

Validation of a shortened Taiwanese version of an asthma quality-of-life questionnaire by Rasch model

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ABSTRACT

The purpose of this study was to assess the one-dimensionality, item fit, redundancy, and differential item functioning (DIF) of a Taiwanese version of the Asthma Quality of Life Questionnaire (TAQLQ) using Rasch model and to examine the test-retest reliability, validity of a simplified version of the TAQLQ and the original AQLQ. The design of this study was a two-time assessment on a 1-month interval. A total of 143 asthmatic outpatients were requested to administer the original 7-point 32-item TAQLQ questionnaires at the first visit and the 5-point 27-item TAQLQ questionnaires at the second visit. Two versions of the questionnaire were analyzed by using the Rasch model (Rasch G, *Probabilistic Models for Some Intelligence and Attainment Tests*, Chicago: University of Chicago Press, 1992) to determine the difference in validity and reliability between the original 32-item and the shortened 27-item TAQLQ scales with different categories responded. The analyzed data show that 5 items in the original 32-item AQLQ are not fitting to the Rasch model's expectations. The shortened 27-item TAQLQ was created by removing the misfit and redundant items. The reliability of the shortened 27-item TAQLQ is greater than the original 32-item AQLQ. The quality of life for asthma patients could be improved and stratified into five strata by summed raw scores of 61, 89, 106, and 120. The cutoff thresholds of averaged raw scores are 2.3, 3.3, 3.9, and 4.4. The simplified 5-point 27-item TAQLQ holds better validity and higher reliability than the original 7-point 32-item TAQLQ. Assessment of the quality of life using an abbreviated 5-point 27-item TAQLQ could be applied to Taiwanese asthma patients who are less educated in southern Taiwan than those in the northern part of Taiwan.

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Key words: AQLQ, asthma, cutoff point, one-dimensionality, questionnaire, Rasch model, TAQLQ, Taiwanese, validity

Various disease-specific instruments for measuring quality of life have been applied to asthma patients, such as the Asthma Quality of Life Questionnaire (AQLQ),^{1,2} the St. George's Respiratory Questionnaire,³ and the Life Activities Questionnaires for Adult Asthma.⁴ Each of these instruments incorporates the functional impairments that are important to asthma patients as to justify symptom impeding the quality of life. Among the scales described, the AQLQ and St. George's Respiratory Questionnaire have most commonly been used and translated into different languages for assessing quality of life in diverse populations of patients.^{5–8} However, no such scales for validation and reliability in asthma patient's quality of life were analyzed by the Rasch analysis,⁹ which offers an advantage over traditional evaluation methods, such as converting raw scores to true interval scores that are reported on a log odds (logit) measurement scale.¹⁰ It

can be precisely used to test hypotheses and accurately referred to statistical inferences.

ISSUES OF CONCERN

The main concern in assessing asthma patients' quality of life is to evaluate whether the items contribute to a single unidimensional construct, which is necessary to justify the summation of scores.¹¹ Furthermore, factor analysis needs to operate an interval scale scores¹² whereas the scales (*e.g.*, AQLQ, etc.) scores are ordinal by nature.

Juniper suggested that the quality of life for asthma patients was grouped into seven levels through the AQLQ average item score (*i.e.*, total scores divided by item number).² However, the ordinal category scores could not be considered as linear interval scores for mathematical and statistical analyses.¹² We are thus concerned with the appropriate criterion for discriminating the quality of life of asthma patients and the determination criterion of cutoff points.

ITEM RESPONSE THEORY-BASED RASCH ANALYSIS

Item response theory (IRT) is increasingly used to assess measures of health outcome.¹³ The IRT-based Rasch analysis⁹ was a new tool and technique, where applicable to measure health status,¹⁴ education,¹⁵ psy-

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Table 1 Two selected characteristics of subjects ($n = 142$; $n = 130$)

Characteristics		First Sample ($n = 143$)	Second Sample ($n = 130$)
Gender	Male/Female	75/68	70/60
Age (yr)		53.0 (17.4)	48.4 (16.1)
Education status	Elementary or less	78 (54.5%)	71 (54.6%)
	Secondary	42 (29.4%)	32 (24.6%)
	College	23 (16.1%)	27 (20.8%)

chology,¹⁶ marketing,¹⁷ economics,¹⁸ and social science.¹⁹ A scale that fits the model's expectations can be considered as a one-dimensional and local independent measurement.²⁰ The characteristics of the Rasch model had been verified as a valid and reliable approach and a specific objective measurement, which is used to (a) compare observed scores with expected values to generate quality control fit statistics to detect data distortion, (b) estimate person measures for knowing the level of quality of life, and (c) clarify the appropriateness of item categories to see whether the outcome spaces exhibit sufficient information on each item and suggest an objectively acceptable cutoff criterion for decision making.²¹

DIFFERENTIAL ITEM FUNCTIONING ANALYSIS FOR GROUP COMPARISONS

In IRT terminology, item/test bias is referred to as differential item functioning (DIF), which refers to a difference in the probability proportion of endorsing an item for members of a reference group (*e.g.*, male) and a focal group (*e.g.*, female) at the same ability level. These proportions, except for random variations, should be the same irrespective of the nature of the group for whom the proportions are plotted.²² If DIF exhibited on an item of a scale, the between-group comparison will be in vain because that DIF item affected by other latent traits instead of the underlying one (*e.g.*, quality of life in this study), *viz.*, the items exhibiting DIF, should be removed from the scale to avoid bias and distortions existing in the inference. Therefore, detection of DIF²³ in polytomous items has attracted much attention in recent years. The items showing significant differences (usually >0.5 logits) on effects of interaction between groups (*i.e.*, age, gender, level of education, race, etc.) will be considered as exhibiting DIF.²⁴

AIMS OF THIS STUDY

The aims of this study are focused on whether (1) the shortened 5-point 27-item Taiwanese AQLQ (TAQLQ) could be reaching the appropriate level of scaling suitable for comparing the quality of life between subgroups that are DIF-free, (2) the validity and reliability

of the simplified short-form TAQLQ is better than the original AQLQ, and (3) the Rasch model can be used to decide the cutoff points that were not indicated in the original AQLQ.

METHODS

Subjects

A total of 143 patients in Table 1 who regularly visited the asthma outpatient clinic of a medical center in southern Taiwan were recruited between December 1, 2005 and January 31, 2006. Each subject was >18 years old and suffered from mild to moderate symptoms of asthma with an ICD-9 code of 493.00–493.91 during the past 3–6 months. Patients with chronic obstructive pulmonary disease were excluded from this study. The procedures conformed to the institutional review board's guidelines for studies with human subjects. Written informed consent of each subject was obtained. The ethics approval process was not enforced during the study period in our hospital.

Instruments

Professor Juniper provided us with the Chinese version of AQLQ, in which 32 items are contained in the questionnaire for assessing the quality of life of adults with asthma. The items with seven-point categories are grouped into four domains (*i.e.*, symptoms, emotions, exposure to environmental stimuli, and activity limitations). All domains were combined in the Rasch rating scale model²⁰ to examine whether they meet a single composite dimensional construct; the appropriateness of level of scaling; were DIF free (or at least DIF trivial); and the criterion regarding severe, mild, and moderate cutoff points in quality of life for asthma patients. A modified 5-point 27-item TAQLQ scale was produced after the first analytical result of the 7-point 32-item AQLQ scale.

Procedure

The design of this study was a two-time assessment on a 1-month interval. Each patient was referred to the pharmacist consultation clinic by either a physician at the outpatient clinic or a frontline pharmacist self-

Table 2 Difficulty and OUTFIT/INFIT statistics

No.	Items	Difficulty Logit	IN.MNSQ	OUT.MNSQ
5	Individual activity	1.87	0.84	1.16
20	Wake in A.M. with symptoms	0.52	1.10	1.12
12	Cough	0.31	1.49	1.48
29	Lack of a good night's sleep	0.30	1.31	1.34
32	Activities in general	0.24	0.81	0.83
24	Woke at night by asthma	0.23	0.81	0.85
23	Exposure to strong smells	0.20	0.77	0.77
17	Exposure to dust	0.19	1.13	1.20
30	Fighting for air	0.17	0.91	1.01
16	Clear throat	0.16	1.02	1.02
13	Feel frustrated due to asthma	0.15	0.90	0.95
2	Individual activity	0.07	1.46	1.45
26	Exposure to strong smells	0.06	0.99	0.99
19	Avoid dust	0.03	0.65	0.66
1	Exertion activity		Misfit item	
9	Exposure to cigarette smoke		Misfit item	
11	Avoid cigarette smoke		Misfit item	
28	Avoiding strong smells		Misfit item	
18	Difficulty breathing out		Misfit item	
7	Concerned asthma	-0.03	0.79	0.77
27	Afraid of getting out of breath	-0.05	0.99	0.97
8	Short of breath	-0.06	0.95	0.90
22	Heaving breathing	-0.13	1.13	1.11
15	Concerned remedication	-0.15	0.67	0.66
31	Range of activities	-0.18	0.62	0.63
25	Avoid weather/air pollution	-0.19	0.97	0.99
10	Wheeze	-0.22	1.32	1.33
14	Chest heaviness	-0.29	0.62	0.61
21	Afraid of not having medications	-0.41	0.98	0.95
6	Chest tightness	-0.83	1.39	1.26
3	Individual activity	-0.85	1.49	1.36
4	Individual Activity	-1.10	1.17	1.10

Note: Standard errors of all item difficulties are in the range of 0.06–0.07; Fit MNSQs are between 0.5 and 1.5.

IN.MNSQ = information-weighted fit mean square; OUT.MNSQ = outlier-sensitive fit mean square; OUTFIT = outlier-sensitive fit; INFIT = information-weighted fit.

finding by checking patient's prescription against the diagnosis. The clinical pharmacist administered the original 7-point 32-item AQLQ and shortened 5-point 27-item TAQLQ (1 month later) to each subject in a face-to-face interview at the pharmacist consultation clinic at their first visit and second visit after 1 month, respectively.

Data Analysis

Both AQLQ and TAQLQ were assessed for one-dimensionality using the Rasch rating scale model²⁰ with WINSTEPS software²⁴ by a statistician. In case the scale complied with both one-dimensionality and interval Rasch transformed measurement scores, the patient estimates could be referred to as the level of daily

activity on quality of life for asthma. The quality control fit statistics of the Rasch model for each item on the questionnaire is assessed by mean square (MNSQ) error such as the information-weighted fit (INFIT) and the outlier-sensitive fit (OUTFIT).^{14,25} An acceptable range of values for the INFIT MNSQ and the OUTFIT MNSQ is 0.5–1.5.²⁶ An MNSQ <0.5 indicates that an item is violated to the assumption of local independence with highly overfitted items and correlated with the remaining items on the scale. In contrast, an MNSQ >1.5 means that the data do not fit (underfit) the Rasch model's expectations. The poorly constructed items will be misunderstood and noised to the single construct. The poorly fitted items attributable to either redundant for overfit (muted) or not-the-same-latent

Table 3 Category difficulties for 7-point and 5-point AQLQ

Item	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Item	Step 1	Step 2	Step 3	Step 4	Step 5
Activities_1	-0.22	-0.06	0.05	0.19	0.57	0.50*	1.43	Activities_1	-0.29	0.00	0.25	0.73	2.01
	0.10	0.10	0.15	0.09	0.12	0.09	0.22		0.14	0.14	0.13	0.11	0.28
Activities_2	-0.50	-0.40	-0.17	0.07	0.07*	0.32	1.01	Activities_2	-0.68	-0.34	0.11	0.29	1.40
	0.33	0.23	0.11	0.10	0.09	0.07	0.14		0.45	0.13	0.14	0.08	0.19
Activities_3	-0.97	-0.21	-0.22*	0.06	0.09	0.23	1.01	Activities_3	-1.29	-0.28	0.08	0.21	1.40
	0.26	0.49	0.08	0.16	0.08	0.07	0.14		0.32	0.18	0.21	0.07	0.18
Activities_4	-0.95		-0.10	0.10	0.34	0.64	1.15	Activities_4	-1.25	-0.25	0.18	0.70	1.59
	0.28		0.13	0.19	0.10	0.18	0.21		0.36	0.21	0.27	0.15	0.26
Activities_5	-0.53	-0.69*	-0.07	0.21	0.19*	0.40	0.86	Activities_5	-0.74	-0.27	0.27	0.44	1.18
	0.08	0.32	0.25	0.15	0.10	0.08	0.14		0.11	0.30	0.23	0.08	0.18
Activities_11	-0.07	0.11	0.13	0.22	0.60	0.89	0.96	Activities_11	-0.10	0.16	0.30	1.02	1.34
	0.10	0.14	0.08	0.09	0.12	0.19	0.28		0.13	0.11	0.13	0.15	0.36
Activities_19	-0.04	-0.11*	0.07	0.36	0.49	0.94	1.79	Activities_19	-0.06	-0.05	0.50	1.02	2.49
	0.10	0.13	0.08	0.07	0.10	0.13	0.34		0.14	0.12	0.10	0.12	0.42
Activities_25	-0.32	-0.32	0.12	0.24	0.25	0.69	1.71	Activities_25	-0.43	-0.08	0.33	0.67	2.40
	0.09	0.16	0.08	0.08	0.07	0.09	0.25		0.12	0.11	0.12	0.08	0.31
Activities_28	-0.08	-0.23*	0.14	0.38	0.40	0.71	1.36	Activities_28	-0.11	-0.01	0.51	0.82	1.89
	0.09	0.15	0.05	0.10	0.11	0.10	0.26		0.13	0.09	0.13	0.11	0.34
Activities_31	-0.45	-0.32	0.12	0.35	0.28*	0.77	1.15	Activities_31	-0.63	0.04	0.51	0.57	1.60
	0.15	0.20	0.07	0.30	0.07	0.12	0.18		0.20	0.09	0.44	0.09	0.23
Activities_32	-0.27	-0.66*	-0.23	0.04	0.22	0.55	1.21	Activities_32	-0.39	-0.54*	0.03	0.56	1.70
	0.22	0.21	0.09	0.07	0.08	0.07	0.18		0.33	0.14	0.10	0.08	0.23
Symptoms_6	-1.28	-0.54	-0.21	-0.11	0.45	1.15	1.62	Symptoms_6	-1.72	-0.45	-0.21	0.96	2.33
	0.17	0.31	0.13	0.12	0.08	0.15	0.23		0.20	0.17	0.16	0.12	0.31
Symptoms_8	-1.45	-0.61	-0.47	0.09	0.39	0.70	1.45	Symptoms_8	-1.93	-0.72	0.13	0.71	2.08
	0.19	0.19	0.14	0.09	0.11	0.12	0.17		0.22	0.14	0.12	0.11	0.24
Symptoms_10	-0.87	-1.07*	-0.03	0.25	0.64	0.89	1.40	Symptoms_10	-1.16	-0.84	0.33	1.04	2.02
	0.21	0.15	0.14	0.11	0.13	0.16	0.21		0.28	0.19	0.16	0.14	0.29
Symptoms_12	-0.79	-0.70	-0.30	0.24	0.47	1.01	1.70	Symptoms_12	-1.10	-0.62	0.35	1.03	2.35
	0.18	0.24	0.13	0.12	0.14	0.12	0.26		0.23	0.16	0.18	0.14	0.34
Symptoms_14	-0.96	-1.31*	-0.47	-0.07	0.57	0.94	1.48	Symptoms_14	-1.30	-1.17	-0.11	1.00	2.05
	0.21	0.22	0.12	0.09	0.11	0.11	0.20		0.27	0.19	0.13	0.11	0.28
Symptoms_16	-1.03	-0.84	0.07	0.46	0.57	1.12	0.95*	Symptoms_16	-1.36	-0.29	0.64	1.06	1.38
	0.32	0.21	0.12	0.16	0.11	0.22	0.32		0.40	0.16	0.24	0.15	0.47
Symptoms_18	-1.08	-1.02	-0.37	0.10	0.52	1.01	1.59	Symptoms_18	-1.42	-0.90	0.13	1.09	2.29
	0.19	0.14	0.10	0.08	0.11	0.10	0.19		0.23	0.13	0.12	0.11	0.27
Symptoms_20	-0.81	-0.64	-0.48	-0.29	0.28	0.46	1.41	Symptoms_20	-1.04	-0.77	-0.39	0.50	2.01
	0.38	0.25	0.25	0.08	0.14	0.10	0.14		0.50	0.23	0.12	0.11	0.20
Symptoms_22	-0.75	-0.92*	-0.05	0.04	0.52	1.06	1.67	Symptoms_22	-1.03	-0.51	0.04	1.10	2.45
	0.19	0.21	0.15	0.11	0.09	0.11	0.23		0.24	0.19	0.14	0.10	0.31
Symptoms_24	-1.10	-0.66	-0.33	-0.05	0.55	0.49*	1.50	Symptoms_24	-1.41	-0.66	-0.11	0.72	2.10
	0.24	0.22	0.20	0.11	0.11	0.12	0.15		0.30	0.20	0.16	0.12	0.21
Symptoms_29	-1.06	-0.49	-0.14	0.37	0.47	1.08	1.60	Symptoms_29	-1.37	-0.41	0.51	0.98	2.28
	0.28	0.12	0.14	0.14	0.12	0.13	0.34		0.36	0.14	0.19	0.14	0.46
Symptoms_30	-1.23	-0.94	-0.43	0.03	0.36	1.04	1.51	Symptoms_30	-1.61	-1.02	0.06	0.86	2.17
	0.19	0.23	0.11	0.11	0.09	0.12	0.22		0.23	0.19	0.15	0.12	0.30
Emotions_7	-1.62	-0.98	-0.55	-0.01	0.58	1.66	2.92	Emotions_7	-2.31	-1.13	-0.12	1.59	3.96
	0.32	0.28	0.16	0.11	0.18	0.18	0.29		0.40	0.20	0.15	0.19	0.32
Emotions_13	-2.17	-0.96	-0.92	-0.17	0.46	1.21	2.98	Emotions_13	-2.94	-1.41	-0.31	1.26	3.98
	0.42	0.25	0.17	0.12	0.17	0.15	0.28		0.53	0.20	0.18	0.17	0.33
Emotions_15	-1.53	-0.83	-0.34	0.20	0.91	1.47	3.23	Emotions_15	-2.17	-0.80	0.31	1.83	4.14
	0.29	0.22	0.10	0.16	0.27	0.14	0.28		0.37	0.15	0.26	0.19	0.31
Emotions_21	-1.64	-0.70	-0.61	-0.01	0.49	1.25	2.76	Emotions_21	-2.28	-1.04	-0.07	1.30	3.75
	0.26	0.26	0.26	0.13	0.12	0.16	0.26		0.34	0.27	0.19	0.16	0.30
Emotions_27	-1.99	-0.64	-0.74*	-0.33	0.26	1.15	2.41	Emotions_27	-2.76	-1.00	-0.52	1.09	3.24
	0.43	0.40	0.11	0.12	0.14	0.17	0.26		0.56	0.36	0.17	0.17	0.33

Table 3 Continued

Item	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Item	Step 1	Step 2	Step 3	Step 4	Step 5
Environment_9	-2.16	-0.42	-0.51*	-0.16	0.33	1.01	1.73	Environment_9	-2.74	-0.78	-0.16	0.94	2.23
	0.52	0.10	0.18	0.13	0.15	0.16	0.33		0.65	0.19	0.18	0.15	0.38
Environment_17	-2.01	-0.87	-0.28	0.26	0.57	1.20	3.00	Environment_17	-2.62	-0.82	0.46	1.18	3.66
	0.58	0.18	0.10	0.08	0.13	0.15	0.41		0.72	0.14	0.13	0.14	0.45
Environment_23	-2.10	-0.67	-0.34	0.14	0.54	1.16	3.51	Environment_23	-2.64	-0.68	0.23	1.16	4.26
	0.62	0.22	0.11	0.09	0.12	0.14	0.39		0.80	0.15	0.14	0.13	0.42
Environment_26	-2.09	-0.97	-0.41	-0.16	0.44	0.95	2.33	Environment_26	-2.63	-0.92	-0.19	1.04	2.93
	0.46	0.24	0.09	0.12	0.08	0.11	0.33		0.58	0.14	0.17	0.10	0.37

for underfit (noised) should be removed from the instrument.

The categories of an item for each examined scale can be considered redundant while step difficulties collapsed (disordered) with the adjacent steps presenting, indicating less information across categories.²¹ The optimal number of categories is evaluated by the order of step difficulty of each item and by the MNSQ OUTFIT statistic for each category.^{26,27}

We assumed that the 5-point 27-item TAQLQ can improve the validity and reliability of the original AQLQ by deleting the poorly fitted items and collapsing redundant categories. The category number for each item can be simplified simultaneously. The person separation index derived from Rasch analysis can differentiate person's ability responses and strata along a measured variable by items. The greater separation index represented better variation separation of person estimates and better distinction between respondents' abilities, which increased the reliability of AQLQ assessment.

DIF analysis was performed to determine the variability of item responses across the subgroup of patients identified by age, gender, and education level. The effect of the different three main characteristics on the overall TAQLQ scores was also inspected. In the DIF analysis, there were two-part gender, four age groups (18–30, 31–50, 51–65, and >66 years), and three education levels of elementary school, secondary school, and college education.

Deciding the Cutoff Criterion of the TAQLQ

The Rasch analysis computes a person separation index, which indicates that the number of person strata defined by the scale with the formula of $Hi = (4Gi + 1)/3$, where Gi is the person separation index and Hi is the person stratum.²⁰ Larger person separation values yield higher test reliability than smaller values.²⁸ K-mean statistics of cluster analysis was employed to define the appropriate cut-off points. Patients with good quality of life may have higher summation scores than those with worse quality of life. A shortened

5-point 27-item TAQLQ was created by removing misfit items. The optimal cutoff criterion for the individual thresholds of strata and differences in discrimination for quality of life on the TAQLQ scale were measured.

RESULTS

Overall Domains Fit to the Model

All but 5 items of the original 32-item AQLQ (*i.e.*, item 1, exertion activity; item 9, exposure to cigarette smoke; item 11, avoiding cigarette smoke; item 28, avoiding strong smells; item 32, activities in general) fitted the model's expectation very well. Five items of the original 32-item AQLQ had INFIT and OUTFIT MNSQ values of <0.5 or >1.5, which indicates that the poor items were misfit to the Rasch model's requirements and should be excluded in subsequent analyses. The remaining 27 items were found to fit the model (Table 2). Subsequent analyses were performed using data for the remaining 27 items (27-TAQLQ).

Rasch Analyses for 27 Fitting Items (27-TAQLQ)

Table 3 shows that the 32 polytomous items from each index exhibited disordered step difficulty (*i.e.*, the difficulty of a higher step was lower than that of its adjacent lower step), which indicated that the second and the fifth category were redundant and were collapsed into five categories to produce a shortened 5-point 27-item TAQLQ, of which the person measures had a mean value of 0.39 logits with an SD of 0.91. The person separation reliability was 0.92 (which can be similar to Cronbach's α) and referred to the reliability 0.92 of the original AQLQ scale, indicating that the questionnaire items yielded acceptable precise estimates for asthmatic patients.

Stability of 27-TQLQ Item Locations

The patients and item difficulty map of the 27-item TAQLQ is shown in Fig. 1, which shows the distribution of measures of the severity of the asthma and the item difficulty on the same linear continuum, based on the Rasch model. To the left of the vertical line are

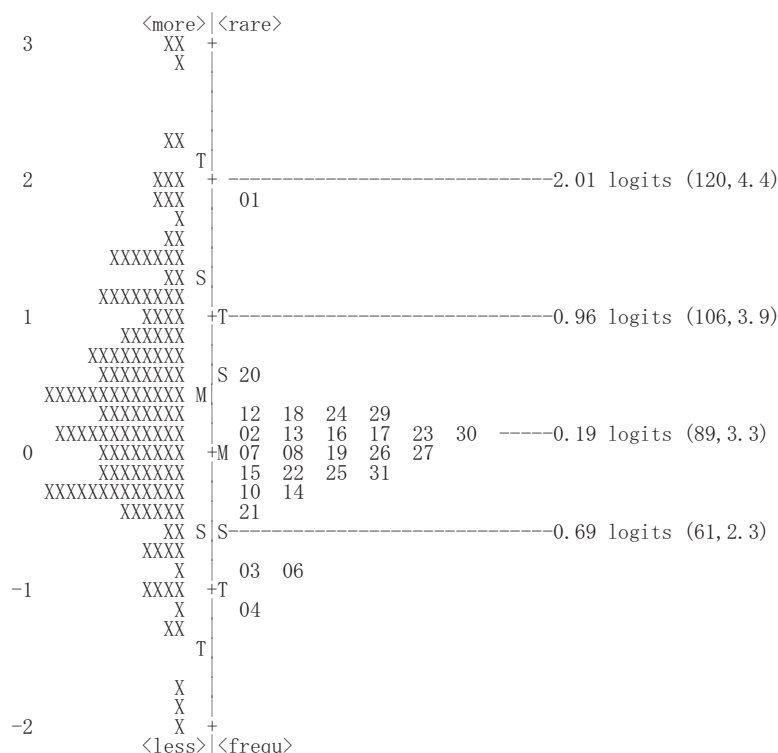


Figure 1. Person and averaged difficulty item map and cutoff points: logits (global, average (raw scores)). Note 1: M = means; S = 1 SD; T = 2 SD. Note 2: The step difficulties under rating scale model are -1.48, 0.15, 0.51, and 1.83.

patients, with the more severe asthmatic patients on the top and the mild asthmatic patients on the bottom. To the right of the vertical line are items; more difficult items are on the top and less difficult ones are on the bottom. Overall, the assessment instrument showed that an item difficulty distribution was well targeted to the severity of patients (represented by X) nearly at the same position on the logit scale.

The most difficult item in the questionnaire for patients was item 1 (exertion activity). The easiest item was item 4 (individual activity). The mean logit scores for the patients and items (0.39 ± 0.25 SE and 0.00 ± 0.10 SE, respectively) indicated that patients were closely matched on the 27 items. Figure 2 also shows the evidence that persons are approaching the targeted zero logit by TAQLQ more than by AQLQ.

In DIF analysis, no items had a significant DIF for gender. However, five items displayed DIF for age and four items for education (Table 4). If we neglect DIF in existence in T AQLQ, significant differences were found in age ($F = 3.017$; $df = 3$; $p = 0.030$) and education ($F = 4.952$; $df = 2$; $p = 0.008$). The results showed that patients with old age (≥ 66 years) and lower education level (elementary school) did not perform well with these items of AQLQ. The shortened version of TAQLQ was created by deleting these misfit items.

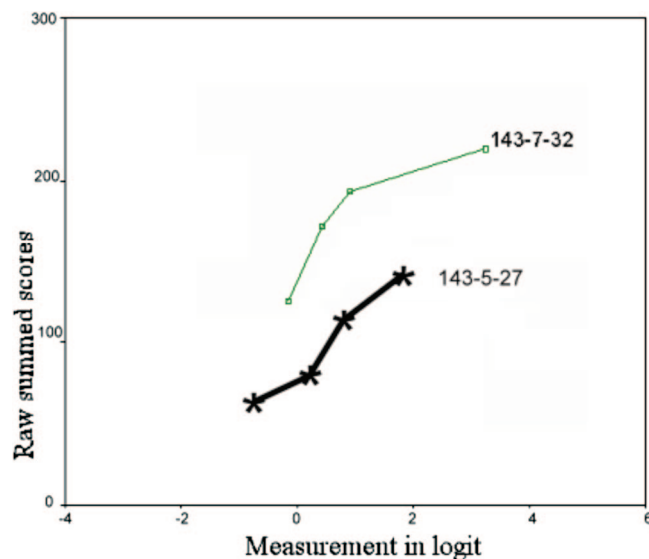


Figure 2. Cutoff scores for 32-item AQLQ and 27-item TAQLQ.

Proper Cutoff Points

The person separation index of the 5-point 27-item TAQLQ was 3.53, higher than the original 7-point 32-item version of 3.03 because of 5 misfit items noising the validity of the scale, and told us there were 5 distinct levels (strata) of change in quality of life. Thus, we used a K-mean of cluster algorithm to decide the cutoff points for the two scales as shown in Fig. 2. We found that the number of each stratum (level) exhibited

Table 4 Maximum differences in the estimates for item difficulty across gender, age, and education level

Questionnaire	Gender	Age (yr)	Education	INFIT MNSQ	OUTFIT MNSQ
1 Exertion activity	0.05	0.54*	0.54*	1.56	1.74
2 Middle exertion activity,	0.06	0.41	0.45	1.29	1.23
3 Social activity (talking, visiting friend, etc.)	0.14	0.48	0.50	1.16	1.13
4 Daily/office activity	0.39	0.40	0.45	1.24	1.07
5 Sleeping	0.19	0.46	0.50	1.26	1.17
6 Chest tightness	0.09	0.25	0.46	0.81	0.81
7 Concerned asthma	0.02	0.22	0.30	0.91	0.87
8 Short of breath	0.27	0.42	0.23	0.83	0.80
9 Exposure to cigarette smoke	0.23	0.66*	0.61*	1.34	1.42
10 Wheeze	0.14	0.38	0.40	0.94	1.00
11 Avoid cigarette smoke	0.32	0.55*	0.29	1.75	2.13
12 Cough	0.08	0.44	0.66	0.99	1.00
13 Frustrated	0.00	0.44	0.29	0.64	0.70
14 Chest heaviness	0.29	0.33	0.44	0.77	0.77
15 Concerned re-medication	0.25	0.23	0.13	0.99	1.06
16 Clear throat	0.21	0.09	0.31	1.24	1.29
17 Exposure to dust	0.09	0.50	0.28	0.92	0.92
18 Difficulty breathing out	0.29	0.83*	0.51*	0.64	0.69
19 Avoid dust	0.05	0.21	0.41	1.25	1.31
20 Wake in A.M. with symptoms	0.16	0.40	0.44	1.02	1.00
21 Afraid of not having medications	0.11	0.29	0.39	0.95	0.94
22 Heaving breathing	0.25	0.21	0.33	0.75	0.76
23 Exposure to strong smells	0.13	0.19	0.47	0.89	0.90
24 Woken at night by asthma	0.07	0.31	0.49	0.95	0.99
25 Avoid weather/air pollution	0.04	0.42	0.49	1.00	1.01
26 Exposure to strong smells	0.18	0.30	0.48	0.98	0.98
27 Afraid of getting out of breath	0.19	0.29	0.35	0.92	0.85
28 avoiding strong smells	0.28	0.61*	0.60*	1.46	1.36
29 Lack of a good night's sleep	0.14	0.44	0.08	1.03	0.99
30 Fighting for air	0.07	0.34	0.44	0.71	0.71
31 Range of activities	0.04	0.33	0.43	1.04	1.02
32 Activities in general	0.04	0.29	0.18	0.73	0.74

*DIF exhibition.

INFIT = information-weighted fit; MNSQ = mean square; OUTFIT = outlier-sensitive fit.

statistically significant differences in each scale, indicating that the one-dimensionality and scaled appropriateness (e.g., lines of 143-5-27 in Fig. 2) are essential to the measurement of latent trait as quality of life in this study.

Convergent Validity of the 27-TQLQ

The shortened version of TAQLQ was scored and the patients were grouped into five strata according to the four raw score cutoff thresholds of 2.3, 3.3, 3.9, and 4.4 (above cutoff point of 4.4, severe asthma; above cutoff point of 3.9, moderate asthma; above 3.3, mild asthma; below cutoff point 2.3, quite mild asthma). The cutoff score for global scores of the individual strata are reported in Fig. 2 and Table 5. The one-way ANOVA on

the five strata presents statistically significant differences ($F = 749.846$; $df = 4$; $p < 0.05$).

DISCUSSION

Overall Domains Fit to the Model

Our study found that a unidimensional TAQLQ can be created by deleting the five items related to activity and environment. The INFIT and OUTFIT MNSQ values were beyond 0.5 and 1.5. The results were similar to the results of previous studies on the validation of the mini-AQLQ; these items may not be considered clinically important^{17,18} because of the ordinal scores in nature instead of Rasch-transformed interval scores in logit.

Table 5 Raw score and Rasch-transformed measures

Raw Score		Rasch Transformed	Standard Error	Cutoff Point	Raw Score		Rasch Transformed	Standard Error	Cutoff Point
Global	Average				Global	Average			
41	1.5	-1.96	0.29		89	3.3	0.19	0.19	*
44	1.6	-1.73	0.27		90	3.3	0.36	0.21	
46	1.7	-1.27	0.24		91	3.4	0.44	0.21	
51	1.9	-1.30	0.23		92	3.4	0.31	0.20	
54	2.0	-1.14	0.22		93	3.4	0.35	0.20	
56	2.1	-1.05	0.21		94	3.5	0.39	0.20	
57	2.1	-1.00	0.21		95	3.5	0.43	0.20	
61	2.3	-0.69	0.20	*	96	3.6	0.47	0.21	
63	2.3	-0.75	0.20		97	3.6	0.51	0.21	
65	2.4	-0.67	0.20		98	3.6	0.56	0.21	
66	2.4	-0.64	0.19		99	3.7	0.60	0.21	
67	2.5	-0.60	0.19		100	3.7	0.65	0.22	
69	2.6	-0.43	0.19		101	3.7	0.70	0.22	
70	2.6	-0.49	0.19		102	3.8	0.75	0.22	
71	2.6	-0.45	0.19		103	3.8	0.80	0.23	
72	2.7	-0.42	0.19		104	3.9	0.85	0.23	
73	2.7	-0.38	0.19		105	3.9	0.91	0.23	
74	2.7	-0.35	0.19		106	3.9	0.96	0.24	*
75	2.8	-0.31	0.19		108	4.0	1.08	0.25	
76	2.8	-0.28	0.19		109	4.0	1.14	0.25	
77	2.9	-0.24	0.19		110	4.1	1.21	0.26	
78	2.9	-0.21	0.19		113	4.2	1.42	0.27	
79	2.9	-0.17	0.19		114	4.2	1.49	0.28	
81	3.0	-0.10	0.19		115	4.3	1.57	0.28	
82	3.0	-0.06	0.19		116	4.3	1.65	0.29	
83	3.1	0.46	0.21		118	4.4	1.82	0.30	
84	3.1	0.01	0.19		120	4.4	2.01	0.31	*
86	3.2	0.14	0.19		123	4.6	2.33	0.34	
87	3.2	0.12	0.19		127	4.7	2.88	0.40	
88	3.3	0.15	0.19		128	4.7	3.05	0.42	

*Cutoff point; average raw score = global raw score ÷ 27 (items).

Advantages of the TAQLQ

The AQLQ is one of the common questionnaires used to measure asthmatic patients' quality of life. Using the Rasch model, we found that the AQLQ can be shortened by removing five items from the original AQLQ and simplifying the seven-point scoring scales into five-point scales. The items of the shortened scale have been shown to measure self-perceived quality of life as a one-dimensional construct for asthmatic patients of southern Taiwan; it is valid to sum the item scores of the scale for further statistical analysis (Table 5). The total score represents a patient's perception on a single continuum constituting the entire range of quality of life. The higher the score, the greater the degree of patients' self-perceived change in their health quality of life and higher severity of the disease.¹¹ The advantages of the shortened version can be expected to produce more easy and accurate measure scales of the

effects of asthma on patients' health quality of life and provide physicians with decisive treatment. The endorsed items are also simplified into five categories. The cutoff point of four thresholds is more reliable than the original AQLQ version.

Rasch-Transformed Interval Score

The total score of the TAQLQ shows whether the patient has problems in their quality of life. A conversion table was compiled showing raw scores (41–128) and their Rasch-transformed scores (–1.96–3.05). The Rasch-transformed scores can be viewed as interval-level measurements,²⁵ whereas the TAQLQ raw scores are ordinal data. Because most statistical techniques assume that the data are at least on an interval scale, the Rasch-transformed scores of the TAQLQ scale are recommended for future applications by using the conversion table to convert the raw score of the patient to

the corresponding Rasch-transformed interval score for further statistical analysis.

Higher Reliability at Proper Cutoff Point

Many item categories near the point of 0.44 logits (SE = 0.04) in the hierarchy as in Fig. 1 could yield higher person reliability for patients at the “mild” cutoff point above the average score of 3.3 exactly with sufficient matching items (*e.g.*, a person with ability of 0.44 in N [0.39, 0.83] and SE of 0.04 has a Rasch person separation reliability of 0.98 greater than the average of 0.92). The same phenomenon of sufficient matching of items to persons was shown at the “very severe” cutoff point above 4.4 with 2.01 logits. A person with the ability of cutoff point 2.3 with -0.69 logits in N (0.39, 0.83) and SE of 0.20 has a Rasch person separation reliability of 0.95 greater than the average of 0.94. The two extreme summation scores of 3.05 and -1.96 have very small reliabilities (SE at 0.46 and 0.29) and can be ignored because it was far from the cutoff decision screening points.

DIF Analysis and Comparisons in Groups

The DIF analysis in this study showed that the items had a significant DIF for age and education but no significant DIF for gender. It means that different age and education level may have a significant influence on the total score of the TAQLQ. This result could raise controversy to other studies on the reliability and validity of AQLQ, in which the results indicated that the relationship between the AQLQ overall score and age was not statistically significant²⁹; however, gender had higher effects on the overall score and symptom subscales.^{30,31}

Only a few studies explore the effect of age and education on the overall score of AQLQ. It may be because there is no significant difference of demographic variables, such as age, gender, and education level between different cities of other countries. The aforementioned three variables are very rare to be considered in the evaluation on the reliability and validity of AQLQ of different language version in previous studies. To the best of our knowledge, this is the first DIF analysis for age, gender, and education of the AQLQ translation version because we thought that such demographic variables may have great discrepancy between different translation versions used in different countries.

Limitations

The limitation of the present study was that the sample was just comprised of Taiwanese asthma patients. Therefore, our findings may not apply to non-Chinese populations or Chinese populations in other regions, such as Hong Kong or Mainland China, where

the spoken language is the same as those studied in this study. It is also necessary to confirm and verify the superiority of the short-form TAQLQ in asthmatic patients for later research. Therefore, our results should be considered as preliminary.

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APPENDIX

Patients Chart No: _____						
Date: _____						
Please complete all questions by circling the number that best describes how you have been during the last 2 weeks as a result of your asthma		Totally Limited	Very Limited	Moderate Limitation	Some Limitation	Not at all Limited
		1	3	4	5	7
1	STRENUOUS ACTIVITIES (such as hurrying, exercising, running up stairs, sports)	☐	☐	☐	☐	☐
2	MODERATE ACTIVITIES (such as walking, housework, gardening, shopping, climbing stairs)	☐	☐	☐	☐	☐
3	SOCIAL ACTIVITIES (such as talking, playing with pets/children, visiting friends/relatives)	☐	☐	☐	☐	☐
4	WORK-RELATED ACTIVITIES* (tasks you have to do at work)	☐	☐	☐	☐	☐
5	Feel FRUSTRATE as experience a feeling of CHEST TIGHTNESS or CHEST HEAVINESS	☐	☐	☐	☐	☐
6	Feel CONCERNED ABOUT HAVING ASTHMA?	☐	☐	☐	☐	☐
In general, how much of the time during the last 2 weeks did you:						
		All of the time	A Good Bit of the time	Some of the Time	A Little of the Time	None of the Time
		1	3	4	5	7
7	Feel SHORT OF BREATH as a result of your asthma?	☐	☐	☐	☐	☐
8	Experience a WHEEZE in your chest?	☐	☐	☐	☐	☐
9	Feel bothered by COUGHING?	☐	☐	☐	☐	☐
10	Feel FRUSTRATED as a result of your asthma?	☐	☐	☐	☐	☐
11	Experience a feeling of CHEST TIGHTNESS or CHEST HEAVINESS?	☐	☐	☐	☐	☐
12	Feel AFRAID OF NOT HAVING YOUR ASTHMA MEDICATION AVAILABLE?	☐	☐	☐	☐	☐
13	Feel need to clear throat	☐	☐	☐	☐	☐
14	Experience Asthma as exposure to dust	☐	☐	☐	☐	☐
15	Difficulty breathing out as a result of Asthma	☐	☐	☐	☐	☐
16	Wake in a.m. with Asthma symptoms	☐	☐	☐	☐	☐
17	Afraid of not having medications	☐	☐	☐	☐	☐
18	Feel bothered by heavy breathing	☐	☐	☐	☐	☐
19	Experience asthmatic symptoms because of WEATHER OR AIR POLLUTION	☐	☐	☐	☐	☐
20	Woken at night by asthma	☐	☐	☐	☐	☐
21	Avoid going outside because of WEATHER OR AIR POLLUTION	☐	☐	☐	☐	☐
22	Experience asthmatic symptoms because of strong smells	☐	☐	☐	☐	☐
23	Afraid of not breathing	☐	☐	☐	☐	☐
24	Lack of a good night's sleep because of asthma attack	☐	☐	☐	☐	☐
25	Feel to exert to breath	☐	☐	☐	☐	☐
26	Limitation on the range of activities because of asthma	☐	☐	☐	☐	☐
27	Limitation on your Activities in general because of asthma	☐	☐	☐	☐	☐

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