.**    | **Item**                     | **CITC** | **Loading** |
| Self-care activity | 11              | Can you wash your whole body? | 0.856   | 0.915       |
|                 | 12              | Can you bath?                 | 0.528   | 0.640       |
|                 | 15              | Can you dress and undress?    | 0.602   | 0.728       |
| Domestic activity | 35              | Can you sweep floors?         | 0.833   | 0.839       |
|                 | 39              | Can you dry the wash?         | 0.835   | 0.856       |
|                 | 41              | Can you make the bed or change the sheets? | 0.822 | 0.837       |
| Outdoor activity | 57              | Can you go grocery shopping?  | 0.835   | 0.892       |
|                 | 60              | Can you carry groceries?      | 0.772   | 0.855       |
|                 | 63              | Can you ride on a bus or electric car? | 0.683 | 0.785       |
| Social interaction activity | 75              | Can you participate in community services? | 0.850 | 0.885       |
|                 | 78              | Can you participate in a club or social circle? | 0.848 | 0.885       |
|                 | 79              | Can you attend religious services and ceremonies? | 0.844 | 0.883       |

CITC, corrected item total correlation. † Principal component analysis.
Development of the COPD Activity Rating Scale

The coefficient correlation of the pulmonary function tests (FVC, FEV1.0, and %FEV1.0 predicted) were also statistically significant ($r = 0.466$, $r = 0.505$, and $r = 0.392$, respectively; $P < 0.01$). In addition, the Pearson's correlation coefficient between the breathlessness scores (Fletcher Hugh-Jones) and the CARS scores was statistically significant ($r = -0.618$, $P < 0.01$).

Table 3. Pearson’s correlation coefficients between the external standard and the Chronic Obstructive Pulmonary Disease Activity Rating Scale scores

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Mean ± SD</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-12(PCS)</td>
<td>—</td>
<td>32.7 ± 9.6</td>
<td>0.578**</td>
</tr>
<tr>
<td>FVC</td>
<td>L</td>
<td>1.87 ± 0.72</td>
<td>0.466**</td>
</tr>
<tr>
<td>FEV1.0</td>
<td>L</td>
<td>0.95 ± 0.37</td>
<td>0.505**</td>
</tr>
<tr>
<td>%FEV1.0 predicted</td>
<td>%</td>
<td>44.38 ± 17.48</td>
<td>0.392**</td>
</tr>
<tr>
<td>Breathlessness (Fletcher Hugh-Jones criteria)</td>
<td>—</td>
<td>2.7 ± 1.05</td>
<td>-0.618**</td>
</tr>
</tbody>
</table>

FVC, forced vital capacity; FEV1.0, forced expiratory volume in 1 s; FEV1.0 predicted, forced expiratory volume in 1 s predicted. SF-12(PCS): MOS Short-Form 12-Item Health Survey (Physical Component Scale); **$P<0.01$.

The relationship between sex and total scores, and between age and total scores was not found to be statistically significant.

Responsiveness

Figure 2 shows the relationship between activity limitation to daily life of the COPD patients and their CARS scores. CARS scores were significantly different across the four classes of activity limitation to daily life.

DISCUSSION

Many studies assessing the QOL of COPD patients have been conducted. Some of these studies have included examining the relationship between functional impairments and mental stress, such as depression, and the amount of activity in which the individual can engage (Hoang et al., 1997; Lee et al., 1991; Mahler et al., 1992; Weaver & Narsavage, 1992; Weaver et al., 1998; Anderson, 1995). It is difficult to confirm the relationships that exist between functional impairment and activity, activity and QOL, and QOL and mental stress derived from impairment or decreased activity. Because of the difficulty in predicting activity caused by functional impairment, weak
relationships between functional impairment and activity have been reported. In their work with COPD patients, Leidy (1999) and Garrod et al. (2000) assessed activity as a restricting factor for QOL. However, their definition of activity was not acceptable to the present investigators because of the conceptual ambiguities in their scales on the activity assessment instrument. There was no assessment of construct validity by way of structural equation modeling. Also, the low GFI of Functional Performance Inventory (FPI), which was assessed by confirmatory factor analysis, was not statistically significant. A cross-validity of FPI was assessed by Larson et al. (1998) and Leidy & Kenbel (1999). However, they did not perform their assessment using factorial structural modeling, except for the assessment of reliability and external validity.

Although the Sickness Impact Profile (SIP) is a very popular scale for assessing the functional status of COPD patients, there are no consistent results from the work of McSweeny et al. (1982), Prigatano et al. (1984) and Jones et al. (1989) regarding functional impairment and activity of COPD patients. The Pulmonary Functional Status Scale (PFSS) developed by Weaver et al. (1998) is also a scale for assessing functional status of COPD patients. The daily activity component in this scale includes social activity. This was not reflected in their conceptual framework. In the London Chest Activity of Daily Living (LCADL) Scale (Garrod et al., 2000), which examines sex and age, an ambiguous conceptual framework and limited explanatory factor analysis was found.

Therefore, in the present study, the investigators took into account participants’ disability and activity levels during the development of CARS. The construct validity of the secondary factor model, as shown in Fig. 1, was assessed by structural equation modeling. CARS, which includes self-care activity, domestic activity, outdoor activity and social interaction activity, showed high GFI (0.929) and positive high values on path coefficient. This suggests that construct validity existed for the four factors. The reliability of scoring on dimension of CARS was assessed with the assumption that a factor score is a true value. From the analysis, the high contribution rate of CARS supported the validity of calculating the total score. Leidy (1999) indicated that many indexes relating to activity are an inordinate burden on COPD patients, because there are too many items. In this study, the investigators restricted the number of question items in each factor and used a 3-point scale. This approach made it easier for the patients with dyspnea to answer the questionnaires. The mean of the CARS score was 16.5, with 24 points the highest score recorded. The numerical value was found to be 2/3. This was the same result as the mean for the highest score, which was around 2/3 using the 4-point scale developed by Larson et al. (1998), or around 3/4 using the 6-point scale developed by Garrod et al. (2000). Accordingly, CARS was found to be simple and easy because it has only a 3-point scale and uses only 12-items to evaluate life-related activities of patients with COPD.

In the examination of validity, using external standards for measurement, the total score of the CARS showed significantly moderate correlations with FVC ($r = 0.466, P < 0.01$), FEV1.0 ($r = 0.505, P < 0.01$), breathlessness ($r = -0.618, P < 0.01$), %FEV1.0 predicted ($r = 0.392, P < 0.01$) and MOS SF-12 (PCS) ($r = 0.578, P < 0.01$). In comparison, the Functional Performance Inventory (FPI) has been correlated with percentage, FEV1.0 predicted ($r = 0.34, P < 0.01$) (Leidy, 1999). The LCADL Scale has not been found to be correlated with FEV1.0 (Spearman correlation coefficient $= -0.18, P = 0.18$), but it has been correlated to FVC (Spearman correlation coefficient $= 0.38, P = 0.007$) (Garrod et al., 2000). Leidy (1999) indicated that it is difficult to interpret coefficient of
correlation values that are greater than 0.4 between the obstructive pulmonary function tests and activities because of the influence of individual and social needs. The coefficient of correlation between obstructive pulmonary function test values and functional capacity and/or exercise tolerance test results, using the 6 min or 12 min walking test, have been found to be approximately 0.5 (Light et al., 1985; Steele et al., 2000). Therefore, the moderate coefficient of correlation between CARS and the pulmonary function test, and the MOS SF-12 (PCS) demonstrates support for the construct validity of CARS. Although the number of female subjects in the present study was small, the total score of CARS was not influenced by sex or age.

The relationship between the degrees of limitation of daily life scores and the CARS scores was assessed. In this study, CARS scores demonstrated discriminative ability for the activity limitation grade in the four groups. These results suggest the ability to assess the activity limitation of COPD patients by using CARS. The findings of the present study indicate that the daily activity levels of COPD patients can be assessed in an efficient manner by using CARS.

LIMITATIONS

The CARS, a new standard scale, was developed to assess the activity level level of COPD patients. Validity was demonstrated by structural equation modeling. However, discriminant validity was not examined nor was predictive validity. This was because the investigation used a cross-sectional approach. As COPD has a higher frequency in males compared to females, the majority of subjects were male. Therefore, use of the CARS on females may need additional testing, even though the present study showed no significant difference between the two sexes.

CONCLUSION

The purpose of the present study was to develop the CARS for the purpose of assessing life-related activity in patients with COPD, and to confirm its reliability and construct validity using a factorial structural model. The secondary structural model consisted of four factors with 12 items. Its construct and concurrent validity and reliability were assessed. In addition, construct validity of CARS using external standards was demonstrated. The CARS is simple and efficient, does not appear to be influenced sex or age, and has the potential of assessing activity restrictions of COPD patients.

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REFERENCES


