ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:1385-96

ORIGINAL RESEARCH

Validity of the Neuromuscular Recovery Scale: A Measurement Model Approach

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Abstract

Objective: To determine how well the Neuromuscular Recovery Scale (NRS) items fit the Rasch, 1-parameter, partial-credit measurement model.

Design: Confirmatory factor analysis (CFA) and principal components analysis (PCA) of residuals were used to determine dimensionality. The Rasch, 1-parameter, partial-credit rating scale model was used to determine rating scale structure, person/item fit, point-measure item correlations, item discrimination, and measurement precision.

Setting: Seven NeuroRecovery Network clinical sites.

Participants: Outpatients (N = 188) with spinal cord injury.

Interventions: Not applicable.

Main Outcome Measure: NRS.

Results: While the NRS met 1 of 3 CFA criteria, the PCA revealed that the Rasch measurement dimension explained 76.9% of the variance. Ten of 11 items and 91% of the patients fit the Rasch model, with 9 of 11 items showing high discrimination. Sixty-nine percent of the ratings met criteria. The items showed a logical item-difficulty order, with Stand retraining as the easiest item and Walking as the most challenging item. The NRS showed no ceiling or floor effects and separated the sample into almost 5 statistically distinct strata; individuals with an American Spinal Injury Association Impairment Scale (AIS) D classification showed the most ability, and those with an AIS A classification showed the least ability. Items not meeting the rating scale criteria appear to be related to the low frequency counts.

Conclusions: The NRS met many of the Rasch model criteria for construct validity.

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Spinal cord injury (SCI) results in a range of functional limitations, but few outcome measures evaluate a return of normal function. Recently, a new outcome measure specifically designed to assess recovery after SCI, the Neuromuscular Recovery Scale (NRS), was developed within the Christopher and Dana Reeve Foundation NeuroRecovery Network (NRN) over an 8-year period by scientists and physical therapists. The network has used the NRS as an outcome measure since 2008. The NRS is an 11-item scale that compares sitting, standing, walking, and transfers relative to typical performance (appendixes 1 and 2). The extent of recovery is classified into 4 phases, with higher phases indicating a greater return of normal movement. Up to 3 subphases per phase capture incremental changes within each task (appendixes 1 and 2). Validity testing is needed for the NRS to establish this important psychometric property of the new scale.

While there are numerous forms of validity testing, construct validity is important in that it includes a wide range of theory

Supported by the Craig H. Neilsen Foundation (grant no. 164521).
Disclosures: none.

0003-9993/15/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.04.004

testing.[1] Psychometricians clearly distinguish between weak and strong forms of construct validity testing.[2] Cronbach[3] describes any correlation of the test score with external criterion (eg, a criterion standard) as a weak determination of construct validity, and defines an explicit theoretical explanation as a strong determination of validity.

One approach to explicating the theoretical basis of an instrument is to demonstrate that the instrument measures the intended construct in a logical manner. For example, the rating scale associated with each NRS item should measure increments of more ability. For example, lower ratings on the Walking item suggest that more weight support is required to perform the movement, whereas higher ratings suggest that less weight support is required. Similarly, the NRS items should reflect different amounts of ability; that is, the Sit item should be easier for the patient to perform than the Walking item. Furthermore, patients measured by the NRS should conform to an expected ordering of patients from lower ability to higher ability.

The Rasch measurement model or the 1-parameter logistic item response theory model offers an empirical way to verify the content validity of clinical measures. This measurement model has been applied to a variety of rehabilitation and health care measures.[4] For example, using Rasch analysis, Avery et al[5] show that the Gross Motor Function Measure-88 demonstrates a logical developmental motor sequence for children with cerebral palsy. Catz et al[6] found that the Spinal Cord Independence Measure III showed that the item rating scales were properly ordered, and the item difficulty hierarchy was logical and stable across most of the clinical subgroups.

The purpose of this study was to investigate the construct validity of the NRS using the Rasch, 1-parameter, item response theory partial-credit model. The following construct structures were investigated for the NRS: (1) dimensionality; (2) item rating structure; (3) fit of items and patients to the Rasch model; (4) item difficulty hierarchy; and (5) person ability—item difficulty match. In addition to investigating the above item and person psychometrics, the ability of the NRS to differentiate persons from different levels based on the American Spinal Injury Association Impairment Scale (AIS) was explored.

Methods

Participants

We examined 188 patients with motor complete and incomplete SCI across 7 outpatient clinical sites in the Christopher and Dana Reeve Foundation NRN: Boston Medical Center, Boston, Massachusetts; Frazier Rehab Institute, Louisville, Kentucky; Kessler Institute for Rehabilitation, West Orange, New Jersey; Magee Rehabilitation Hospital, Philadelphia, Pennsylvania; Ohio State University Medical Center, Columbus, Ohio; Shepherd Center, Atlanta, Georgia; and The Institute for Rehabilitation and Research (TIRR) Memorial Hermann, Houston, Texas. Exclusion criteria included patients who (1) were ventilator dependent; (2) used a phrenic or diaphragmatic pacer; (3) had undergone tendon transfer procedures; (4) were pregnant; (5) used a cardiac demand pacemaker; (6) used oral or intrathecal delivery of antispasticity medications or morphine (could become eligible if complied with weaning from these medications); (7) had uncontrolled autonomic dysreflexia; (8) were currently using illegal drugs; (9) had active, untreated deep vein thrombosis; or (10) noncompliant participants. Enrollment criteria for patient entry in the NRN locomotor training program included (1) the presence of a nonprogressive spinal cord lesion above T11; (2) no current participation in an inpatient rehabilitation program; and (3) a medical referral by an NRN physician. Enrollment characteristics of the entire population are provided in table 1. Patients with motor incomplete SCI considered in this article were enrolled in the NRN between February 2008 and April 2011. Patients with injuries classified as AIS A and B were enrolled in this study between August 2011 and February 2013.

List of abbreviations:

AIS	**American Spinal Injury Association Impairment Scale**
CFA	**confirmatory factor analysis**
NRN	**NeuroRecovery Network**
NRS	**Neuromuscular Recovery Scale**
PCA	**principal components analysis**
SCI	**spinal cord injury**

Neuromuscular Recovery Scale

While recovery involves internal and external mechanisms, the NRS is designed to provide a functional recovery measure that focuses on noncompensatory recovery. The NRS includes 11 items focused on the capacity of the trunk and lower extremity musculature to perform set tasks (Sit, Reverse Sit-up, Sit-up, Trunk extension, Sit-to-stand, Stand, Walking, Stand retraining, Stand adaptability, Step retraining, Step adaptability) (see appendixes 1 and 2). Across

Table 1 Demographics (N = 188)

Demographic and Clinical Characteristics	Values
Sex	
Male	141 (75)
Female	41 (22)
Missing data	6 (3)
Age (y)	39.3 (18—79)
AIS level	
A	20 (11)
B	19 (10)
C	49 (26)
D	98 (52)
Missing data	2 (1)
Injury level (missing data)	2 (1)
Cervical	132 (70)
Thoracic	53 (28)
Lumbar	3 (2)
Mechanism of injury	
Motor vehicle collision	67 (36)
Fall	30 (16)
Sporting accident	36 (19)
Nontrauma	16 (9)
Medical/surgical	14 (7)
Violence	16 (9)
Other	9 (5)
Time since SCI (y)	1.2 (0.1—53.1)
<1	81 (43)
1—3	56 (30)
>3	51 (27)

NOTE. Values are n (%) or mean (range).