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Psychometric properties of the Cystic Fibrosis Eating Attitudes and Behaviours scale (CFEAB) in an adult population.

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— 5, 224 words inclusive —

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Abstract

Objectives: Individuals with Cystic Fibrosis (CF) may be at an increased risk of developing a range of eating difficulties. Scales designed to measure disordered eating in the general population do not cover CF-specific behaviours resulting in a knowledge gap. The CFEAB was developed as a CF-specific measure assessing eating behaviours and attitudes however little evidence exists regarding its psychometric quality. The aim of this cross-sectional study was to provide a robust assessment of its internal consistency, structural validity, and criterion validity. **Methods:** One-hundred and thirty-two people with CF completed self-report scales pertaining to mental health, eating disorders, and the Cystic Fibrosis Eating Attitudes and Behaviours (CFEAB). **Results:** Results of exploratory structural equation modelling indicated that a three-factor structure produced good fit with the 24-item CFEAB but a purified 12-item CFEAB displayed superior fit and internal consistency. Also, the 12-item scale predicted significant amounts of variance for anxiety, depression, and eating disorders showing enhanced relevance for clinical use. **Conclusions:** These findings add emphasis to the importance of the validation and development of CF-specific measures and the possible inclusion at clinics to help improve CF patient care.

Keywords: CFEAB, Cystic Fibrosis; Eating Disorders; Exploratory Structural Equation Modelling; Internal Consistency.

Introduction

Cystic Fibrosis is a life threatening, genetic condition which affects over 100,000 individuals worldwide (UK CF Registry, 2020). The majority affected develop recurrent and chronic infections, mucous plugging in the lungs, and digestive problems with insufficient pancreatic enzymes (Abbott et al., 2000). In recent years, better management and new therapies are leading to increasing survival rates (Sawicki, Sellers & Robinson, 2011). Issues such as quality of life and psychological wellbeing are now recognised as significant factors in predicting longevity (Szyndler et al., 2005; Linkson et el., 2018). Given the importance of diet and weight gain in the management of CF treatment, a small body of research has begun to explore the issue of disordered eating in CF samples (Gilchrist & Lenney, 2008). Nonetheless, this literature is limited by measurement issues.

Scales designed to measure disordered eating in the general population, like the 'EAT-26' (Garner et al., 1982), contain questions pertaining to lack of control of eating high calorific food (e.g., bulimic-type behaviours) or severe restriction of food (e.g., anorexic-type behaviours). These scales do not cover CF-specific behaviours such as refusal to follow prescribed treatment as a mechanism to manipulate weight gain. Research demonstrates that ED behaviours, such as the manipulation of digestive enzyme medications have been discovered within the CF population (Byron, Shearer & Davies, 2008) along with recurrent episodes of binge eating, fasting, intense exercising, laxative misuse, and insulin misuse (Shearer & Byron, 2004). Individuals with CF may be risk of developing a range of difficulties not covered by traditional diagnostic categories often referred to as eating disorder not otherwise specified (Quick et al., 2012; Conviser, Fisher & McColley, 2018). For example, in a sample of women with CF, a quarter engaged in self-induced vomiting and medicine manipulation to control their weight (Quick & Bryd-Bredbenner, 2012). In multiple previous studies, CF patients did not meet the criteria for anorexia or bulimia nervosa

(Raymond et al., 2000). Until recently, researchers and clinicians did not have at their disposal an appropriate tool to assess for eating-related difficulties among CF individuals providing rationale for the current work.

A draft version of the CFEAB was developed with 29 items for patients aged over 11 years old (Byron et al., 2006). Body image questions were then removed, as the assessment of this was beyond the scope of the measure. Randlesome, Byron and Evangeli, (2011) developed the CFEAB further in a sample of 155 participants from one adult and two paediatric CF centres in London. Their 24-item self-report scale measures three factors of disordered eating; *appetite*, expressing general pleasure with eating behaviours, *disturbed eating and behaviours*, related to eating disordered psychopathology, and *desire for thinness and weight loss*, describing feelings about appearance and weight management. In Randlesome and colleagues (2011) original study, alpha coefficients of each of the three subscales were: 0.92 (Desire for Thinness), 0.89 (Disturbed Eating Attitudes and Behaviours (DEABs), 0.77 (Appetite). Three items that did not achieve content validity were removed, with 21-items remaining. Randlesome et al. (2013) concluded that the CFEAB demonstrated promising psychometric properties.

The researchers adopted an exploratory approach providing only preliminary evidence of the scale's psychometric properties. Thus, there is a need for replication and further evaluation with more sophisticated analytical techniques before the CFEAB can be used in patient settings (Melhuish, 2013). Exploratory factor analysis, whilst appropriate in the validation context, is subject to measurement limitation due to its simplicity and increased subjectivity in identifying a factor solution (Russell, 2002). This may be particularly relevant in Randlesome and colleagues (2013) work, as researchers suggest at least four items per subscale (Comrey & Lee, 2013), however, factor three, desire for thinness and weight loss, was measured with only three items reducing its conceptual coverage in comparison to the

other two subscales. Finally, exploratory structural equation modelling (ESEM) offers a method of estimating the CFEAB's factor structure addressing the limitations of Randlesome et al. (2013). In this case, ESEM combines the advantages of exploratory factor analysis (e.g., allows for unrestricted intercorrelation between items and factors) and confirmatory factor analysis (e.g., estimation of model fit) therefore enabling researchers to determine redundancy in the item set and possible improvements in model fit (Vaughan & Laborde, 2018).

The aim of the current work was twofold; first to assess the internal consistency and factor structure of the CFEAB using state-of-the-art procedures, and two, to determine the criterion validity of the CFEAB by assessing its relationship with existing related measures of mental health and disordered eating. We predict that support will be found for the CFEAB's reliability and validity.

Methods

Participants

The sample consisted of 132 (M^{age} = 29.70, *SD* = 9.19; 66.7% female) adults with CF recruited through online CF support groups ranging from 18 to 72 years old. In this sample possible ED diagnosis was high with 91% prevalence for 'Bulimia', 86% prevalence for 'Oral Control', and 94% for 'Dieting' according to the EAT-26 criteria of scores over 20 (Garner et al., 1982).

General 'rules of thumb' regarding sample size for factor analysis were followed with 100 participants considered the minimum (MacCallum et al., 2001). Power analysis suggested that a sample of 107 participants was required for multiple regression modelling with a medium effect size (0.15 at $p < 0.05$ with 0.80 power) for the criterion validity assessment (G*Power; Faul et al., 2007).

Materials

The CFEAB (Randlesome et al., 2013) is a 24-item self-report measure assessing eating attitudes and behaviours specific to a CF population. The scale captures three factors; Desire for Thinness, Appetite and Disturbed Eating Attitudes and Behaviours. Participants indicate agreement on a five-point Likert scale ('never' to 'always') and higher scores indicate more problematic eating attitudes and behaviours.

The GAD-7 (Spitzer et al., 2006) is a 7-item self-report measure assessing anxiety symptoms over the last two weeks. Participants respond on a four-point Likert scale ranging from 'not at all,' 'several days,' 'more than half the days' and 'nearly every day' with higher scores indicating higher anxiety (Spitzer et al., 2006). Research supports the internal consistency of the 'GAD-7' ($\alpha = 0.89$; Lowe et al., 2008).

The PHQ-9 (Kroenke, Spitzer & Williams, 2001) is a 9-item measure of depressive symptoms over the last two weeks. Participants respond on a four-point Likert scale ranging from 'not at all,' 'several days,' 'more than half the days' and 'nearly every day' with higher scores indicating higher depression (Kroenke et al., 2001). Research supports the internal consistency ($\alpha = 0.89$) and test-retest reliability of the PHQ-9 (Kroenke et al., 2001).

The EAT-26 is a 26-item scale (Garner et al., 1982) measuring eating attitudes in the general population. Three subscales measure dieting, bulimia symptoms and food preoccupation and oral control. Participants respond to a 6-point Likert scale ranging from 'Never' to 'Always,' with higher total scores indicating higher problematic eating. Individuals scoring over 20 are advised to seek consultation from a medical professional. Previous work supports the three-factor structure and internal consistency of the scale (e.g., $\alpha = 0.90$; Garner et al., 1982).

Procedure

Ethical approval was granted from the ethics committee at Ulster University (Northern Ireland). Data were collected online via Qualtrics. Gatekeepers to CF groups were emailed and asked to distribute the survey link to CF people within their network. Participants were briefed prior to data collection, informed of their ethical rights, and provided informed consent. Participants then completed all scales in a random order. Finally, participants read debriefs and were thanked for their participation. Data were first entered onto SPSSv26 for preliminary analyses and then Mplus 7.8 for model testing (Muthen & Muthen, 2017). Data and study materials were made available on the Open Science Framework (https://osf.io/3jbvw/) and the unpublished manuscript was made available as a pre-print via PsyArXiv (Mc Hugh et al., 2022).

Design and Data Screening

A cross-sectional design with random sampling was adopted. A small amount of data was missing (2%). Following recommendations (Tabachnick & Fiddell, 2007), we used ipstatized estimation of relevant cases to replace missing values. Multivariate skewness (.906, $p > .05$) and kurtosis (.241, $p > .05$) coefficients indicated no departure from normality (Muthén & Muthén, 2017).

Analytic Strategy

First, descriptive statistics and internal consistency was completed for the CFEAB. Omega was used to test internal consistency due to previous research suggesting it outperforms alpha making more realistic assumptions (e.g., tau-equivalence) and less risk of overestimating or underestimating reliability in multifactorial scales (Dunn et al., 2014). Next, we tested a three-factor model using ESEM for all 24 items proposed by Randlesome et al. (2013). Factor loadings <.32 were considered non-significant. We also provided scale purification by proposing a shortened more economical 12-item CFEAB – the short-CFEAB. For these analyses, we used the robust maximum likelihood estimator which can handle

instances of missing data, non-normality, and categorical variables with at least five response categories (Muthen & Muthen, 2017).

We used an oblique target rotation to estimate how the 24 items and subsequent latent factors of the CFEAB were interrelated for the ESEM. An epsilon value of .55 was adopted to enable as many items as possible to be optimally identified within one component while minimising the potential number of doublets (Comrey & Lee, 2013). To evaluate model fit, we examined the χ^2 statistic, comparative fit index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) with 95% Confidence Intervals (CI), and Standardised Root Mean Square Residual (SRMR) using the following criteria: $CFI > 0.90$, $TLI > 0.90$, $RMSEA < 0.06$, $SRMR < 0.06$ (Marsh, Hau, & Wen, 2004).

In order to select the most parsimonious model, the Bayes Information Criterion (BIC) and Akaike's Information Criterion (AIC) were used to compare models. The AIC and BIC assign a greater penalty to model complexity and therefore have a better propensity to select more efficient models. Standardised solutions were examined to evaluate the significance and strength of parameter estimates. The following criteria were used to evaluate the standardised factor loadings (> .71 = excellent, > .63 = very good, > .55 = good, > .45 = fair, > .32 = poor; Comrey & Lee, 2013).

Finally, we used multiple linear regression with the CFEAB subscales as predictors to examine their influence on the mental health and disordered eating as outcome variables. Age and gender were not entered as covariates as they did not correlate with the outcome variables. Positive associations with similar concepts support criterion validity.

Results

Means, standard deviations, and internal consistency are displayed in Table 1. Results indicate support for the 'short-CFEAB' over the 24-item version regarding internal consistency.

Insert Table 1 here

Next, we assessed the factor structure of the 24-item CFEAB. Results suggested good fit to the data (χ^2 [207] = 289.254, p < .001; RMSEA = .055 [.447-.014]; SRMR = .033; TLI = .948; CFI = .961; AIC = 7676.563; BIC = 8013.851). However, the 12-item version indicated superior fit (χ^2 [33] = 44.161, p < .001; RMSEA = .051 [.246-.735]; SRMR = .019; TLI = .972; CFI = .986; AIC = 3994.903; BIC = 4159.223). Reductions in AIC and BIC values favouring the 12-item version supports this assumption.

Inspection of the factor loadings of the 24-item CFEAB shows comparability with previous work (Melhuish, 2013; Randlesome et al., 2013). The original study suggested that the items measure three factors of 'Desire for thinness (items 2, 3, 6, 14, 15, 17, 18, 19, 21, 22)', 'Disturbed EABs' (items 8, 10, 11, 12, 16, 20, 23, 24)', and 'Appetite' (Items 1, 9, 13) after Randlesome et al. removed 3 items (Items 4, 5, 7). The current factor solution largely supports this structure with good factor loadings (i.e., > 0.42; see Table 2). For example, items 2, 3, 6, 14, 15, 17, 18, 21, and 22 of 'Desire for thinness', and items 8 and 20 of 'Disturbed EABs' (Items 12, 16, 19, 24) produced the highest loading on their target factor. The latent factor correlations indicated moderate correlations between the CFEAB subscales supporting the subscales independence.

Insert Table 2 here

Nonetheless, no items loaded on the 'Appetite' factor questioning the factorial validity of the 24-item CFEAB. Moreover, nine items cross-loaded between factors indicating distortion in the factor solution, and some factor loadings exceeded 1.00 indicating redundancy in the item set therefore supporting assessment of a shortened scale. We removed excess loadings, cross-loadings, and items that scored lower than the 0.32 cut-off (see Table 3). Specifically, the 'Desire for Thinness' subscale was reduced, the 'Appetite' subscale included item 5 which was dropped by Randlesome et al., and the 'Disturbed EABs' subscale

included item 19, which was originally in the 'Desire for Thinness' subscale. Thus, the scale was reduced from 24, down to 12-items. This produced a 12-item scale with 'Desire for Thinness' (items 3, 14, 17, 18), 'Appetite' (items 5, 8, 13, 20) and 'Disturbed EABs' (items 12, 16, 19, 24). The latent factor correlations indicated strong correlations between the CFEAB subscales. Inspection of the 12-item solution indicated less misspecification in the structure, improved fit, and higher internal consistency suggesting improved performance against the 24-item scale.

Insert Table 3 here

Finally, we assessed the criterion validity of the 12-item CFEAB. Multiple linear regression with the three new factors as predictors was performed to examine their influence on experiences of anxiety, depression, and disordered eating measures as outcome variables. Results indicated that the three subscales of the short-CFEAB predicted significant amounts of anxiety (r^2 = .271), depression (r^2 = .205), and disordered eating (r^2 = .665). Summary of multiple linear regressions for anxiety, depression, and disordered eating are presented below in Table 4.

Insert Table 4 here

Discussion

The aim of the current study was to first assess the internal consistency and factor structure of the CFEAB using state-of-the-art procedures, and second, to determine the criterion validity of the CFEAB by assessing its relationship with existing related measures of mental health and disordered eating. Results supported the three-factor structure with the 24-item CFEAB, however a large degree of misspecification was found in the factor structure. Therefore, a 12-item was investigated and indicated superior fit. Scores for the three subscales predicted significant amounts of anxiety, depression, and disordered eating

variance indicting good criterion validity, which varied depending on different eating behaviours.

The findings of this study corroborate research which suggest that disordered eating behaviour is evident in the CF population (Linkson et al, 2018). The higher prevalence of disturbed eating attitudes and behaviours found within this CF sample is higher than the low prevalence of ED and disturbed eating attitudes and behaviours found in previous CF studies (Byron et al., 2008, Truby & Paxton, 2001, Abbott et al., 2000, 2007). As previous research has suggested that individuals with CF did not meet the criteria for anorexia nervosa or bulimia nervosa (Raymond, 2000) and reported no indication of increased diagnostic ED in the CF population (Melhuish, 2013), these findings offer an alternative viewpoint highlighting the need for additional research.

The original study suggested that 24-items measured three factors: 'Desire for thinness (10-items)', 'Disturbed EABs' (8-items), and 'Appetite' (3-items). In this study, we interpreted this as a new 12-item scale: 'Desire for thinness' (4-items), 'Disturbed EABs' (4-items) and 'Appetite' (4-items). The 12-item short-CFEAB indicated superior model fit and improved internal consistency suggesting less redundancy in the item set (McCrae et al., 2011). Discrepancy between our findings and previous work may be due to individual differences in sampling. For example, Randlesome et al. (2013) included two pediatric clinics, and one adult clinic, whereas the current sample consisted of adults only. It is likely that disordered eating may be more ingrained in adulthood compared to adolescence therefore future work should examine invariance of the CFEAB across different age groups to test this equivalence theory (Johnston et al., 2019; Quick et al., 2012).

Contribution and Implications

Previous studies determining the link between ED and CF have often used measures developed for the general population, which are not validated or applicable to the CF

population. This means there is the potential for misclassification of behaviours and attitudes reflecting eating disturbances. For example, these may reflect skills and attitudes learned as part of self-care within CF management (Melhuish, 2013, Abbott et al., 2007, Pumariega et al., 1986). A CF-specific measure is therefore important to determine the differences between CF-related eating issues and disordered eating psychopathology. The short-CFEAB also offers a more clinical efficient assessment with improved reliability and validity in comparison to the original version.

The sample in this study was sourced online, and an important aspect of this sample was the vast age range for this group, ranging from 18 to 72 years old. A plan forward could be the introduction of screening for disturbed eating attitudes and behaviours at regular clinic visits using the revised 'short-CFEAB' measure. Rather than simply focusing on calorie intake and weight gain, some authors have also recommended interventions from clinical psychologists and team dieticians (Bryon et al. 2008). The identification of ED can then be referred to specialists for appropriate help and guidance, which would ultimately improve the patient's physical and mental health. Research indicates that health care providers believe that the development of evidence-based guidelines for screening and treating disordered eating among CF patients is warranted, including development of a CF-specific disordered eating screening tool (Quick & Chang, 2019).

Limitations & Future Research

Those who access online support are likely to be a specific subgroup of individuals with CF, and may not be fully representative of the wider CF population. Given that the invitation to participate in the survey was posted on online CF-related support websites, to which the researchers had no control or responsibility for, no data was obtainable to ascertain how many people viewed the post in each group or to determine the percentage of users who responded. The limitations of self-report data should also be considered, and patients with

severe CF or mental health issues might not have chosen to participate in the study, introducing bias and further limiting the generalisability of the results. Due to the cross-sectional nature of the study, with no longitudinal data available which is lacking in this area, it cannot be ascertained if disturbed eating attitudes or behaviours precede anxiety and depressive symptoms, or note the impact of these. The limitation of using anxiety and depression scales for evidence of validity in this population. There is a large degree of overlap between these scales therefore some relationship is to be expected (and why they were selected as criterion validity variables). The results indicate that these are significant predictors but that the appetite subscale is the most important for these constructs. This may be due to the fact that appetite changes may overlap with other symptoms of CF, and appetite issues may be most associated with symptoms of CF.

Previous studies reported that more males in CF report a desire to be heavier (Abbott et al., 2007, Tierney, 2012). Therefore, it would be beneficial to explore whether females with CF do not adhere to dietary recommendations or disrupt their treatment regimens to lose weight or due to being too ill to eat. As mentioned, future research should examine the measurement invariance of the scale to test its equivalence across important groupings (e.g., youth vs adult samples). New considerations such as the breakthrough drugs 'Ivacaftor,' 'Lumacaftor/Ivacaftor' and recently 'Elexacaftor/Tezacaftor/Ivacaftor' since 2020 for people with CF, with a main side effect of more efficient fat absorption is important, as is the impact of this for individuals who could not gain weight before (Polenakovik & Sanville, 2013). Research has been conducted on the biological and genetic impact of these drugs and weight gain, but not the psychological changes or impact. It is important in a clinical sense to determine predictive validity of this measure, and also which individuals with CF are at risk of developing an ED, and to develop and validate more CF-specific measures like the

'CFEAB' to identify detrimental behaviours and attitudes.

Conclusion

This work supports the factor structure, internal consistency, and criterion validity of the short-CFEAB - a 12-item CF-specific measure. We hope that this shortened scale offers a viable method for researchers, practitioners, and health care providers interested in disordered eating in people with CF and increases interest in this under-researched area of CF patient care.

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Table 1: Means, Standard Deviations and Internal Consistency for 24- and 12-item CFEAB, EAT-26, GAD-7 and PHQ-9.

Factor	M (SD)	ω
24-item version CFEAB	54.7 (10.48)	0.731
Desire for Thinness	21.2 (7.28)	0.681
Appetite	10.7 (1.95)	0.692
Disturbed EABs	16.4 (4.35)	0.614
12-item version CFEAB	25.2 (8.68)	0.808
Desire for Thinness	8.0 (4.33)	0.753
Appetite	10.7 (2.16)	0.729
Disturbed EABs	6.50 (3.80)	0.796
EAT-26		
Dieting	59.8 (14.6)	0.878
Bulimia	29.6 (6.1)	0.811
Oral Control	28.3 (13.7)	0.766
GAD-7	14.0 (6.2)	0.931
PHQ-9	16.9 (6.4)	0.887

N = 132.

Table 2: Factor structure for 24-item CFEAB.

Item	Factor 1	Factor 2	Factor 3
1	0.027	**1.011**	0.014
2	**1.086**	0.037	*0.376*
3	**0.711**	0.000	*0.446*
4	**1.325**	0.071	*0.399*
5	0.227	**0.655**	0.317
6	**1.053**	0.294	0.298
7	0.060	**0.454**	0.221
8	0.075	**0.447**	*0.446*
9	0.160	**0.431**	0.068
10	0.011	0.226	**1.061**
11	0.010	0.043	**0.393**
12	0.037	0.005	**0.932**
13	0.172	**0.974**	0.011
14	**0.949**	0.035	*0.348*
15	**1.147**	0.007	0.025
16	0.003	0.031	**0.596**
17	**0.798**	0.186	*0.503*
18	**0.702**	0.023	0.272
19	*0.619*	0.095	**0.685**
20	0.138	**0.720**	0.128
21	**1.206**	0.247	0.013
22	**0.596**	0.099	0.220

23	0.074	*0.405*	**0.476**
24	*0.341*	0.071	**0.798**
Correlations			
Factor 1		0.230	0.388
Factor 2			0.478

Notes. Values in bold are highest loading; Values in italics represent cross loadings; Values below 0.32 are non-significant but maintained for completeness. N = 132.

Table 3: Factor structure for the 12-item CFEAB.

Item	Factor 1	Factor 2	Factor 3
3. I cut down on food to lose weight.	**0.950**	0.028	0.072
5. I don't feel like eating when others tell me to eat.	*0.538*	**1.031**	0.057
8. The thought of eating food makes me feel worried.	0.046	**0.693**	0.163
12. So I won't gain weight, I deliberately don't take my extra feeds or supplements.	0.027	0.283	**0.700**
13. I have a good appetite for food.*	*0.635*	**1.008**	0.012
14. I would like to eat less to lose weight.	**1.466**	0.006	*0.412*
16. I make myself vomit (sick) after I eat to control my weight.	0.020	0.217	**0.503**
17. I feel I am too fat.	**0.957**	0.267	0.000
18. I exercise as a way to lose weight.	**0.720**	0.206	0.258
19. I feel I need to be thin to be happy with myself.	0.237	0.245	**0.750**
20. I am put off eating because my CF makes me feel sick.	0.013	**1.000**	*0.582*
24. I feel guilty after eating.	*0.389*	0.022	**0.652**
Correlations			
Factor 1		0.490	0.739

Factor 2	0.676

Notes. Values in bold are highest loading; Values in italics represent cross loadings; Values below 0.32 are non-significant but maintained for completeness. Factor 1 = Desire for Thinness; Factor 2 = Appetite; factor 3 = Disturbed EABs. N = 132.

* = negatively scored item.

Table 4: Multiple regression analyses of the three new factors on anxiety, depression and disordered eating.

Model	Anxiety			Depression			Disordered Eating		
R^2	.271*			.205**			.665**		
	β	SE	Part	β	SE	Part	β	SE	Part
Desire for Thinness	.085	.196	.059	.150	.222	.098	.024	.453	.025
Appetite	.265*	.258	.269	.329**	.282	.316	.138	.582	.211
Disturbed EABs	.279	.226	.182	.073	.252	.045	.766**	.519	.607

Note. N = 132. β = standardised beta coefficient; Part = semi-partial correlations. * $p < .05$; ** $p < .01$.