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Measuring Frailty in Old Age: Rasch Analysis of the FRAIL Scale

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Measuring Frailty in Old Age: Rasch Analysis of the FRAIL Scale

Abstract

Objective. To evaluate by Rasch analysis the validity of the FRAIL scale for measuring frailty in older people in Colombia. **Methods.** Cross-sectional study including 2506 people aged ≥60 years living in Bucaramanga, Medellín, Pereira, Popayán, and Santa Marta in 2021. Guidelines for analysis of the FRAIL scale were followed and the Rasch model was used with adjustment of response categories, items and people, differential functioning of the items, dimensionality, local independence of the items, Wright reliability, and adjustments of the infit and outfit mean squares. **Results.** Overfitting of the weight loss item was identified although it did not compromise the unidimensionality or the total score. Wright reliability was 0.80; the measure explained 45.2% of the variance in raw scores. **Conclusions.** The FRAIL scale is a valid tool for assessing frailty in elderly people. It is unidimensional, reliable and unbiased by age for the frail state but not for the prefrail condition. Inclusion of the gender variable and categorization of the age variable with 70 years as cut-off point are suggested.

Keywords: elderly, frailty, validation study, psychometrics.

Medición de la fragilidad en la vejez: análisis Rasch de la escala FRAIL

Objetivo. Evaluar la validez de la escala FRAIL para medir la fragilidad en personas mayores de Colombia, mediante el análisis Rasch. **Métodos.** Estudio transversal, con la participación de 2506 personas de 60 y más años, residentes en cinco ciudades de Colombia en el 2021. Se siguieron los lineamientos para análisis de la escala de FRAIL, usando el modelo Rasch con ajuste de categorías de respuesta, de los ítems y las personas, funcionamiento diferencial de los ítems, dimensionalidad e independencia local de los ítems y confiabilidad Wright, con ajustes de las medias cuadráticas Infit y Outfit. **Resultados.** Se identificó sobreajuste del item pérdida de peso, pero no compromete la unidimensionalidad ni el puntaje total. La confiabilidad Wright fue de 0,80, la medida explicó el 45,2% de la varianza de las puntuaciones crudas. **Conclusiónes**. La escala FRAIL es una medición válida para determinan la fragilidad de la persona mayor, unidimensional, confiable e insesgada por edad para el estado frágil, no tanto para la condición prefragil. También se sugiere la inclusión de la variable sexo y categorizar la variable edad, con 70 años como punto de corte.

Palabras clave: anciano, fragilidad, estudio de validación, psicometría.

Introduction

The classification of frailty in older people presents difficulties regarding conceptualization and standardization (Sobhani et al., 2021). Despite it may be carried out through different approaches (Wleklik et al., 2020) and measurement tools (Sutton et al., 2016)there is insufficient evidence at present to determine the best tool for use in research and clinical practice. Further in-depth evaluation of the psychometric properties of these tools is required before they can fulfil the criteria for a gold standard assessment tool.\n\nElectronic supplementary material\nThe online version of this article (doi:10.1186/s12877-016-0225-2, there is uncertainty about whether fragility is a construct that may be measured or merely classified (Mayo et al., 2023). The frail condition is defined as a clinical syndrome wherein the individual has low reserves and is vulnerable to stressors occurred with aging (Chen et al., 2018). Among the recommended tools for its detection is the FRAIL scale (Van K. et al., 2008), fatigue (refers to feeling tired most or all of the time in the past 4 weeks), resistance (finds difficulty or is unable to climb a flight of stairs), ambulation (has difficulty or cannot walk a block), illness (has more than 5 illnesses), loss of weight (have lost more than 5% of weight in the last 6 months) (Morley, 2017), which combines elements proposed by Fried and Rockwood (Nidadavolu et al., 2020). According to this approach, frailty is a unidimensional formative construction quantified by counting such physical manifestations (Mayo et al., 2023). In one study, high diagnostic accuracy was reported for the frailty condition with hypothesis testing using FRAIL (O'Caoimh et al., 2023); similarly, another investigation reported a general Cronbach's Alpha of 0.786, which represented acceptable consistency (Alqahtani & Nasser, 2019)test-retest reliability over two visits with a one-week interval. We assessed criterion-related validity with the Fried Frailty Index as a reference measure and construct validity with other related measurements. MAIN OUTCOME MEASURES: Arabic version of the FRAIL Scale, grip strength, the Mini-Mental State Examination, a short physical performance battery, the Timed Up and Go test, the Fried Frailty Index, and the Duke Comorbidity Index.SAMPLE SIZE AND CHARACTERISTICS: 47 community-dwelling older adults (66% male, mean [SD] age 70 [4] years. Also, in a systematic review and meta-analysis FRAIL is a feasible tool for assessing frailty of older adults in community settings, with good criterion validity and test-retest reliability (Ng et al., 2024) and this scale is a promising short screen to stratify and help operationalize the perioperative care of older surgical patients (Gleason et al., 2017)the FRAIL scale, to categorize the level of frailty of older adults admitted with a fracture to determine the association of each frailty category with postoperative and 30-day outcomes. Design: Retrospective cohort study. Setting: Level 1 trauma center. Participants: A total of 175 consecutive patients over age 70 years admitted to co-managed orthopedic trauma and geriatrics services.\nMeasurements: The FRAIL scale (short 5-question assessment of fatigue, resistance, aerobic capacity, illnesses, and loss of weight.

Thus, the FRAIL scale was the starting point of this research and for its development a psychometric evaluation was required (Rosas-Carrasco et al., 2016) through Rasch analysis can be used to document and evaluate the measurement performance of instruments that measure a construct. The Rasch technique also allows us to explain the meaning of a test score and thus provide a mechanism by which the quality of the tests can be optimized (Boone, 2016); in the same way Rasch relates the difficulty of the items, individual ability and the probability of a correct answer. It also recognizes that the probability of a correct response to each individual item depends not only on the difficulty of the item but also on the skill level of the individual. This is a probabilistic model that estimates the probability of a correct response to an item based on the difficulty of the item and the skill level of the individual (Christensen et al., 2024), based on the item response theory (IRT). The IRT refers to

probabilistic measurement models according to the number of analyzed parameters; in addition, it provides an idea of the internal consistency of the scale and may relate the difficulty of the item to the person's ability (Mayo et al., 2023). Therefore, new characteristics related to its validity could be provided, offering the professional elements for decision-making and interpretation of frailty in old age. Consequently, this study aimed to evaluate through Rasch analysis the validity of the FRAIL scale to measure frailty in older people in Colombia.

Materials and Methods

Design

This validation study included 2506 people aged ≥60 living in the urban area of 5 Colombian towns (Bucaramanga, Medellín, Pereira, Popayán, and Santa Marta) due to the difficulty of access in the rural area given the situation in the country and added to the time of the pandemic in which restrictions were presented and made access to this population more complex, with a 2-stage probabilistic sampling. In the first stage 51 neighborhoods in each town were selected as a secondary unit of the sample, through systematic random sampling. Within each neighborhood 2 blocks were selected as the primary unit of the sample by simple random sampling. The information was collected between April and May 2021 (Cardona et al., 2022).

Variables

The FRAIL scale (Van K. et al., 2008) may be used at community level; it does not require equipment, takes <5 minutes, and may be self-completed. The tool has been recommended as a screening test for disability and mortality (Morley et al., 2012). Frailty is classified according to the scores of the items: 0 for robust health status, 1-2 for prefrail, and ≥3 for frail (Rosas-Carrasco et al., 2016). This study aimed to test the validity and reliability of the tool in elderly Colombians living in urban areas by using the Rasch model.

Statistical analysis

The scale was analyzed using the Rasch model for dichotomous items (Boone, 2016). According to this model, a positive response from an older person is a probabilistic function of the level of attributes (ability) and the difficulty of the item, so the probability of a positive response in a person ≥60 years of a certain level of attributes to an element of a given difficulty is equal (Engelhard et al., 2018). Consequently, this type of analysis focuses on establishing whether the data obtained using the tool provide an invariant, unidimensional, interval-scale representation of the latent attribute of interest (frailty) (Rojas-Gualdrón et al., 2019). The analyzes were carried out using Winsteps 3.92.1 and Jamovi 23.28 free version.

Adjustment of response categories

The fit of the items to the assumptions of the Rasch model was assessed using outfit and infit mean squares, item-measure correlations, and local independence analysis. For these 3 statistics, mean squares between 0.50 and 2.00, item-measure correlations ≥0.30, and correlation between the residuals of the items <0.70 were taken as expected values (Bond & Fox, 2015)this classic text facilitates a deep understanding of the Rasch model. The authors review the crucial properties of the model and demonstrate its use with a variety of examples from education, psychology, and health. A glossary and numerous illustrations aid the reader's understanding. Readers learn how to apply Rasch analysis so they can perform their own analyses and interpret the results. The authors present an accessible overview that does not require a mathematical background.\n\nHighlights of the new edition include:\n-More learning tools to strengthen readers' understanding including chapter introductions, boldfaced key terms, chapter summaries, activities, and suggested readings.\n-Divided chapters (4, 6, 7 & 8. The scale was assesed using Linacre's effectiveness criteria (J. M. Linacre, 2002)2002, based on outfit and infit mean squares adjustment, measure → category and category → measure coherences, and the measures (in logits) of the response options.

Adjustment and differential items functioning (DIF)

In the Rasch measurement, several fit indices based on residuals are used. Fitting the data to the Rasch model (content validity) was done by means of the mean square residuals (MNSQ), and the infit and outfit indices were calculated. The former indicates the adjustment between the expected and the observed value of the average values, while the later takes into account people's unexpected responses (Engelhard et al., 2018). The expected values of these statistics range between 0.50 and 1.50 (Bond, 2015) this classic text facilitates a deep understanding of the Rasch model. The authors review the crucial properties of the model and demonstrate its use with a variety of examples from education, psychology, and health. A glossary and numerous illustrations aid the reader's understanding. Readers learn how to apply Rasch analysis so they can perform their own analyses and interpret the results. The authors present an accessible overview that does not require a mathematical background. Highlights of the new edition include: More learning tools to strengthen readers' understanding including chapter introductions, boldfaced key terms, chapter summaries, activities, and suggested readings.\n-Divided chapters (4, 6, 7 & 8. Standardized measured square values (MNSQ) ≥1.00 reflect response patterns with larger than expected variation, while values lower than the reference tend to reflect less variation (Engelhard et al., 2018). Local independence between the items was established through correlations between the residuals and expected values <0.40 (M. Linacre, 2023). The locations of the items with standard errors were calculated and are expressed in logits. Each item was examined to detect DIF according to 2 variables (Aryadoust et al., 2019): gender (female/male) and age (≥70 and <70 years). Comparisons of 2 groups were carried out using the Bland and Altman limits of agreement (Bland & Altman, 1986).

Unidimensionality, reliability and Wright's map

To define the unidimensionality of the items, the variance explained and not explained by the test was assessed, with an explained variance >30% being aceptable (Bond, 2015) this classic text facilitates a deep understanding of the Rasch model. The authors review the crucial properties of the model and demonstrate its use with a variety of examples from education, psychology, and health. A glossary and numerous illustrations aid the reader's understanding. Readers learn how to apply Rasch analysis so they can perform their own analyses and interpret the results. The authors present an accessible overview that does not require a mathematical background. Highlights of the new edition include: More learning tools to strengthen readers' understanding including chapter introductions, boldfaced key terms, chapter summaries, activities, and suggested readings. Divided chapters (4, 6, 7, & 8. It was explored through principal component analysis (PCA) of the residuals between the observed data and the model estimation (Cantó-Cerdán et al., 2021) infit and outfit mean square, local dependency using Yen's Q3 statistic, Differential item functioning (DIF. For the contrasts with these characteristics, 3 groups of items were constructed and the correlation ≥0.5 was calculated. These were considered irrelevant and evidence of the validity of a unidimensional approach to the FRAIL scale (Cantó-Cerdán et al., 2021)infit and outfit mean square, local dependency using Yen's Q3 statistic, Differential item functioning DIF. The reliability of the items, separation of items and internal consistency were calculated, the hierarchy and orientation of the elements were analyzed, with a separation into 2 strata. In addition, the Rasch model allowed us to assume when an item measured a certain attribute or phenomenon and was presented with an item characteristic curve (ICC). The probability of obtaining a positive value in the response to the given item is shown on the Y axis and the ability

of the individual on the X axis (Cantú González & Rodríguez Macías, 2017).

Ethical Considerations

This minimal risk study was derived from the *Health and mental well-being of the elderly, 2020 (SABAM)* (Cardona et al., 2022) research. It was approved by the Ethics committee of CES University (Minute 161, Project code 991, Resolution 8430; May 3, 2021), and financed by CES University.

Results

Sociodemographic characteristics of the study population consisting of 2506 elderly people are shown in Table 1. Approximately 60% of the subjects were <70 years of age and more than 50% were female and of low socioeconomic status. Regarding education, 79.8% had a basic educational level and 11.9% had higher instruction. As about marital status, >50% were single, separated/divorced or widowed.

Table 1
Sociodemographic characteristics of elderly participants in 5 towns–2021

Variable	Total	Age (years)	
		≤70	>70
Gender	**n (%)**	**n (%)**	**n (%)**
Male	1153(46)	691(27,6)	462(18,4)
Female	1353(54)	825(32,9)	528(21,1)
Household socioeconomic status			
Low	1533(61,2)	925(36,9)	608(24,3)
High/middle	973(38,8)	591(23,6)	382(15,2)
Educational level			
None	210(8,4)	85(5,6)	125(12,6)
Basic	1999(79,8)	1227(80,9)	772(78,0)
High	297(11,9)	204(13,5)	93(9,4)
Marital status			
Single	603(24,1)	399(26,3)	204(20,6)
Married/cohabiting	1065(42,5)	693(45,7)	372(37,6)
Separated/divorced	312(12,5)	206(13,6)	106(10,7)
Widowed	526(21,0)	218(14,4)	308(31,1)

Adjustment of the Items

Table 2 shows the function of all of the responses. The model adjusts appropriately with a 1.0-2.1 variation of outfit. All items with outfit mean squares ranging from 0.6–3.4 and infit mean squares ranging from 0.6-2.1 are presented. Problems were identified in the weight loss item due to overfitting in relation to the 3.4 oufit associated with a negative response to weight loss and infit of 2.1, which represents a maladaptive structure of the item.

Table 2
Funtion of response in the FRAIL scale of elderly people participating in 5 towns–2021

	n	%	Mean	Infit	Outfit	M → C	C → M
Total responses*							
Absent	9874	79	-2.7	1.0	2.1	87	92
Present	2656	21	0.7	0.9	1.0	79	68
Comorbidities							
No	2490	99	-2.5	1.1	1.0	99.7	90.7
Yes	16	1	0.0	1.5	1.3	3.3	50.0
Resistance							
No	1966	78	-3.0	0.7	0.7	86.1	99.3
Yes	540	22	-0.4	0.6	0.6	94.2	41.9
Ambulation							
No	1946	78	-3.1	0.7	0.7	85.2	99.2
Yes	560	22	-0.5	0.7	0.6	93.3	40.0
Fatigue							
No	2289	91	-2.7	1.0	1.0	94.7	93.7
Yes	217	9	-0.4	1.2	1.1	40.0	44.2
Weight loss							
No	1183	47	-3.2	2.1	3.4	50.0	95.7
Yes	1323	53	-1.8	1.1	1.2	78.8	14.3

*Number of responses (items*people). Mean (logit). Infit y outfit (mean squares). M → C (measure – category). C → M (category–measure), Sensibility and specificity (criterion: total classification).

Adjustment of Response Categories

The 5 dichotomous items with measurements and standard errors for each item in logits are listed in decreasing fit order (Table 3), according to the original responses structure. The weight loss category sets quadratic outfit measures out of the expected range of 0.50-1.50, which is consistent with the response function, with minor overfitting issues. The adjustment for elderly people is suitable both in infit and oufit. The measured item correlation ranges between 0.13 for comorbidities and >0.40 for fatigue and low weight loss, and 0.70 for resistance and ambulation. The model and its categories show sufficient adjustment to the requirements of the Rasch model.

Table 3
Statistics and items adjustment

Item	Measurement	Standard error	Infit	Outfit	Measures item correlation
Comorbidities	3.95	0.26	1.04	1.26	0.13
Fatigue	0.76	0.08	1.06	1.10	0.41
Weight loss	-3.12	0.06	1.36	2.87	0.46
Resistance	-0.76	0.06	0.69	0.61	0.70
Ambulation	-0.83	0.06	0.69	0.63	0.70

Unidimensionality, Wright reliability

The Rasch measurement explained 47.6% of the variance. The first component presented a residual contrast of 18.6% (residual), with a correlation (measurement and the residual component) of -0.57; others explained <10% of the residual variance with 1.36 and 0.9 eigenvalues, respectively. All of the deattenuated correlations between the 2 formed strata identified within the contrasts were ≥0.80, which is sufficient evidence to disregard them. However, when analyzing the first contrast, 2 separated groups were identified: 1) weight loss, comorbidities and fatigue ítems, and 2) resistance and ambulation items.

The measurement obtained from the 5 items included in the final version of the scale is explained with a 0.80% Wright reliability of the variance.

Uniform Differential Items Functioning

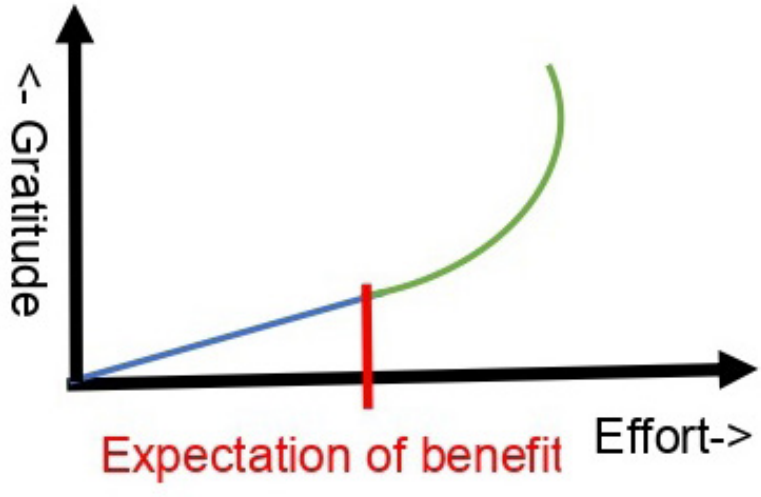
The DIF analysis was carried out to establish whether the calibrations of the items were consistent by gender and age in the groups ≥70 and <70 years of age (Table 4). The difficulty of the age-related items (resistance, fatigue, weight) is reported to be significantly higher in people aged ≥70 while for gender-related items (resistance, ambulation, and weight), difficulty is significantly higher in females than in males.

Table 4
Differential functioning according to age and gender

Item	<70 years	≥70 years	DIF	*p*	Males	Females	DIF	*p*
Comorbidities	3.95 (0.36)	3.95 (0.37)	0	1.000	3.76 (0.39)	4.09 (0.35)	-0.33	0.529
Resistance	-0.58 (0.08)	-0.97 (0.09)	0.39	**0.001**	-0.61 (0.09)	-0.87 (0.08)	0.27	**0.028**
Ambulation	-0.77 (0.08)	-0.9 (0.09)	0.14	0.241	-0.64 (0.09)	-0.97 (0.08)	0.33	**0.006**
Fatigue	0.97 (0.12)	0.54 (0.12)	**0.43**	**0.009**	0.86 (0.13)	0.69 (0.1)	0.17	0.316
Weight loss	-3.43 (0.08)	-2.72 (0.08)	**-0.72**	**0.000**	-3.45 (0.09)	-2.83 (0.08)	**-0.63**	**0.000**

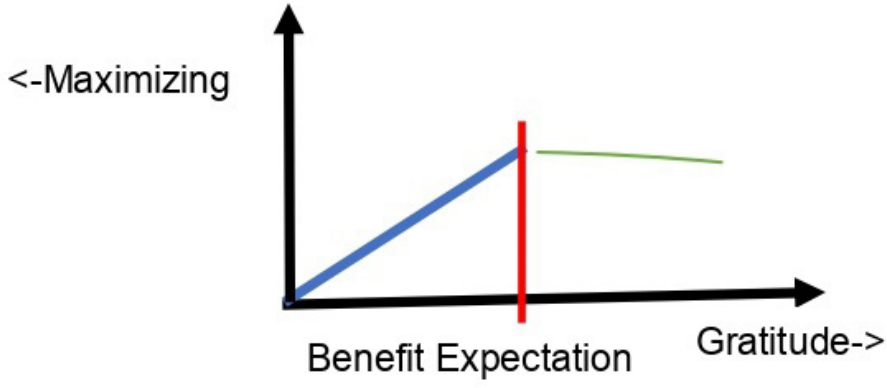
According to the DIF contrast of gender and age, the most difficult question corresponded to weight loss; fatigue and comorbidities were the items most likely to be responded (Figure 1).

Figure 1.
Age-gender interaction in the DIF.



For the estimation of the frailty measure obtained from the form without the DIF item (weight loss), the Bland and Altman limits of agreement are shown in Figure 2; 7705 cases were outside the limit but most were within limits of agreement. The difference was relevant in a small proportion of cases.

Figure 2.
DIF impact on FRAIL measurement in elderly subjects.



Two strata are shown in Table 5, one corresponding to comorbidity and fatigue, and the other one to resistance, ambulation, and weight loss. Due to the prevalence of the response to weight loss, qualifying its score is more difficult but does not affect the total score around score 3.

Table 5
FRAIL score

Score	%	Items	
5	0	Comorbidities	
4	0.92		
3	8.66	Fatigue	
2	15.56	Resistance	Ambulation
1	45.21	Weight loss	
0	29.65		

Discussion

The authors aimed to evaluate the validity of a unidimensional approach for measuring frailty in elderly people, using the FRAIL scale. Developing valid psychometric measures of frailty in community elderly is essential for strengthening health information, research, theory, and policies. This condition has been widely assessed since the development of the classical test theory (Bielderman et al., 2013; De et al., 2021; Huang & Lam, 2021)a preliminary draft scale was formed. This draft was pre- and pilot-tested to check feasibility and modified accordingly. The final scale was validated on 107 older adults by confirmatory factor analysis and was named the Frailty Assessment and Screening Tool FAST, but measures based on the fit of the items and the attributes of older people according to data of a frail condition have not been evaluated. Historically, the data model has focused on item fit. The analyzes undertaken allowed us to investigate the structural validity and reliability of the tool (Van K. et al., 2008). Regarding the residuals of the proposed measure, no relevant factors

were identified in terms of explained variances, but for the weight loss item difficulties were seen; it did not fit the model, meaning that the item was not related to the evaluated construct (J. M. Linacre, s. f.) for overfitting occurred. However, this condition was not reflected in the function of all responses and thus fit and consistency were considered adequate because it ranged between 0.6 and 2.1, with no serious consequences for the measurements (Arizaga-Iribarren et al., 2022). It might be stated that since it is a question about memory and self-reported data, it could be underestimated as people age. Findings suggest older people do not report accurately their weight in self-reports, so direct collection should be considered (Kkeli & Michaelides, 2023) where these are available. Previous research has suggested that there are differences between self-reports and measurements of weight. Nevertheless, empirical findings are inconclusive, and the determinants of misreporting have been examined in isolation. The study aimed to investigate the differences between selfreports and actual measurements of weight, whether gender, weight status, and age were related to these differences, and if weight reporting accuracy changed after frequent measurements of weight. Using a representative sample of Dutch individuals from the Longitudinal Internet Studies for the Social Sciences Panel, the study supported that on average participants underestimated their weight. No significant gender differences were found. Individuals with higher body mass index BMI. A longitudinal study of a 3-year follow-up of elderly people reported a 5% weight loss among all participants 70 to 90 years of age. It is said this finding at community level is influenced by risk factors as diabetes mellitus, cognitive impairment, smoking, absence of a spouse, low educational level, and low income (Yano et al., 2023). The weight item is related to several components, which may lead to functional dependence and fragility associated with increased morbidity, mortality, and disability in this age group (Acosta-Benito & Martín-Lesende, 2022). Consequently, its identification should be carried out as part of the geriatric evaluation with emphasis on nutritional status. Reliability of the items and people is another issue as the internal consistency was ≥0.8. In general, the evidence suggests eliminating the item, with differential functioning identified in this study, and to consider adding the gender variable to the tool because the prevalence of the condition is higher in females, which would confer a better predictive capacity and would improve the correlation of the variables and model fits (Arizaga-Iribarren et al., 2022; Nguyen et al., 2022). According to a multicenter and cross-sectional study, dynamic balance is poorer in females and prevalence of frailty is higher than in males (Arizaga-Iribarren et al., 2022); consequently, the gender variable may render the study tool a better fit. Similarly, advanced age (≥70 years) is a factor associated with frailty (Menéndez G. et al., 2021), which is consistent with this study findings.

The adjustments of the items and the people, as well as the item-measurement correlations shown in the scale suggest that the operationalization of frailty from the 5 items is adequate for the latent attribute (fragility), although there are no useful biomarkers. More than 60 different frailty classification methods have been published; reported prevalences have varied as there is no gold standard method for validating this syndrome rating scales (Akner, 2023). Nevertheless, the evidence of the questionnaire shows it is a tool with predictive capacity for evaluating frailty in the elder community, as well as a predictor of disability and mortality within 9 years (Ruiz et al., 2020). This suggests that the response trends according to the level of measurement of the items and the frailty classification of older people follow the rule assumed by the Rasch model (Tesio et al., 2023) linear measures. The Rasch Analysis allows you to turn raw scores into measures with an error estimate, satisfying fundamental measurement axioms unidimensionality, linearity, generalizability. Despite the above, classifying prefrailty is complicated because the number of items may

classify only 2 characteristics. Prefrail condition is important because the transition to the frail status sometimes occurs in an unnoticed manner (Oliveira et al., 2022).

This study has several strengths, one of them is related to the characteristics of the sample. From a clinical point of view, a tool as offers practical benefits for screening purposes at community level as it may help identify a condition prior to frailty. Because the population ≥60 may suffer conditions associated with greater risks in case of situations affecting health, their identification at an earlier age may be useful for preventing them and for promoting activities that delay or avoid health status impairment. Consequently, this study is another starting point for new researches.

The analyzes were carried out on a large sample, which was obtained probabilistically. Furthermore, the statistics of the items are independent of the sample. The sampling used makes the Wright map informative both for the locations of the items and for the distribution of scores of the older adults. This allows us to use the interpretations obtained by an individual in relation to fragility.

Limtation

A limitation an obvious pertains to the fact that the results were obtained from a poblation urban, and thus further research is warranted in people olderly of rural order to try to replicate these findings in the general population.

Conclusions

The FRAIL scale is a valid measurement to determine frailty in elderly subjects. It is unidimensional, reliable, and unbiased by age for the frail state, not as much for the prefrail condition. Inclusion of the gender variable and categorizing the age variable with 70 years as the cut-off point are suggested. Despite these findings, this instrument allows measurements of frailty in older people in the community, these recommendations will allow future development of specify and sensitivity analysis for the measure to determine their appropriate use. scale is a measure reliable and valid in development. therefore, should be reconsidered in future confirmatory analysis to ensure a more accurate measure. This analisys highlights gaps in the range of implementation constructs that are assessed by existing measures developed for use in public health and community settings. Moreover, without rigorous tools, the factors associated with the successful implementation of innovations in these settings will remain unknown.

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Disclosure statement

The authors declare no conflict of interest.

Author contributions

Víctor Hugo Arboleda Campo: directed the writing of the manuscript. Participated in data analysis and writing of the manuscript, as well as reviewing all versions.

Diego Fernando Rojas: data analysis, writing of the manuscript, review of all versions.

Diana Isabel Muñoz Rodríguez: participated in the macro project, writing the manuscript, reviewing all versions.

Dorys Cardona Arango: leader of the macro project, obtaining financing. Manuscript writing, review of all versions.

Ángela María Segura Cardona: Design of the statistical component, sampling and analysis. Manuscript writing, review of all versions.

Alejandra Segura Cardona: participated in the macro project, writing the manuscript, reviewing all versions.

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