行政院國家科學委員會專題研究計畫　成果報告

以 Rasch 模式發展中風病人平衡量表(2/2)

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計畫主持人：薛漪平
共同主持人：謝清麟，王文中

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Note: We have written the following manuscript which is almost ready for submission. We are also writing another manuscript regarding developing a brand new balance scale based on Rasch analysis. It should be finished and submitted in the early of next year.

Comparison of measurement properties of three balance measures in stroke patients using item response theory

Background and Purposes: This study used Mokken scale analysis and Rasch analysis to examine whether items of three balance measures (the balance subscale of the Fugl-Meyer Test (FMB), the Berg Balance Scale (BBS), and the Postural Assessment Scale for Stroke patients (PASS)) in stroke patients individually contribute to a unidimensional hierarchical construct, and whether their sum scores can be transformed to interval-level measurements. We also examined whether the measurement properties of three balance measures are stable over time points after stroke.

Method: A total of 301 patients were followed up prospectively using the three balance measures at 14, 30, 90, 180 and 365 days after stroke. The data at different time points after stroke were individually analyzed by Mokken scale analysis followed by Rasch analysis.

Results: The unidimensionality of the three measures was strong and stable over time, as measured by the Mokken *H* statistic ($H \geq 0.74$). After 5 poor-fitting items (infit standardized Z value > 2.58 and infit mean square > 1.4, or outfit standardized Z value > 2.58 and outfit mean square > 1.4) were deleted, the resulting 6-item FMB, 12-item BBS, and 10-item PASS over the 5 time points fitted the Rasch model's expectation fairly well. Both the BBS and PASS had satisfactory test reliabilities (≥ 0.89).

Conclusions: A strong and stable unidimensional construct was found for each of the three balance measures over time. The Rasch-transformed interval scores of the 6-item of FMB, 12-item BBS, and 10-item PASS are provided to quantify the balance function in stroke patients. Furthermore, the potential for using the12-item BBS and 10-item PASS in assessing balance function for stroke patients is well supported.

Balance is a crucial ability for stroke patients to achieve independence in daily activities.[1-2] Accurately measuring balance is one of the prerequisites for balance training of stroke rehabilitation and it assists clinicians in clinical decision making (e.g., selection of the most appropriate therapy, prediction of the long-term outcome) and outcome measurement.[3-4]

Several functional scales for measuring balance have been developed and applied to stroke patients in clinical and research settings.[1,5-10] Among these, the Balance subscale of the Fugl-Meyer Test (FMB),[8] the Berg Balance Scale (BBS),[9]and the Postural Assessment Scale for Stroke patients (PASS)[10] are the most commonly used. Although many researchers have examined the psychometric properties of each of the 3 balance measures using classical test theory, [7-15] at least 3 shortcomings should be taken into account in using these measures. First, the three balance measures have not been tested for unidimensionality. The unidimensional construct of a scale indicates whether all items of the scale measure the same construct, which is required to justify the summation of scores to quantify characteristics of interest (Sodring KM, et al, 1995). Second, even if the unidimensionality of the three balance measures have been verified, the sum score of the measures attain only the status of an ordinal score. Interval scores, rather than ordinal ones, can provide a more accurate reflection of disease impact, differences between individuals and groups, and treatment effects. Furthermore, an interval measure can be analyzed by parametric statistics, which are often more powerful than non-parametric methods.[16-18] Third, the balance measures are often administered repeatedly to monitor the recovery of balance function and to make clinical decisions for patients with stroke. It is thus critical to determine whether or not the meanings of the construct remain the same over time. Only if the meanings remain unchanged will the recovery of balance function over time be uniquely measured. These shortcomings limit further application of these measures in stroke patients.

The modern psychometric method known as Rasch analysis or item response theory (IRT) in general can be useful in solving these aforementioned shortcomings.[19,20] Mokken scale analysis, a non-parametric IRT, examines the accuracy of ordering between persons' scores on a measure to determine the dimensionality of the measure.[21] Rasch analysis, a parametric IRT, transforms ordinal sum scores into interval measures in logit unit, in addition to dimensionality assessment.[22] Therefore, the purposes of this study were to use Mokken scale analysis and Rasch analysis to examine whether items of these three balance measures (i.e., the FMS, BBS, and PASS) in stroke patients individually contribute to a unidimensional construct, and to examine whether the sum scores could be transformed to interval scores. We also examined whether the psychometric properties of the measures are stable over 5 time points within a year after stroke.

Method

Subjects

The subjects were recruited from the registry of the Quality of Life after Stroke Study in Taiwan between December 1, 1999 and December 31, 2001. Patients were included in the study if they met the following criteria: (1) diagnosis of cerebral hemorrhage or cerebral infarction; (2) without other major diseases; (3) stroke onset within 14 days prior to hospital admission; and (4) giving informed consent personally or by proxy. Further selection and exclusion criteria can be found elsewhere.[14]

Procedure

The FMB, BBS and PASS were administered to the patients at five time points after stroke. An occupational therapist familiar with these measures administered all the assessments.

Measures

The FMB is one of the six subscales of the FM, which was designed to evaluate impairment following stroke.[8] The FMB contains 7 three-point items, 3 for sitting and 4 for standing. The BBS is designed to evaluate a person's performance on 14 items related to balance function tasks that are frequently encountered in everyday life, according to five-point scales.[9] The PASS was developed for patients with stroke and those with poor postural performance.[10] The PASS contains 12 four-point items that are used to grade performance for situations of varying difficulty in maintaining or changing a given posture. The psychometric properties (including reliability, validity and responsiveness) of the three balance measures in stroke patients have been reported to be satisfactory using classical test theory.[14]

Data Analysis

Mokken scale analysis was conducted to examine the unidimensional hierarchical construct of the scales using the MSP5 computer program.[23] Rasch analysis was conducted to examine the dimensionality and parametric function of the scales using the WINSTEPS program.[24]

The data analysis consisted of three parts. First, the dimensionality of the items of the FMB, BBS and PASS was examined using the monotone homogeneity (MH) model for polytomous items.[23] The MH model has three assumptions: (1) items form a unidimensional scale (measuring the same construct or latent trait), (2) item scores are locally independent (measuring that item scores are independent within a group of persons with the same value of the latent trait), and (3) the item response function for each item is a monotonically nondecreasing function of the latent trait.[23] The fit of the MH model is evaluated by calculating the scalability coefficient H for the whole scale and H_i for each item.[23] Scalability coefficient H is a global indicator of the degree to which patients can be accurately ordered on the latent trait by means of their sum scores. Higher values indicate fewer violations of the assumptions and a better scale. A scale was considered to be strong if $H \geq 0.50$.[23]

Second, we then tested whether the items of the FMB, BBS, and PASS possessed an invariant hierarchical ordering across the latent trait scale using the double monotonicity (DM) model. The DM model adds a fourth assumption: The item response functions do not intersect, indicating that the (hierarchical) ordering of the items is the same for all patients.[23] The fit of the DM model was investigated by Crit values. Two criteria including 'Pmatrix crit' and 'Restscore crit' were used to check DM in this study. These two criteria check whether the two item step characteristic curves of different items do not intersect. Crit values > 80 were considered to indicate that this item seriously violates the invariant hierarchical ordering.[23]

Third, we used the Rasch partial credit model[25] to fit the data of the FMB, BBS, and PASS individually and assessed model-data fit using the item fit statistics. The infit mean square is sensitive to unexpected behavior affecting responses to items near the person's proficiency measure; the outfit mean square is sensitive to unexpected behavior by persons on items far from the person's proficiency level. Mean square can be transformed to a t statistic, termed the standardized Z value, which follows approximately the t or standard normal distribution when the items fit the model's expectation. In this study, misfit criteria were defined as: (1) an infit standardized Z value > 2.58 and infit mean square > 1.4, or (2) an outfit standardized Z value > 2.58 and outfit mean square > 1.4. Once an item was found misfitting at any time point, then it would be removed from further analysis. The item parameter estimates obtained from the 5 time points were set identical so that the Rasch scores over time were on the same scale and were readily comparable.

Both Mokken scale analysis and Rasch analysis calculate reliability coefficients (which can be similarly interpreted as Cronbach's alpha) for the scale. A reliability coefficient ≥ 0.9 is recommended for individual comparisons in clinical application.[26] Mokken scale analysis and Rasch analysis were applied to the individual data sets collected at the five time points after stroke. The results were compared over time to check whether the meanings of the construct remained unchanged.

Results

A total of 301 patients participated at 14 days after stroke; 276, 226, 213 and 206 of these patients completed the follow-up assessments at 30, 90, 180 and 365 days after stroke, respectively. The subjects had a wide range of balance deficits and the FMB, BBS, and PASS scores at 14 days after stroke were scattered throughout the full range of possible scores. Further characteristics of the study sample are shown in Table 1.

Mokken Scale Analysis

Table 2 shows that the ranges of scalability coefficient H_i of each item of the FMB, BBS, and PASS over five time points after stroke were 0.74-0.99, 0.88-1.00 and 0.81-0.96, respectively. The reliabilities of the three measures were all above 0.90 at five time points after stroke.

The Pmatrix and Restscore Crit values of each item of the FMB, BBS, and PASS at five time points after stroke were all below 80, except for one PASS item, "supine and roll to non-affected side" at 14 days after stroke, which was 82 Pmatrix Crit (Table 3).

Rasch Analysis

Item 3 (parachute reaction in affected side) of the FMB, Items 7 (standing with feet together) and 14 (standing on one foot) of the BBS, and Items 6 (supine and roll to affected side) and 7 (supine and roll to non-affected side) of the PASS did not fit the Rasch model's expectation. After these poor-fitting items were removed, the reliabilities of the 12-item BBS and 10-item PASS were good (reliability coefficient ≥ 0.89), but those of the 6-item FMB were less satisfactory (0.65 – 0.79) over time, as shown in Table 4. The parameter estimates and standard errors for the three measures are shown in Table 5. Table 6 shows the raw scores and their corresponding Rasch-transformed scores (i.e., person measures in logit) for the ~~6-item FMB,~~ 12-item BSS and 10-item PASS, which can be used for future applications in both clinical and research settings.

Discussion

This study is the first to use non-parametric Mokken scale analysis and parametric Rasch analysis to examine the measurement properties of the FMB, BBS, and PASS in stroke patients at different recovery stages. The items of the three balance measures over the 5 time points fitted the MH and DM models' expectation very well; that is, the unidimensionality and hierarchical ordering of the items od each of the three measures were good and stable over time after stroke. In addition, most items fitted the Rasch model's expectation fairly well. Therefore, unidimensionality assumption was justified and the sum scores can be transformed to interval Rasch scores. However, only the 12-item BBS and 10-item PASS fitted Rasch model's expectation well and showed sound reliability at all 5 time points for clinical application.

By using the MH model of Mokken scale analysis, our results indicated that the unidimensionality of the three measures was strong in measuring the same latent trait (i.e., balance) and justify the use of sum scores of the measures. The equally high Mokken reliability coefficients of the FMB, BBS, and PASS indicated that these items of each instrument yielded precise estimates of the ability for the patients. In addition, these results were consistently found at 5 specific time points after stroke for an extended period (up to 365 days after stroke). These findings support further the clinical and research utility of the three measures as valid measurements to monitor balance function recovery after stroke.

With the exception of one PASS item, "supine and roll to non-affected side" at 14 days after stroke, the unidimensional hierarchical (invariant item difficulty ordering) scales for the FMB, BBS, and PASS could be individually constructed over a series of time measurements. An invariant item ordering scale can be used for adaptive testing, indicating that only a part of the measure needed to be performed, based on the abilities of the patient, in either the more difficult or the less difficult range of the measure. Furthermore, the reliabilities of the 6-item FMB were between 0.65 to 0.79 over time. New items are needed to raise its reliability. Even better, item banks for the three measures can be created and computerized adaptive testing (CAT) can be developed. CAT has been proven to be very effective in reducing testing time and achieving more efficient and precise measurement.[27] Efficient assessment of balance function in stroke patients will benefit both clinicians and researchers. Further combination of IRT and CAT appears promising to improve psychometric properties of a measure and measurement efficiency in both clinical and research settings.

In this study, the 12-item BBS and 10-item PASS met the fitness criteria with good reliability at all 5 specific time points after stroke. We compiled a conversion table showing 12-item BBS raw scores (0-48) and 10-item PASS raw scores (0-30) and their Rasch-transformed scores. The Rasch-transformed scores can be viewed as interval-level measurements,[22] whereas the raw scores are ordinal data. Most balance measures currently used on stroke patients are developed based on classical test theory and consist of ordinal levels of measurement.[14,15] This means that a given difference in scores at one end on the scale does not necessarily represent the same amount of functional change for an identical difference at another end on the scale.[28] For example, suppose that a patient gained 6 points of progress (e.g. 6 to 12) and then 12 points of progress (e.g. 12 to 24) on the PASS in two subsequent evaluation periods, the score changes cannot be interpreted to mean that the patient has improved his or her balance function by two folds. Interval scores, on the contrary, represent an underlying trait in which equal intervals between any two points on a scale are of equal value. This property maintains the numerical meaning of score gains from a scale and allows the scores to serve beyond being just categories on an ordinal scale. Therefore, clinicians and researchers can know exactly how much functional ability patients have gained or how certain two patients with different scores differ from others in their functional status. In the above example, 12 points of progress on an interval scale would indicate a doubling of the gain in the balance function of the patient. Furthermore, an ordinal scale precludes the use of standard parametric statistical inferences. Therefore, the sum scores of the interval-level measurement are useful in quantifying the amount of change in balance function for the subjects and the Rasch-transformed scores are recommended for future applications.

Any measurement tool requires extensive psychometric examination for the purpose of understanding its particular strengths and limitations.[29] Future studies to examine other psychometric properties (e.g., sufficiency/redundancy of the items and appropriateness of scaling level) of the measures in stroke patients are needed to further establish their utility in both clinical and research settings.

In summary, our results provide strong evidence of a stable unidimensional hierarchical scale for each of the three balance measures in stroke patients. The Rasch score is an interval measurement and is recommended for both clinicians and researchers. Furthermore, the12-item BBS and 10-item PASS are highly recommended in assessing balance function for stroke patients.

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References:

1. Horak FB, Esselman P, Anderson ME, Lynch MK. The effects of movement velocity, mass displaced, and task certainty on associated postural adjustments made by normal and hemiplegic individuals. J Neurol Neurosurg Psychiatry 1984;47:1020-8.
2. Dettmann MA, Linder MT, Sepic SB. Relationships among walking performance, postural stability, and functional assessments of the hemiplegic patient. Am J Phys Med 1987;66:77-90.
3. Bohannon RW, Leary KM. Standing balance and function over the course of acute rehabilitation. Arch Phys Med Rehabil 1995;76:994-6.
4. Wade DT. Measurement in Neurological Rehabilitation. Oxford, UK: Oxford University Press; 1992.
5. Leonard E. Balance tests and balance responses: performance changes following a CVA: a review of the literature. Physiother Can 1990;42:68-72.
6. Berg K, Norman KE. Functional assessment of balance and gait. Clin Geriatr Med. 1996;12:705-723.
7. Poole JL, Whitney SL. Motor assessment scale for stroke patients: concurrent validity and interrater reliability. Arch Phys Med Rehabil 1988;69:195-7.
8. Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient I. a method for evaluation of physical performance. Scand J Rehabil Med 1975;7:13-31.
9. Berg K, Wood-Dauphinee S, Williams JI. The balance scale: reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med 1995;27:27-36.
10. Benaim C, Perennou DA, Villy J, Rousseaux M, Pelissier JY. Validation of a standardized assessment of postural control in stroke patients: The Postural Assessment Scale for Stroke Patients (PASS). Stroke 1999;30:1862-8.
11. Sanford J, Moreland J, Swanson LR, Stratford PW, Gowland C. Reliability of the Fugl-Meyer assessment for testing motor performance in patients following stroke. Phys Ther 1993;73:447-54.
12. Malouin F, Pichard L, Bonneau C, Durand A, Corriveau D. Evaluating motor recovery early after stroke: Comparison of the Fugl-Meyer assessment and the motor assessment scale. Arch Phys Med Rehabil 1994;75:1206-12.
13. Wood-Dauphinee S, Berg K, Bravo G, Williams JI. The balance scale: responsiveness to clinically meaningful changes. Can J Rehabil 1997;10:35-50.
14. Mao HF, Hsueh IP, Tang PF, Hsu CF, Hsieh CL. Analysis and comparison of the psychometric properties of three balance measures for stroke patients. Stroke 2002;33:1022-7.
15. Wang CH, Hsueh IP, Mao HF, Yao KPG, Hsieh CL. Psychometric properties of two simplified 3-Level balance scales used for patients with stroke. Phys Ther 2004: 84:430-438.
16. Sodring KM, Bautz-Holter E, Ljunggren AE, Wyller TB. Description and validation of a test of motor function and activities in stroke patients. The Sodring Motor Evaluation of Stroke Patients. Scand J Rehabil Med. 1995;27:211-217.
17. Sheng X, Carriere KC. An improved CML estimation procedure for the Rasch model with item response data. Stat Med 2002; 21:407-16.
18. MacKnight C, Rockwood K. Rasch analysis of the hierarchical assessment of balance and mobility (HABAM). J Clin Epidemiol 2000; 53:1242-7.
19. Pagano M, Gauvreau K. Principles of Biostatistics. Melmont, CA: Duxbury Press, 1993. p. 283.

20. Hambleton RK. Item Response Theory: Principles and Application. 1985. Boston: Kluwer Academic Publishers.
21. Lindeboom R, Vermeulen M, MMath RH, De Haan RJ. Activities of daily living instruments: optimizing scales for neurologic assessments. Neurology 2003;60:738-742.
22. Sijtsma K. Methodology review: Nonparametric IRT approaches to the analysis of dichotomous item scores. *Appl Psychol Meas.* 1998;22:3–31.
23. Wright BD, Mok M. Rasch models overview. *J Appl Meas.* 2000;1:83-106.
24. Molenaar IW, Sijtsma K. *User's Manual MSP5 for Windows: a program for Mokken Scale analysis for polyromous items*. Groningen: lec ProGamma, 2000.
25. Linacre JM. WINSTEPS Rasch Measurement Computer Program. Chicago, IL: 2003.
26. Wright BD, Masters GN. *Rating scale analysis*. Chicago: MESA Press.; 1982.
27. Bland JM, Altman DG. Cronbach's alpha. BMJ. 1997;314:572.
28. van der Linden WJ, Glas CAW. *Computerized adaptive testing: Theory and practice.* Boston, MA: Kluwer Academic Publishers; 2000.
29. Wright BD, Linacre JM. Observations are always ordinal; measurements, however, must be interval. *Arch Phys Med Rehabil* 1989;70:857-860.
30. Dodds TA, Martin DP, Stolov WC, Deyo RA. A validation of the functional independence measurement and its performance among rehabilitation inpatients. *Arch Phys Med Rehabil* 1993;74:531-536.

Table 1. Baseline characteristics of the study patients (n = 301)

Characteristic		
Gender	Male	58%
Age	Mean year (SD)	66.7 (10.7)
Diagnosis	Cerebral hemorrhage	84 (28%)
	Cerebral infarction	217 (72%)
Side of hemiplegia	Right/left	101/147<301?
At 14 days after stroke		
FMB score	Median (inter-quartile range)	8 (2 – 10)
BBS score	Median (inter-quartile range)	17.5 (0 – 46)
PASS score	Median (inter-quartile range)	22 (7 – 30)

Table 2. Checking the assumptions of monotone homogeneity of the balance measures at 5 time points after stroke resulting from the Mokken scale analysis

Days After Stroke	n*	Scalability coefficient H for individual items median (range)			Scale Reliability rho		
		FMB	BBS	PASS	FMB	BBS	PASS
14	301	0.89 (0.78-0.94)	0.96 (0.93-0.99)	0.92 (0.85-0.94)	0.94	0.99	0.98
30	276	0.91 (0.83-0.96)	0.95 (0.93-1.00)	0.92 (0.87-0.95)	0.94	0.99	0.98
90	226	0.86 (0.74-0.99)	0.93 (0.88-0.99)	0.91 (0.86-0.94)	0.90	0.99	0.97
180	213	0.88 (0.77-0.98)	0.93 (0.89-0.99)	0.89 (0.82-0.93)	0.90	0.99	0.97
365	206	0.92 (0.85-0.93)	0.94 (0.91-0.99)	0.91 (0.81-0.96)	0.92	0.99	0.98

* Number of subjects varied slightly for each measure because of missing data

Table 3. Checking the assumptions of double monotonicity (DM) of the balance measures at 5 time points after stroke resulting from the Mokken scale analysis

		FMB		BBS		PASS	
Days After Stroke	n*	Pmatrix median (range)	Restsc median (range)	Pmatrix median (range)	Restsc median (range)	Pmatrix median (range)	Restsc median (range)
14	301	21 (11-35)	27 (7-55)			66 (14-82†)	27 (9-66)
30	276	4 (2-6)		6 (1-17)		18 (7-43)	7 (2-15)
90	226	12 (9-18)		14 (1-50)	8 (8)	21 (1-47)	
180	213		13 (10-15)	16 (6-25)		30 (12-38)	
365	206			13 (1-34)		29 (10-35)	

* Number of subjects varied slightly for each measure because of missing data

† Pmatrx crit of an item of the PASS "supine and roll to non-affected side" at 14 days after stroke was 82 beyond the DM criterion (80)

Table 4. Test reliabilities for the 6-item FMB, 12-item BBS, and 10-item PASS at 5 time points after stroke

Days After Stroke	n*	FMB	BBS	PASS
14	301	0.79	0.94	0.93
30	276	0.79	0.95	0.93
90	226	0.69	0.91	0.89
180	209	0.65	0.89	0.89
365	206	0.76	0.93	0.91

* Number of subjects varied slightly for each measure because of missing data

Table 5. Parameter estimates and stand error for the 6-item FMB, 12-item BBS, and 10-item PASS

	1st Step		2nd Step		3rd Step		4th Step	
Item	Measure	SE	Measure	SE	Measure	SE	Measure	SE
FMB								
1	-5.49	0.63	-4.29	0.35				
2	-4.02	0.41	-3.06	0.31				
4	-2.43	0.34	-2.11	0.30				
5	-0.79	0.29	0.05	0.24				
6	3.33	0.23	5.11	0.28				
7	6.15	0.29	7.67	0.52				
BBS								
1	-1.39	0.22	0.54	0.19	0.19	0.18	0.44	0.14
2	-0.32	0.28	-1.48	0.28	-1.09	0.23	-0.35	0.15
3	-9.97	0.65	-7.62	0.43	-7.92	0.35	-6.09	0.24
4	-2.12	0.24	1.34	0.22	-1.98	0.21	0.76	0.13
5	-4.81	0.23	0.45	0.21	-1.29	0.19	1.28	0.12
6	2.08	0.32	-3.37	0.33	0.23	0.28	-3.15	0.25
8	1.81	0.28	-2.70	0.28	-1.51	0.23	0.58	0.13
9	1.59	0.24	0.39	0.25	0.08	0.24	-2.20	0.21
10	NA	NA	-1.58	0.24	1.16	0.16	0.89	0.13
11	1.93	0.16	0.33	0.15	5.15	0.14	2.59	0.15
12	3.09	0.15	1.93	0.15	4.60	0.15	1.60	0.15
13	1.62	0.21	-1.03	0.21	-0.22	0.15	6.07	0.19
PASS								
1	-5.42	0.31	-2.91	0.19	-1.76	0.14		
2	-2.93	0.20	-1.88	0.18	-1.16	0.14		
3	0.31	0.15	-0.16	0.15	2.46	0.11		
4	4.11	0.12	5.44	0.13	5.98	0.13		
5	6.51	0.11	7.63	0.16	8.77	0.26		
8	-3.59	0.20	-1.23	0.14	1.31	0.12		
9	-3.13	0.20	-1.92	0.16	0.76	0.12		
10	-1.52	0.16	-0.42	0.15	1.51	0.12		
11	-0.54	0.16	-0.62	0.15	1.52	0.12		
12	1.57	0.16	0.55	0.17	0.13	0.15		

Note. NA = not available due to missing data.

Table 6. Raw score, Rasch-transformed score, and standard error (SE) of the 6-item FMB, 12-item BBS, and 10-item PASS

	FMB		BBS		PASS	
Raw	Rasch	SE	Rasch	SE	Rasch	SE
0	-6.99	1.93	-10.93	2.06	-6.80	1.95
1	-5.50	1.19	-9.09	1.32	-5.29	1.19
2	-4.36	0.98	-7.87	0.98	-4.25	0.89
3	-3.48	0.90	-6.86	1.08	-3.59	0.75
4	-2.71	0.86	-5.40	1.30	-3.10	0.66
5	-1.96	0.89	-3.65	1.28	-2.70	0.61
6	-1.11	0.96	-2.52	0.84	-2.34	0.58
7	-0.11	1.07	-2.03	0.58	-2.02	0.56
8	1.74	1.77	-1.76	0.46	-1.71	0.55
9	4.04	1.26	-1.58	0.40	-1.42	0.53
10	5.55	1.23	-1.44	0.35	-1.14	0.53
11	7.11	1.30	-1.32	0.33	-0.87	0.52
12	8.73	1.96	-1.22	0.31	-0.60	0.51
13			-1.13	0.30	-0.35	0.50
14			-1.04	0.29	-0.10	0.49
15			-0.96	0.28	0.13	0.48
16			-0.88	0.28	0.36	0.48
17			-0.81	0.28	0.59	0.48
18			-0.73	0.27	0.82	0.49
19			-0.66	0.27	1.07	0.51
20			-0.58	0.27	1.36	0.56
21			-0.51	0.27	1.72	0.64
22			-0.43	0.27	2.20	0.75
23			-0.36	0.27	2.85	0.88
24			-0.28	0.27	3.74	0.99
25			-0.21	0.27	4.71	0.96
26			-0.13	0.28	5.56	0.91
27			-0.06	0.28	6.41	0.94
28			0.02	0.28	7.34	1.00
29			0.10	0.29	8.48	1.18
30			0.19	0.30	9.94	1.92
31			0.28	0.31		
32			0.39	0.33		
33			0.50	0.35		
34			0.63	0.37		

35	0.78	0.40
36	0.95	0.43
37	1.15	0.47
38	1.39	0.50
39	1.66	0.55
40	1.98	0.58
41	2.33	0.60
42	2.70	0.61
43	3.08	0.62
44	3.48	0.65
45	3.93	0.71
46	4.53	0.85
47	5.70	1.42
48	7.81	2.12