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Analysis of the Foot and Ankle Activity Level Scale (FAALS) Instrument Using the Rasch Measurement Model

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INTRODUCTION

Patient reported outcomes are important for healthcare providers, and measuring latent variables can be challenging. The Foot and Ankle Activity Level Scale (FAALS) is a survey instrument for orthopaedic practitioners to collect information from patients. I used Item Response Theory, specifically the Rasch Measurement Model, to check the reliability and validity of the FAALS instrument based on a sample of 800 responses collected via web-based survey platforms.

Objectives:

1. Test for Unidimensionality (One Factor = Ankle Activity)
2. Test for Reliability of the instrument scores (Repeatability)
3. Test for Validity of the instrument scores (Accuracy)
4. Examine various outputs of the instrument

METHODS

- Collected data from web-based survey platforms.
- Exactly 800 good quality, usable responses:
  - 406 from SurveyMonkey and
  - 394 from Qualtrics
- Imported data into SAS for cleaning and sorting.
  - Data cleaning described in another poster.
- Used WinSteps software for Rasch Analysis.
- Rasch Measurement Model for polytomous data:
  - $P_{nik}(x_{ni} = k \mid B_n, D_i, F_k) = e^{(Bn-[Di+Fk])} / 1+ e^{(Bn-[Di+Fk])}$
- Answers were on 5-point Likert Scale.
- Used Principal Components Analysis of raw data to check for Unidimensionality.
- Rasch Measurement Model estimates Person and Item Reliability scores.
- Rasch Measurement Model estimates Infit and Outfit scores for validity using chi-square test.
- Rasch Measurement Model estimates Person Ability and Item Difficulty.

SAS CODE SAMPLES

Used SAS for Data Clean Up, Organization, and Principal Components Analysis

Used WinSteps software for Rasch Analysis

Principal Components Analysis:

```
proc factor data=PCA method=prin plots=all;
var FAALS_1 through FAALS_22;
where REJECT=0;
run;
or
proc princomp data=PCA;
var FAALS_1 through FAALS_22;
where REJECT=0;
run;
```

Unidimensionality:

Are we measuring one factor?
First factor should explain > 50% of variance.

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	13.9205091	11.4590160	0.6328	0.6328
2	2.4614932	1.6421739	0.1119	0.7446

Reliability:

Value should be near 1.0

PERSON	800 INPUT	800 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	63.1	22.0	1.91	.54	.99	-.1	1.00	.0
P.SD	21.4	.0	2.36	.50	.52	1.4	.81	1.3
REAL RMSE	.74 TRUE SD	2.24	SEPARATION	3.05	PERSON RELIABILITY			.90

ITEM	22 INPUT	22 MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT	MEASURE	REALSE	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	2294.4	800.0	.00	.06	1.00	-.1	1.01	.0
P.SD	483.2	.0	1.34	.01	.16	2.7	.28	2.6
REAL RMSE	.06 TRUE SD	1.34	SEPARATION	22.81	ITEM	RELIABILITY		1.00

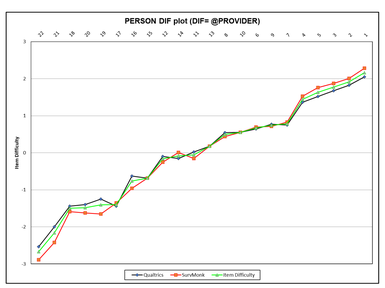
Validity:

InFit and OutFit between 0.4 and 1.4

NAME	INFIT.MSQ	OUTFIT.MSQ
FAALS_1	1.27	1.34
FAALS_2	1.24	1.19
FAALS_3	1.21	1.12
FAALS_4	0.99	1.02
FAALS_5	0.96	0.95
FAALS_6	1.15	1.29
FAALS_7	0.79	0.72
FAALS_8	0.72	0.89
FAALS_9	1.02	0.99
FAALS_10	0.92	0.96
FAALS_11	0.92	0.80
FAALS_12	0.81	0.69
FAALS_13	0.93	0.89
FAALS_14	1.10	1.32
FAALS_15	1.27	1.39
FAALS_16	0.81	0.72
FAALS_17	0.91	1.77
FAALS_18	0.87	0.57
FAALS_19	0.89	0.77
FAALS_20	1.06	0.97
FAALS_21	1.06	0.99
FAALS_22	1.19	0.79

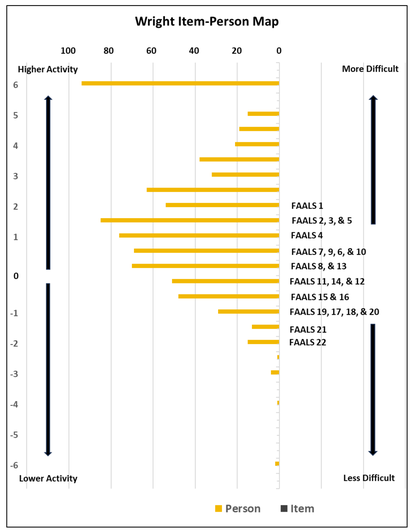
Invariance:

Does the instrument perform the same on different platforms?

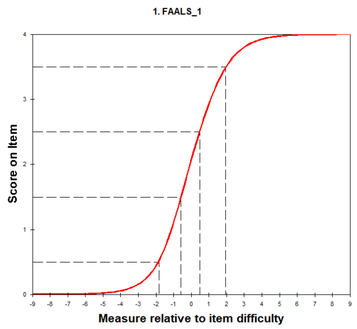


Rasch Model Outcomes for Measuring Ankle Activity:

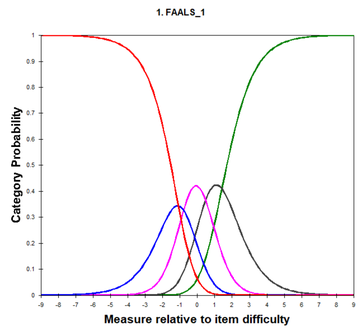
Wright Person-Item Map



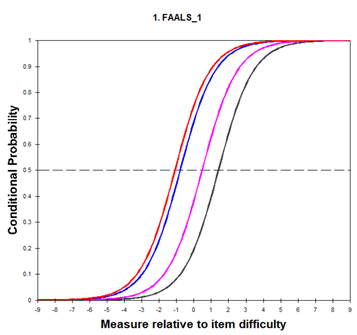
Item Characteristic Curve



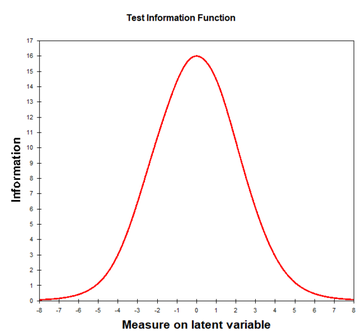
Probability Category Curve



Conditional Probabilities



Test Information Curve



RESULTS

Unidimensionality:

Principal Components Analysis indicates one factor explains 63.28% of variance. To meet assumptions, first factor should explain > 50% of variance.

Reliability:

Person Reliability = 0.9 and Item Reliability = 1.0

Both well within accepted values.

Validity:

Person InFit = 0.99, Person OutFit = 1.00, Item InFit = 1.00 and Item OutFit = 1.01. All values near target of 1.0

Invariance (Differential Item Functioning):

Measured by testing for Differential Item Functioning. Items 16, 19, and 21 suspect in SurveyMonkey ($t > 1.96$)

Measuring Ankle Activity and Item Difficulty:

Wright Person-Item Map:
Shows person ability and item difficulty on the same scale (logit scale, or log-odds). Shows number of people at each ability level, and item difficulty for each question.

Item Characteristic Curve:
This curve ties together Person Ability and Item Score on each item. X-axis is difference between Person Ability and Item Difficulty. Higher ability = Higher score.

Probability Category Curve:
Curve that indicates the probability of selection for each of the answer categories (Unable to Do, Extreme Difficulty, Moderate Difficulty, Slight Difficulty, and No Difficulty). Higher ability = Higher score.

Conditional Probabilities:
Indicates the thresholds between the answer categories.

Test Information Curve:
Indicates the amount of information yielded by the test at any given ability level.

CONCLUSIONS

FAALS is a reliable, valid, unidimensional, survey instrument that can be used by orthopaedic specialists to assess ankle activity level in patients both prior to or following treatment and rehabilitation.

LIMITATIONS

- Data were collected through 2 different pay-for data crowdsourcing platforms: Qualtrics and SurveyMonkey.
- Rasch Measurement Model does not account for :
  - Item Discrimination or Guessing
- Other modeling approaches could be used:
  - Classical Test Theory (See James Down Poster)
  - 1-Parameter or 2-Parameter Item Response Theory