Total score or subscales in scoring the acromegaly quality of life questionnaire: using novel confirmatory methods to compare scoring options

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Abstract

Context: Impaired quality of life (QoL) is common in patients after long-term remission of acromegaly. The acromegaly QoL (AcroQoL) is a disease-specific QoL questionnaire for patients diagnosed with acromegaly. The summed total score is the most frequently used scoring method of the AcroQoL. However, the total score does not capture all of the aspects of QoL that are outlined by the World Health Organization (WHO).

Objective: The aim of the present study was to use novel and sophisticated confirmatory methods to identify the optimal number of subscales for the AcroQoL.

Design and patients: Patients in remission from acromegaly were recruited from the Leiden University Medical Center and were asked to complete the AcroQoL (Dutch version) questionnaire ($n=72$).

Results: The three-subscale version of the AcroQoL consisted of subscales reflecting Physical Complaints, Appearance Issues, and Personal Relations Issues related to QoL. Model fit indices (i.e., comparative fit index and root mean square error of approximation) indicated that the three-subscale version represented the data better than the total score and two-subscale models did. A χ^2 difference test indicated that the three-subscale model was a significantly better fit than the total score and two-subscale models were ($P<0.05$).

Conclusion: Model fit and comparison statistics indicate that the three-subscale model is a better scoring method than the total score and two-subscale versions of the AcroQoL are. The three-subscale version also better reflected the WHO's recommendation of using a multidimensional measure of QoL than the total score and two-subscale methods did. Therefore, it is recommended that values from the three-subscales of the AcroQoL be reported in future research.

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Introduction

Acromegaly is a rare disease characterized by a growth hormone (GH)-secreting pituitary adenoma (1). The physical symptoms of acromegaly include frontal bossing, swelling of extremities, and swelling of soft tissue (i.e., heart, intestines, and tongue) (2) resulting from chronic GH overexposure. Psychological issues include negative illness perceptions (3) and a decreased quality of life (QoL)

(1, 4). Furthermore, patients with acromegaly are at risk for various health issues, such as arthritis, heart disease, hypertension, and diabetes mellitus (5). Acromegaly can be treated by selective removal of the adenoma via trans-sphenoidal surgery, followed by additional radiotherapy if needed. If surgery and/or radiotherapy is not preferred, or when this treatment is not (completely) successful,

patients can be treated with suppressive medication, such as somatostatin analogs (1) and/or GH receptor agonists (5). Upon remission of acromegaly, physical and psychological symptoms usually improve, although QoL often does not return to premorbid levels (6, 7).

The acromegaly QoL (AcroQoL) (8) is the first and only disease-specific QoL questionnaire for patients diagnosed with acromegaly. Webb *et al.* (8) developed the AcroQoL using literature searches, interviews with expert endocrinologists and patients, and exploratory statistical methods, and they found the measure to contain a three-subscale, a two-subscale, and a single total score scoring method. At present, many studies have measured QoL and changes in QoL predominantly using the single total score of the AcroQoL (9, 10, 11). However, the World Health Organization (WHO) has recommended that QoL be treated as a multidimensional construct that, at a minimum, contains physical, psychological, and social aspects of QoL (12). There have been a few studies that examined the properties of a two-subscale and a three-subscale scoring method of the AcroQoL, but the total score is still the most frequently used scoring method (6, 8, 13, 14). However, these studies have all relied on exploratory methods to examine the different number of subscales embedded in the AcroQoL. Exploratory methods are designed for use when a measure is being created and there are few or no ideas about scale dimensionality (i.e., potential subscales), and they are often regarded as a first step in test construction.

A disadvantage of using the total score of the AcroQoL is that it collapses across the dimensions that reflect QoL. Although the AcroQoL contains questions that assess the WHO's recommended dimensions of QoL, the use of the total score makes it impossible to distinguish among those dimensions of QoL. A second limitation is that the psychometric properties of the AcroQoL have only been studied using exploratory methods. Test construction typically begins with a literature search, expert and patient interviews, and exploratory statistical methods. The next logical step in test construction is to use confirmatory statistical methods to assess the generalizability of results and to compare scoring options (15, 16). Previous studies (8, 13, 14, 17) have all implemented exploratory methods to assess the psychometric properties of the AcroQoL without comparing the performance of alternative scoring solutions. A subsequent step to using exploratory methods is to implement confirmatory methods, which are necessary to examine hypotheses about scale dimensionality (18). Therefore, the aim of the present study was to use sophisticated and novel confirmatory methods to determine the optimal number of subscales for the

AcroQoL. Given the WHO's recommendations, the three-subscale scoring solution was hypothesized to be the best solution for the AcroQoL.

Participants and methods

Participants

Patients in the present study were recruited by Tiemensma *et al.* (9), who examined associations between illness perceptions and QoL in patients with long-term remission of acromegaly. Patients were eligible for participation if they were more than 18 years of age and had been in remission, as defined by strict biochemical criteria, for at least 1 year. Patients were asked to complete the AcroQoL (Dutch version) at home and return it in a prepaid envelope. The protocol was approved by the Leiden University Medical Center Medical Ethics Committee. The long-term treatment outcome for these patients has been characterized in detail previously (9, 19). As per protocol, all patients had been in remission at the time of the present study for at least 1 year (mean $\pm$ s.d. 16 ± 10 years). In total, 72 patients (59.7% male; age 60.29 ± 11.89 years) completed the AcroQoL questionnaire.

AcroQoL questionnaire

The AcroQoL is a disease-specific QoL questionnaire designed to assess QoL in patients with acromegaly (8). The questionnaire consists of 22 items measured on a five-point Likert-type scale that assesses frequency of occurrence (always to never) or degree of agreement (completely agree to completely disagree) with the statements. The AcroQoL consists of questions that reflect dimensions of QoL related to Physical Complaints (e.g., 'My legs are weak'), Psychological Complaints, such as Appearance Issues (e.g., 'I feel ugly'), and problems with Personal Relations (e.g., 'I try to avoid socializing').

Statistical analysis

Data were analyzed with confirmatory factor analyses (CFA) using *Mplus* version 7.2 (20; Mplus, Muthén & Muthén, Los Angeles, CA, USA). The amount of missing data was low (1.2% missing), and the default settings in *Mplus* for missing data imputation and model identification were used unless otherwise noted (20). Model fit was assessed to examine the degree to which particular scoring methods of the AcroQoL scale (e.g., two-subscales, etc.) reflect the response patterns exhibited in the data. The fit of the models (i.e., the different

scoring options) was assessed using the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the χ^2 test. The CFI is a goodness-of-fit index, wherein values closer to one indicate acceptable fit of the model (e.g., a two-subscale model, etc.). The RMSEA is an index that reflects levels of model misfit, wherein larger values signify a worse-fitting model. Finally, a significant χ^2 test (i.e., $P < 0.05$) indicates a poorly fitting model (21).

The fit indices used in the present study are all absolute measures of fit that are used to assess how well the specific model is fitting the data. In contrast to the absolute fit measures, the χ^2 difference test can be used to compare the fit of several competing models (22). Models were compared by calculating a difference score for the χ^2 values. A significant χ^2 difference value ($P < 0.05$) indicates that the model with the lower χ^2 value is the better-fitting model (22).

The models examined in the present study include: i) the total score version of the AcroQoL; ii) the two-subscale version, comprised of Physical Symptoms and Psychological Symptoms; and iii) the three-subscale version, comprised of Physical Symptoms, Appearance Issues, and Personal Relations Issues. Subscale correlations were calculated, and no collinearity issues were found. Results are presented as

standardized coefficients (β) and S.E.M. Statistically significant ($P < 0.05$) β values larger than 0.4 are deemed to be meaningful relationships between items and subscales.

Results

Single total score model

The first scoring method assessed was the total score model, which was originally proposed by Webb *et al.* (8). The β coefficients and S.E.M. for each of the items are presented in Table 1. The fit indices for the total score model were CFI=0.804, RMSEA=0.182 (90% CI 0.168, 0.197), and χ^2 (209)=709.274, $P < 0.001$. Together, the fit indices indicate a poor model fit. Each item significantly (all $P < 0.05$) related to the total scale, although Items 11 (i.e., body size) and 16 (i.e., snoring) loaded relatively weakly ($\beta = 0.366$ and 0.321 respectively).

Two-subscale scoring model

The two-subscale model, which was also described by Webb *et al.* (8), was examined next. The Physical Symptoms

Table 1 Standardized β coefficients for single total score and two-subscale models. Single total score model: χ^2 (209)=709.274, $P < 0.001$; CFI=0.804; RMSEA=0.182 (90% CI 0.168, 0.197). Two-subscale model: χ^2 (208)=631.348, $P < 0.001$; CFI=0.834; RMSEA=0.168 (90% CI 0.153, 0.183). Correlation of Physical subscale with Psychological subscale: $r = 0.722$.

Single total score AcroQoL			Two-subscale AcroQoL			
Item	β coefficient	S.E.M.	Subscale 1: Physical Symptoms		Subscale 2: Psychological Symptoms	
			β coefficient	S.E.M.	β coefficient	S.E.M.
13	0.868*	0.031	0.908*	0.031		
09	0.877*	0.031	0.902*	0.031		
19	0.837*	0.042	0.883*	0.044		
22	0.826*	0.035	0.857*	0.033		
15	0.810*	0.035	0.845*	0.034		
01	0.726*	0.049	0.767*	0.048		
14	0.674*	0.049	0.720*	0.051		
03	0.537*	0.079	0.588*	0.082		
20	0.842*	0.036			0.984*	0.049
04	0.870*	0.038			0.905*	0.037
02	0.786*	0.042			0.822*	0.041
18	0.683*	0.058			0.730*	0.056
05	0.677*	0.080			0.720*	0.079
21	0.647*	0.051			0.688*	0.050
12	0.596*	0.079			0.633*	0.083
07	0.558*	0.071			0.602*	0.068
06	0.509*	0.096			0.555*	0.100
08	0.482*	0.081			0.527*	0.082
10	0.483*	0.078			0.521*	0.077
17	0.491*	0.085			0.522*	0.091
11	0.366*	0.093			0.394*	0.093
16	0.321*	0.084			0.339*	0.088

*Indicates significant factor loading at $P < 0.05$.

Table 2 Standardized β coefficients for three-subscale model. χ^2 (207)=529.057, $P<0.001$; CFI=0.874; RMSEA=0.147 (90% CI 0.132, 0.163). Correlation of Physical subscale with Appearance subscale: $r=0.546$. Correlation of Physical subscale with Personal Relations subscale: $r=0.746$. Correlation of Personal Relations subscale with Appearance subscale: $r=0.475$.

Three-subscale AcroQoL						
Item	Subscale 1: Physical Symptoms		Subscale 2: Appearance Issues		Subscale 3: Personal Relations Issues	
	β coefficient	S.E.M.	β coefficient	S.E.M.	β coefficient	S.E.M.
13	0.905*	0.032				
09	0.904*	0.031				
19	0.875*	0.044				
22	0.859*	0.033				
15	0.849*	0.034				
01	0.771*	0.048				
14	0.722*	0.051				
03	0.591*	0.081				
04			0.967*	0.041		
02			0.882*	0.043		
12			0.756*	0.089		
07			0.697*	0.065		
17			0.618*	0.109		
11			0.499*	0.095		
16			0.409*	0.107		
20					0.977*	0.043
05					0.977*	0.043
18					0.790*	0.052
21					0.769*	0.048
06					0.611*	0.101
08					0.514*	0.088
10					0.489*	0.092

*Indicates significant factor loading at $P<0.05$.

subscale consisted of eight items (i.e., Items 1, 3, 9, 13–15, 19, and 22), and the Psychological Symptoms subscale consisted of the remaining 14 items. The two-subscale scoring method had a slight improvement in model fit from the total score model: CFI=0.834, RMSEA=0.168 (90% CI 0.153, 0.183), χ^2 (208)=631.348, $P<0.001$. Table 1 contains β coefficients, S.E.M., and subscale. Each item significantly related to its corresponding subscale (all $P<0.05$). However, consistent with the total score model, Items 11 and 16 related relatively weakly to the Psychological Symptoms subscale ($\beta=0.394$ and 0.339 respectively).

Three-factor model

Finally, the three-factor model described by Webb *et al.* (8) was tested. The Physical Symptoms subscale consisted of eight items (i.e., Items 1, 3, 9, 13–15, 19, and 22), the Appearance Issues subscale had seven items (i.e., Items 2, 4, 7, 11, 12, 16, and 17), and the Personal Relation Issues subscale had the remaining seven items. To avoid estimation issues tied to a negative residual variance, Item 20 was constrained to be equal to the path for Item 5.

Upon inspection of the item content, this constraint was implemented because Item 5 (i.e., 'I avoid going out very much with friends because of my appearance') was similar in content to Item 20 (i.e., 'The physical changes produced by my illness govern my life'). Model fit improved from the total score model and the two-subscale model: CFI=0.874, RMSEA=0.147 (90% CI 0.132, 0.163), χ^2 (207)=529.057, $P<0.001$. All of the items loaded onto the subscales significantly (all $P<0.05$), with each item relating to its respective subscale above the 0.40 cut-off. Table 2 contains β coefficients, S.E.M., and subscale correlations.

χ^2 difference test

In order to compare models directly with one another, a χ^2 difference test was used. The two-subscale model was found to be a significant improvement over the total score model, $\chi^2_{\text{change}}(1)=43.49$, $P<0.05$. The three-subscale model was found to be a significant improvement over both the total score model ($\chi^2_{\text{change}}(2)=95.040$, $P<0.05$) and the two-subscale model ($\chi^2_{\text{change}}(1)=48.421$, $P<0.05$) of the AcroQoL.

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Table 3 Example AcroQoL total and subscale scores.

Participant	Total	Physical Symptoms	Appearance Issues	Personal Relations Issues
3	95.45	100.00	85.71	100.00
4	60.23	84.38	57.40	35.71
15	75.00	75.00	96.43	53.57
35	38.64	25.00	64.29	28.57
45	43.18	53.13	60.71	14.29
46	94.32	87.50	100.00	96.43
47	78.41	93.75	89.29	50.00
52	81.82	84.38	100.00	60.71
53	71.59	84.38	92.86	35.71
70	77.27	93.75	96.43	39.29

Bold scores indicate when the total score and the subscales disagree.

Discussion

The present study demonstrated that the three-subscale scoring version is the best method for scoring and interpreting the AcroQoL as compared to the widely used single total score method. The present study is the first to use novel and sophisticated confirmatory methods to assess the scoring options of the AcroQoL. Confirmatory methods and model fit and comparison indices revealed that the three-subscale model better reflected the data than the two-subscale and total score did. Therefore, the three-subscale model is the optimal scoring method for the AcroQoL.

Previous exploratory studies elected to use the total score version over the two-subscale and three-subscale models of the AcroQoL (8, 17). Although the total score version is simple to use and exhibits desirable psychometric properties (i.e., acceptable relationships between the items and the total score), it is impossible to extract information associated with various dimensions of QoL from it. The WHO (12) recommends that measures of QoL consist of three dimensions that reflect physical, psychological, and social issues. The three-subscale scoring method of the AcroQoL, which consists of subscales that measure Physical Complaints, Social Issues, and Appearance Issues, better reflects the WHO's recommendation of a multidimensional measure of QoL as compared to the total score and two-subscale versions.

The better performance of the three-subscale model of the AcroQoL is further supported by the increased β coefficients for Items 11 (i.e., 'Some parts of my body are too big') and 16 (i.e., 'I snore at night'). In the total score and two-subscale models, these items related weakly to the total score and the Psychological Issues subscale respectively. In the three-subscale model, Items 11 and 16 related strongly to the Appearance Issues subscale. Therefore, the three-subscale model was able to capture

the item patterns of the AcroQoL better than the total score and two-subscale models were.

When using the AcroQoL, values for the AcroQoL subscales can be calculated by summing the scores within each subscale. Because the subscales contain a different number of items and are not directly comparable, the following transformation from Badia *et al.* (23) can be used:

$$\frac{(X)-L}{H-L} \times 100,$$

where X is the total score of the subscale of interest, L is the lowest possible score of that subscale, and H is the highest possible score for that subscale. This equation transforms scores to a 0 to a 100 scale, with 100 indicating best possible QoL. The equation can also be used for the total score of the AcroQoL, because it keeps all three subscales and the total score on the same metric (23).

To further highlight the benefit of using the three-subscale version of the AcroQoL, a sample of scores for this scoring solution is presented in Table 3. For example, Patient 52 received a total AcroQoL score of 81.82, which reflects a moderately high QoL. Further examination of the subscales reveals that Patient 52 received a relatively high score for the Physical Complaint subscale. Examination of the Personal Relations Issues subscale reveals a perfect QoL score of 100, whereas the Appearance Issues subscale revealed a score of 60.71. Although Patient 52 exhibited a relatively high overall QoL, he or she was clearly experiencing impaired QoL with respect to his or her appearance. The relatively high scores from the other subscales masked the impairment from Appearance Issues, which suggests that the single total score did not completely capture the patient's actual QoL.

In summary, the three-subscale model, which consists of dimensions of QoL that reflect Physical Symptoms,

Appearance Issues, and Personal Relation Issues, is the preferred scoring method of the AcroQoL. The three-subscale version exhibits superior psychometric properties as compared to the two-subscale and total score models when using confirmatory methods. Theoretically, the three-subscale model also performs better than the two-subscale and total score models because it closely follows the recommendations of the WHO regarding dimensions of QoL. Evidence for using the three-subscale version is further highlighted in a sample of scores provided in Table 3; this evidence demonstrates how the subscales can provide alternative conclusions about QoL than those that the total score may provide.

Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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