Balance, falls, and risk of falls in COPD: systematic review of assessment instruments, measurement properties, and clinical utility

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Abstract

Objectives: to identify balance assessment instruments, issues and risks of issues used in COPD, evaluate their measurement properties, quality of evidence and clinical utility. *Method*: A review was produced following the PRISMA and COSMIN guidelines, registered in PROSPERO: CRD42021235118. Searches were carried out from November 2021 to September 2022 in the PubMed, LILACS, CINAHL, Embase, Web of Science and PEDro databases. Cross-sectional and cohort observational studies were included, without restrictions on language or year of publication, as long as they described clinical instruments for assessing balance, falls and risk of falls reporting at least one of the measurement properties: validity, reliability and responsiveness. Two reviewers will independently apply the eligibility criteria, travel risk by COSMIN, quality of evidence by the GRADE approach and assessment of clinical utility by the Tyson and Connell Scale. *Results*: 9,102 studies were selected and 21 included in the review, nine studies demonstrated adequate and sufficient measurement properties and 12 instruments were identified, of which six were evaluated for the quality of evidence. *Conclusion*: Systematic reviews of measurement properties require specialized reviewers and skills in qualitative analysis. With a recommendation GRADE of "A", the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test were the most recommended instruments for COPD. By requiring the evaluation of the clinical utility of the result, the TUG demonstrates superiority to the BBS, proving to be a great tool for judging individuals who need a thorough assessment of balance, falls and risk of falls.

Keywords: Chronic Obstructive Pulmonary Disease. Balance. Falls. Risk of falls. Measurement properties.

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable and treatable disease, characterized by persistent respiratory symptoms and the presence of airflow limitation[1-4]. The impairment of COPD is not limited to respiratory function[4,5]. People with COPD have impaired postural control when compared to healthy individuals in the same age group[5-7]. Deficits in function and mobility have been associated with a greater risk of falls in older adults[7] and have a negative impact on quality of life[8-10].

Studies suggest that COPD is one of the chronic diseases with the highest prevalence of falls[1,5,6]. In a study with a sample of 4,050 women, aged between 60 and 79 years, the prevalence of falls increased with the number of chronic diseases. The population attributable risk of having suffered at least one fall in the last 12 months estimated by adjustable models was 17.4% (10.4% to 23.9%) for arthritis, 9.4% (5.4% to 13.3%) for depression, 8% (3.3% to 12.4%) for COPD, 6.2% (1.6% to 10.5%) for circulatory diseases and 6.2% (2% to 10%) for coronary heart disease[11]. Falls are associated not only with mortality and morbidity, but also with loss of autonomy[5,6,8]. Physiological mechanisms, such as changes in muscle strength, proprioception, body sway and compromised balance, may be associated with a greater risk of falls in COPD and contribute to worsening health conditions[7-13]. Research has highlighted the importance of identifying risk factors for falls and promoting prevention[14, 15]. For prevention to be effective, it is necessary to identify the population at risk, introduce standardized and reliable assessment measures, and then establish specific multidimensional interventions focused on reducing the identified modifiable risk factors[10, 13,14].

The instruments for assessing balance, falls and risk of falls when applied to COPD allow professionals to identify and quantify possible deficits found in balance, the presence of falls and the risk of a fall occurring. Such instruments allow monitoring of these changes and favor appropriate clinical decision-making aimed at better intervention. Instruments must be valid, reliable and responsive, otherwise there is a risk of obtaining results that could lead to erroneous conclusions and conduct[6, 16,17].

Systematic reviews of outcome measurement instruments are important tools for selecting the most appropriate instrument for the construct of interest and providing an overview of quality through measurement properties[16-20]. Therefore, it is important to determine whether the available assessment instruments capture all dimensions related to the construct. A better understanding of measurement properties will help professionals select the most appropriate instruments to use in their clinical practice.

A wide variety of instruments to measure balance, falls, and fall risk can be used in COPD. Our objective was to identify instruments for assessing balance, falls and risk of falls used in COPD, evaluate their measurement properties, quality of evidence and clinical utility.

METHOD

This systematic review complies with PRISMA and COSMIN guidance for systematic reviews of outcome measurement instruments and the protocol has been registered with PROSPERO: CRD42021235118. This review included cross-sectional observational and cohort studies of adults aged 50 years or over, diagnosed with COPD, in accordance with international guidelines[1,3], regardless of gender or level of disability. Studies that reported balance, falls and risk of falls instruments including tests, scales or questionnaires, methodological studies that developed the instruments and/or evaluated their measurement properties reporting the evaluation of at least one of the following measurement properties were eligible: validity, reliability and responsiveness. Case studies and series reports, study protocols, clinical trials and studies not available in their entirety were excluded. Classifications were agreed upon by consensus among the review team to reduce variability in interpretation.

An extensive literary search was carried out in electronic databases from November 2021 to September 2022 in the *PubMed*, LILACS, CINAHL, *Embase*, *Web of Science* and PEDro databases. The search did not restrict language or year of publication. The search strategy was carried out for each database,

including controlled database vocabulary when available (MeSH, EMTREE and CINAHL *Subjective Headings*) and free terms with the combination of the words "Chronic Obstructive Pulmonary Disease", "balance", "falls", "risk of falls". Then the words "measurement properties", "reliability", "validity" and "reproducibility" were added with the purpose of increasing the sensitivity of the research and adapting it to the COSMIN methodology.

Two reviewers (A.L. and B.L.) independently applied the eligibility criteria for the selection of studies, such as study objectives, population characteristics, clinical measure evaluated, measurement instruments, examiners, operationalization of measures and type of statistical analysis. Another reviewer (S.V.) was requested in case of disagreement or doubt. All collected data was allocated to the *Mendelay* reference management program and reference analysis was performed manually. After removal of duplicates, reviewers (A.L. and B.L.) independently screened titles and abstracts followed by full-text screening in a blinded manner using standardized electronic forms. Disagreements were resolved by consensus.

Two researchers independently (A.L. and B.L.) analyzed the quality of the included studies through the *Consensus-based in* COSMIN *Risk of Bias tool to assess the quality of studies on reliability and measurement error of outcome measurement instrument* [15-19]. *The* COSMIN *Risk of Bios tool* tracks the risk of bias of the individual studies included and describes the elements that together assist us in constructing a research question and provides a comprehensive overview of the components of the outcome measure as well as the design requirements and preferred statistical methods regarding instrument measurement reliability and error.

The classification of instrument evidence was performed using the GRADE approach modified by COSMIN.

Two independent researchers (A. L. and B. L.) evaluated the clinical utility of the measurement instruments found in the systematic review using the Tyson and Connell clinical utility scale[20] which evaluates four items: instrument application time, data analysis and interpretation, cost, need for equipment and specific training, and portability. The final score quantifies whether a specific instrument can be used and recommended for clinical practice. For the instrument to be recommended, it must have a score greater than or equal to nine.

DATA AVAILABILITY

The entire dataset supporting the results of this study is available upon request from the corresponding author [Ana Cristina Lamezon]

RESULTS

The search strategy identified 9,102 studies. The results of the database search and the selection process are detailed in Figure 1. Of this total, 21 studies met the eligibility criteria and were included in this systematic review and 12 instruments for assessing balance, falls and risk of falling were found. Participant characteristics in the included studies are summarized in Table 1.

The instruments for assessing balance, falls and risk of falls found in this review were categorized into performance instruments (PerFORM): *Berg Balance Scale* (BBS), *Balance Evaluation Systems Test* (BESTest), MINI-BESTest, Brief-BESTest, *Timed up and Go* (TUG), *Timed up and Go* dual task (TUGDT), *Single-Leg Stance* (SLS), *Tinetti get up and go test, Unipodal Stance Test* (UST); Instruments with results reported by the evaluator, (ClinROM): Force platform or posturography; Self-report questionnaires (PROM): self-report of falls and the *Elderly Falls Screening Test* (EFST).

The risk of bias of the included studies according to COSMIN *Risk of Bias checklist*[9-12] is presented in Table 2. The main measurement properties evaluated were reliability, internal consistency and construct validity. Criterion validity was demonstrated only in one study where the abbreviated MiniBESTest instrument was validated from BESTest. Of the 21 studies included, nine presented measurement properties considered adequate and sufficient, five adequate and insufficient, one adequate and indeterminate, four studies were classified as doubtful and insufficient and one study classified as doubtful and indeterminate following the COSMIN methodology.

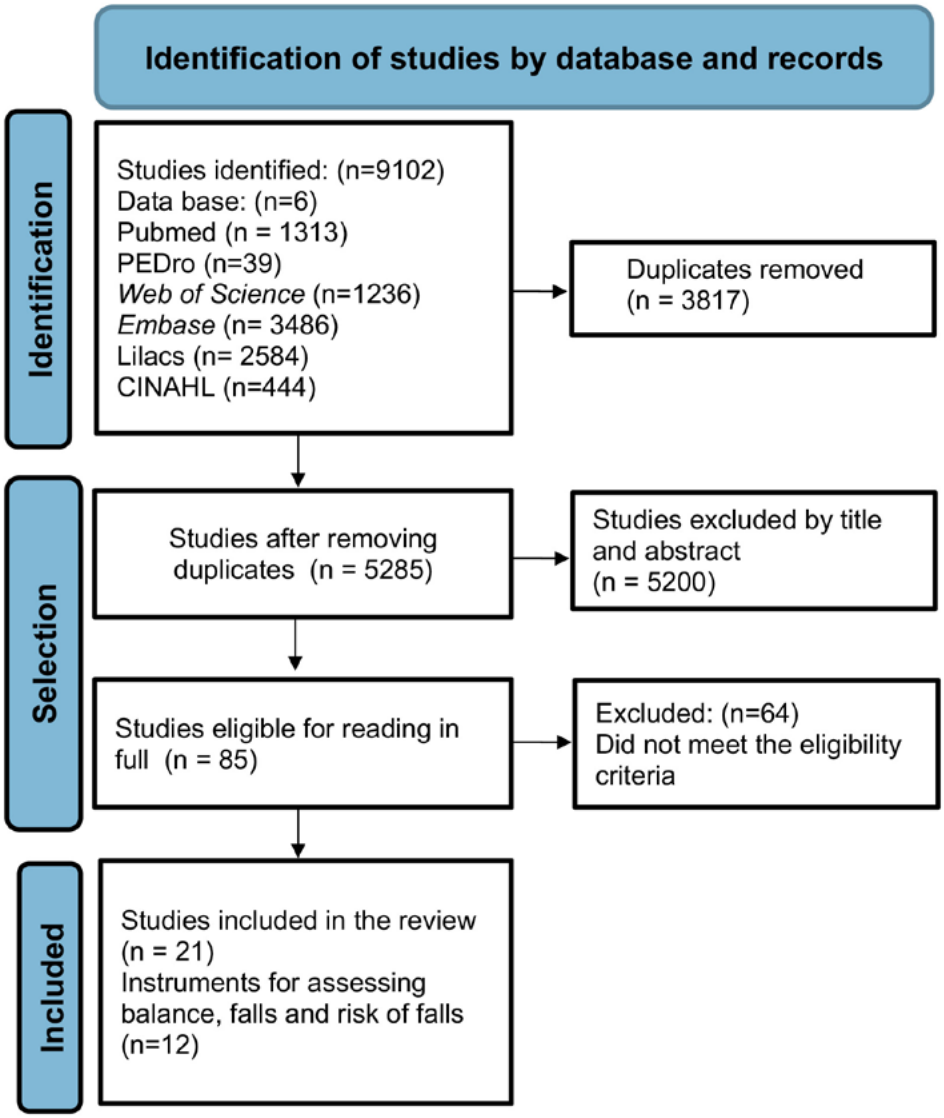

Figure 1. Flowchart of study selection according to the *Preferred Reporting Items for systematic Reviews and Meta Analyses*. Curitiba, PR, Brazil, 2023.

Table 1. Characteristics of the studies included in the Systematic Review. Curitiba, PR, Brazil,2023.

Studies	COPD (n)	M (n)	F (n)	COPD Sta (n)	COPD Exa (n)	Contr (n)	Age (years)	Smo (a/m)	O_2 Sup (n)	FEV_1 (%pred)	Falls 12m (n)
Mclay et al.[21]	86	45	41	86	0	0	72.9(±6.8)	46.0(±27.0)	25(±29.1)	47.3(±20.3)	34
Crisan et al.[22]	46	NM	NM	29	17	0	62.5(±5.0)	>10	NM	NM	17
Jacome et al.[23]	46	24	22	46	0	0	75.9 (±7.1)	NM	NM	69.4(±19.9)	23
Oliveira et al. [24]	40	19	21	40	0	25	71(±8.1)	49.6 (±25.8)	18	45.1(±16.2)	13
Ozalevli et al. [25]	36	25	11	36	0	20	70.3(±3.0)	42.1(±11.2)	NM	43.5(±6)	10
Voica et al.[26]	27	NM	NM	27	0	17	NM	>10	NM	NM	NM
Nantsupawat et al.[27]	14	8	6	14	0	0	69.7(±6.0)	NM	3(±21.4)	36.9(±.6)	3
Muti et al.[28]	50	NM	NM	50	0	0	66.2(±8.2)	NM	NM	51.8(±15.9)	23
Porto el al. [29]	132	72	60	132	0	39	67.3(±10)	49.1(±23)	NM	89.2(±23.6)	35
Hellstrom et al.[30]	80	29	51	80	0	0	65(±9.0)	NM	NM	47.5(±13)	20
Park et al.[31]	34	14	20	34	0	22	68.9(±1.3)	NM	20	44.1(±3.1)	21
Mkacher et al.[32]	60	NM	NM	60	0	0	61.2(±3.2)	0	NM	58.6(±8.6)	NM
Beauchamp et al.[8]	39	18	21	39	0	0	71.1(±6.8)	>10	18	41.5(±17)	18
Al Haddad et al.[33]	132	74	62	132	0	58	68(±8.0)	46.0(±26)	NM	59(±18)	27
Singh et al.[34]	41	38	3	41	0	41	NM	NM	0	47.6(±17.9)	NM
Pereira et al.[35]	70	46	23	70	0	0	67(±9.3)	56.0 (±38.2)	0	42.7(±14.2)	29
Harrison et al.[36]	32	17	15	32	0	0	68.5(±9.9)	62.3 (±30.4)	NM	38.2(±14.7)	NM
Roig et al.[14]	20	NM	NM	20	0	20	72.3(±6.7)	NM	0	46.7(±13.0)	4
Roig et al.[37]	101	56	45	101	0	0	NM	NM	31	43.4(±36.9)	32
Tudorache et al.[38]	61	NM	NM	22	19	20	60(±4.0)	>20	0	27.5(±7.0)	NM
De Castro et al.[39]	72	27	20	47	0	25	68(±5.0)	NM	NM	45(±15)	NM

n: sample; M: masculine; F: feminine; DPOC sta: DPOC stable; DPOC exa: DPOC exacerbated; Control: control group ; smo: smoking; a/m: anos/maço; O_2 Sup: supplemental oxygen; FEV1: Expiratory volume in the first second ; %pred: predicted percentage; NM: not mentioned; Falls 12m: number of falls in the last 12 months. Source: the author.

Table 2. Risk of bias according to COSMIN Risk of Bias Checklist. Curitiba, PR, Brazil, 2023.

Study	Year	Content Validity	Construct Validity	Internal Cons.	Transcul. Validity	Reliab.	Measure Error	Criterion Validity	Hypot. Test	Respons.	Final Class.
Mclay et al.[21]	2020	A/+	N/I	N/I	N/I	N/I	N/I	N/I	O/+	N/I	A/+
Harrison et al.[36]	2019	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	A/-	A/-
Voica et al.[26]	2016	A/?	N/I	N/I	N/I	N/I	N/I	N/I	A/-	N/I	A/?
Hellstrom et al.[30]	2009	A/?	N/I	N/I	D/?	N/I	N/I	N/I	D/-	N/I	D/-
Nantsupawat et al.[27]	2015	A/?	N/I	N/I	N/I	N/I	N/I	N/I	D/-	N/I	D/-
Muti et al.[28]	2019	A/+	N/I	N/I	N/I	A/ +	N/I	N/I	A/+	N/I	A/+
Roig et al.[15]	2012	A/-	N/I	N/I	N/I	N/I	N/I	N/I	D/?	N/I	D/?
Porto el al.[29]	2017	A/+	N/I	N/I	N/I	A/+	N/I	N/I	A/+	N/I	A/+
Jacome et al.[23]	2016	A/+	N/I	N/I	N/I	A/+	A/-	A/+	A/+	N/I	A/-
Park et al.[31]	2020	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/+
Mkacher et al.[32]	2017	A/+	N/I	N/I	N/I	A/+	A/-	N/I	A/+	N/I	A/-
de Castro et al.[39]	2016	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/+
Al Haddad et al.[33]	2016	A/+	N/I	N/I	N/I	A/+	N/I	N/I	A/+	N/I	A/+
Tudorache et al.[38]	2015	A/-	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/-
Ozalevli et al.[25]	2011	A/-	N/I	N/I	N/I	N/I	N/I	N/I	A/-	N/I	A/-
Singh et al.[34]	2019	A/-	N/I	N/I	N/I	N/I	N/I	N/I	D/-	N/I	D/-
Pereira et al.[35]	2019	A/+	N/I	N/I	A/+	N/I	N/I	A/+	A/+	N/I	A/+
Beauchamp et al.[8]	2009	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/+
Oliveira et al.[24]	2015	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/+
Roig et al.[37]	2011	A/+	N/I	N/I	N/I	N/I	N/I	N/I	A/+	N/I	A/+

Internal Cons.: internal consistency; Transcul Validity: transcultural validity; Reliab. : reliability; Hypot Test.: hypothesis testing; Respons: responsiveness; Final Class.: final classification; Quality of study development: "O": excellent or very good; "A": adequate; "D": doubtful; "I": inadequate; Quality of studies on measurement properties: "+":sufficient; "-": insufficient; "?": indeterminate; "±": inconsistent; N/I: not investigated.
Source: the author.

After consensus among the authors, we chose to analyze only the assessment instruments of the included studies that presented adequate and sufficient measurement properties. The reliability domain was the most addressed in these studies (five studies) and the quality of the evidence in these instruments was determined through the modified GRADE approach and characterized by the level of evidence in A, B or C. Instruments classified as "A" have sufficient evidence to recommend their use in COPD, "B" are not recommended and "C" require further studies for recommendation and are presented in Table 3.

The BBS and TUG instruments presented an "A" rating for quality of evidence, and are recommended for assessing balance and risk of falls in COPD. The BESTest, MiniBESTest, BriefBEST-test and UST instruments were classified as moderate "C" evidence and require further studies for recommendation. None of the instruments included in this review with measurement properties classified as adequate and sufficient were classified as "B".

The Tyson and Connell Scale[20] was applied to instruments that presented adequate and sufficient measurement properties according to the risk of bias and quality of evidence. We observed that most instruments obtained the maximum score (9/10 or 10/10) in the assessment of clinical utility, as can be seen in Table 4.

Table 3. Quality of evidence according to modified GRADE. PR, Brazil, 2023

Instrument	ICC	Sample	Quality of evidence	Recommendation
BBS	0.82-0.93	106	High	A
BESTest	0.87	46	Low	C
MiniBESTest	0.88	46	Low	C
TUG	0.91-0.95	237	High	A
Brief-BESTTest	0.82	46	Low	C
UST	0.91	60	Moderate	C

BBS: *Berg Balance Scale*; BESTest: *Balance Evaluation Systems Test*, TUG: *Timed up and Go;* UST*: Unipodal Stance Test*; Variation-ICC: upper and lower limits of intraclass correlation; n: sample; A: recommended instrument; C: instruments with the possibility of recommendation.

Table 4. Clinical utility of measuring instruments. Curitiba, PR, Brasil, 2023.

Instrument	Administration time	Total cost	Equipment portability	Equipment training	Final score
BBS	2	3	2	2	9
BESTest	1	3	2	2	8
MiniBESTest	2	3	2	2	9
TUG	3	3	2	2	10
Brief-BESTTest	3	3	2	2	10
UST	3	3	2	2	10

BBS: *Berg Balance Scale*; BESTest: *Balance Evaluation Systems Test*, TUG: *Timed up and go*; UST: *Unipodal Stance Test.*

DISCUSSION

This systematic review was designed to determine the most appropriate balance, falls and fall risk assessment instruments for use in COPD and provide a comprehensive view of the properties of measurements found in the literature and provide support for recommendation in clinical practice with sufficient evidence.

The selection of included instruments was based on evidence of the quality of the outcome of these measurement instruments (i.e. reliability, validity and responsiveness) as well as aspects of feasibility or clinical utility following the COSMIN initiative criteria and clinical utility scale by Tyson and Connell[20]. We identified the following balance, falls and risk of falls instruments used in COPD: (1) BBS - assesses functional balance and risk of falls; (2) BESTest, MiniBESTest and BriefBESTest - static and dynamic balance; (3) TUG and TUGDT - functional mobility and risk of falls, (4) SLS, Tinette Test, UST and posturography, assessment of static balance, (5) EFST and Self-report of falls - assessment of retrospective falls. Of the 12 instruments found, only six presented sufficient quality of evidence for some degree of recommendation in COPD. The quality of evidence was assessed only in instruments included in studies with at least adequate quality in the development of the study and sufficient reliability assessment[15,16].

Every instrument must reflect the internal structure of the construct, that is, the empirical structure of the instrument must reflect the theoretical structure that must be covered by the measure. The assessment of the internal structure, which comprises structural validity, internal consistency, cultural validity, will only be relevant if the instrument is composed of multiple items and based on a reflective model, which assumes that all items of a scale or subscale are manifestations of an underlying construct[14-19].

Regarding cross-cultural validity, although many original versions have been translated into other languages or adapted to other cultures, we identified only three studies that cited validations[23, 31,35], that is, they did not evaluate such a measure and only in one study the property was evaluated and it was classified as adequate[35]. Such studies are necessary to assess whether measurements from a population of a given culture are equivalent to those from another population.

The most frequently found measurement property, and for which the instruments showed sufficient evidence, was the hypothesis test for construct validity, where only four studies presented doubtful classification. Authors often use the term criterion validity for studies in which an instrument is compared to others that measure a similar construct. In most cases, this would be considered evidence for construct validity, rather than criterion validity following the considerations of the COSMIN methodology. Its definitions and analyzes must be demonstrated in hypothesis testing for construct validity[15-19].

Criterion validity is the degree to which an instrument's scores are a reflection of a "gold standard"[15-18]. Based on the COSMIN guidelines, we agree that there is no gold standard for the identified instruments[15,17,18], unless the instrument has a long and a short form. In this case, the full version of a measure is the "gold standard" of the short form[11]. In our study, criterion validity was only scored in the MiniBEST and BriefBESTest instruments, which are summarized versions of BESTest[23,32].

The reliability domain through test-retest was evaluated in seven studies with adequate and sufficient measures[22,27,28,31,32]. The measurement error was reported in only two studies and with insufficient data for an adequate classification[22,31].

We identified that the BBS and TUG were the most appropriate instruments for COPD, with a recommendation grade of "A", but in the clinical utility criterion[20] the TUG stood out due to the shorter application time compared to the BBS, which proves to be useful for screening patients who will require a more in-depth balance assessment[14,19]. With recommendation grade B, the BESTest, MiniBESTest, BriefBESTest and UST instruments can be provisionally recommended until new studies are developed, mainly because in the studies found with adequate and sufficient evidence the number of participants was below 100, which according to

the Modified GRADE[15] evaluation is enough to downgrade the evidence.

Broad, comprehensive and sensitive database research and the use of rigorous methodology are aspects to be highlighted in this review. The studies were independently reviewed, as recommended by COSMIN's best evidence, in accordance with the *Cochrane* methodology. Classifications were agreed upon by consensus among the review team to reduce variability in interpretation.

As an eligibility criterion, our study sought individuals diagnosed with COPD aged 50 years or older. Most of the included studies fully met this criterion, but in the study by Singh et al[34] part of the recruited sample was aged over 40 years. It is possible that in a younger population with COPD, the recommendations of this study cannot be extrapolated.

As there are currently no standards and criteria for content validity, face validity, which is a very subjective judgment about whether the content of the instrument really appears to be an adequate reflection of the construct being measured, the evaluation of this criterion by reviewers may suffer from interpretation bias.

As no instrument was developed for COPD specifically, content validity was assumed and classified as adequate, since during the validation process for other diseases the instrument was analyzed and presents relevant, comprehensive and understandable items with regard to the construct of interest. It would be interesting that in future validation studies of measurement instruments for COPD, content validity is carried out for this specific population.

CONCLUSION

Systematic reviews of measurement properties are complex and involve reviewers with knowledge of the construct of interest, experience in the target population, and expertise in measurement properties and qualitative analysis. Researchers and professionals who are deciding on the most appropriate balance, falls, and fall risk measurement instrument for use in COPD can often find multiple instrument models, and the recommendations noted in this systematic review can assist in making the most appropriate clinical decision about the use of these instruments.

BBS and TUG were the instruments with the highest degree of recommendation for application in COPD, but in the clinical utility criterion, the TUG stood out due to the shorter application time.

This review identifies gaps in the presence of quality evidence in available measurement instruments and therefore provides a useful framework both for further evaluations of these instruments and for the development of new specific instruments to assess balance, falls and risk of falls in COPD. The results of this review will also help researchers and healthcare professionals make evidence-based decisions about the use of these measurement instruments.

AUTHORSHIP

- Ana Cristina Lamezon - Conception, design or analysis and interpretation of data; writing the article or its critical review; approval of the version to be published; responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work are addressed.
- Bruna Cavon Luna - Analysis and interpretation of data; writing of the article; critical review; approval of the version to be published; responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work are addressed.
- Silvia Valderramas - Conception, design or analysis and interpretation of data; writing the article or its critical review; approval of the version to be published; responsible for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work are addressed.

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