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ORIGINAL RESEARCH

Test-Retest Reliability of the Neuromuscular Recovery Scale

Andrea L. Behrman, PhD, PT,[a,b] Craig Velozo, PhD, OTR,[c] Sarah Suter, MS, PT,[d] Doug Lorenz, PhD,[e] D. Michele Basso, EdD, PT[f]

From the [a]Department of Neurological Surgery, University of Louisville; [b]Kentucky Spinal Cord Injury Research Center, University of Louisville, Louisville, KY; [c]Division of Occupational Therapy, Medical University of South Carolina, Charleston, SC; [d]Department of Occupational Therapy, University of Florida, Gainesville, FL; [e]Department of Biostatistics, University of Louisville, Louisville, KY; and [f]Department of Health and Rehabilitation Sciences, Ohio State University, Columbus, OH.

Abstract

Objective: To determine the test-retest reliability of the Neuromuscular Recovery Scale (NRS), a measure to classify lower extremity and trunk recovery of individuals with spinal cord injury (SCI) to typical preinjury performance of functional tasks without use of external and behavioral compensation.

Design: Multicenter observational study.

Setting: Five outpatient rehabilitation clinics.

Participants: Physical therapists (N = 13), trained and competent in conducting NRS, rated outpatients with SCI (N = 69) using the NRS. Testing occurred on 2 days, separated by 24 to 48 hours, on the same patient by the same therapist.

Interventions: Not applicable.

Main Outcome Measures: Spearman rank correlation coefficients to compare NRS results. The NRS scores of motor performance were based on normal, preinjury function on 11 items: 4 treadmill-based items (standing and stepping), 7 overground/mat items (sitting, sit-up, reverse sit-up, trunk extension, sit to stand, standing, walking).

Results: Test-retest reliability was very strong for the NRS items. Ten of the 11 items exhibited Spearman correlation coefficients $\geq$.92, and lower bounds of the 95% confidence intervals (CIs) for these items met or exceeded .83. The exception was stand retraining (ρ = .84; 95% CI, .68−.96). The test-retest reliability of the measurement model-derived summary score was very strong (ρ = .99; 95% CI, .96−.99).

Conclusions: The NRS had excellent test-retest reliability when conducted by trained therapists in adults with chronic SCI across all levels of injury severity. All raters had undergone standardized training in use of the NRS. The minimal requirement of training to achieve test-retest reliability has not been established.

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Many outcome measures have been recommended to evaluate the physical capabilities of persons with spinal cord injury (SCI) for use in clinical practice[1,2] and clinical trials.[3-5] While SCI-specific measures exist, these assessments do not differentiate as to how a task is accomplished, whether by compensatory strategies or preinjury movement patterns.[6-9] Compensation at a behavioral level refers to the use of an alternative body segment, assistive device, brace, technology, or physical assistance to achieve a goal, while recovery indicates use of movement patterns exhibited before injury.[10-12] With the emerging role of activity-based and biological therapies in the treatment and rehabilitation of SCI,[13,14] discernment of recovery post-SCI via reliable, valid, and sensitive measures is paramount.

The Neuromuscular Recovery Scale (NRS) was developed by physical therapists and scientists within the Christopher and Dana Reeve Foundation NeuroRecovery Network (NRN)[15] to assess recovery of function without external or behavioral compensation.[16]

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Our aim is to test a patient's intrinsic neuromuscular capacity in a permissive, safe environment providing a means of quantification without compensation by compensatory movements, assistive devices, or physical assistance. The reference for comparison is typical preinjury movement patterns during task performance. The NRS as described in our companion article[17] on construct validity includes 11 items (sit, reverse sit-up, sit-up, trunk extension, sit to stand, stand, walk, stand retraining, stand adaptability, step retraining, step adaptability) and classifies motor function into 4 phases. Each of the items represents a hierarchy of performance capacity from the lowest level (scored 1A) to a high level of capacity (scored 4). The lowest level of capacity for the item Sit, for example, is unable to sit, whereas the highest level of capacity is the ability to sit and reach forward and laterally >10in and return to midline with typical, appropriate kinematics. Phase 1 represents the greatest impairment relative to normal movement patterns, with most people being nonambulatory and sitting being the goal. In phase 2, people begin to stand and weight support independently with associated proper kinematics. At phase 3, walking begins with several steps to continuous stepping. Phase 4 reflects normal locomotor performance with marked adaptability to varying conditions and return to recreational activities (eg, running). The NRS consistently has been used at baseline evaluations, reevaluations, and discharge for goal-setting, progression, and outcomes assessment within the NRN outpatient clinics.[15,16]

As a first step in development of the NRS, we previously determined that the NRS effectively differentiates people with American Spinal Injury Association Impairment Scale (AIS) classification C or D[18] into 3 distinct phases based on neuromuscular capacity (eg, phase 1, phase 2, phase 3). Classifying based on injury severity (ie, AIS) produced wide variability and heterogeneity for balance and locomotor performance outcomes. For example, scores for the Berg Balance Test ranged nearly the entire span of the scale (0−56) for persons with AIS D.[16] When the same population was reclassified using the NRS, 3 distinct performance groups emerged. Thus, therapeutic outcomes may be more easily detected when patients have been initially classified according to the NRS than with the AIS for injury severity. Our next steps toward developing both a clinical and scientific assessment tool were to examine construct validity,[17] interrater reliability,[19] and then test-retest reliability of the NRS.

The purpose of this study was to determine the test-retest reliability of the NRS for people with SCI representing all degrees of injury severity based on the AIS classification.[18] We hypothesized that the NRS would demonstrate good agreement for test-retest conditions when conducted by trained physical therapists applying a standardized NRS protocol. In secondary analyses, we explored the relationship of several covariates on test-retest disagreement including neurologic level and injury severity.

Methods

All aspects of the study were approved by, and follow the rules and regulations of the University of Florida Health Sciences Center Institutional Review Board with the University of Florida as the administrative site, and approved by the institutional review board at each participating site: Frazier Rehabilitation Institute, Kessler Rehabilitation Institute, Magee Rehabilitation Hospital, Shepherd Center, and Ohio State University. All participants provided signed informed consent. Additionally, each NRN rehabilitation center has institutional review board approval to collect data from NRN-enrolled patients and enter it into a network-wide data base. Subsequent and continued approval for the study was attained by the University of Louisville Institutional Review Board on the principal investigator's (A.B.) relocation to Louisville, Kentucky.

List of abbreviations:

AIS **American Spinal Injury Association Impairment Scale**
CI **confidence interval**
NRN **NeuroRecovery Network**
NRS **Neuromuscular Recovery Scale**
SCI **spinal cord injury**

Participants

Sixty-nine adults (≥18y of age) with SCI post−acute rehabilitation participated in this study, representing all levels of injury severity (AIS A−D) and varying clinical and demographic characteristics (table 1). Exclusion criteria were (1) preexisting neurologic conditions (eg, Parkinson disease, multiple sclerosis, stroke); (2) conditions that preclude giving informed consent (eg, severe intellectual disability); (3) conditions that prevent trunk or lower extremity mobility testing (eg, acute deep vein thrombosis, fracture, severe sprain/strain, botulinum toxin type A muscle injection, lower motor neuron lesion); (4) ventilator dependence; and (5) known pregnancy so as to avoid any unknown risks to the woman and fetus. Thirteen physical therapists conducted the NRS rating on each participant with SCI (table 2). Therapists received training to conduct a standardized NRS protocol through the NRN

Table 1 Demographic and clinical characteristics of participants (N = 69)

Variables	Values
Site	
Frazier	6 (9)
Kessler	18 (26)
Magee	16 (23)
OSU	19 (28)
Shepherd	10 (14)
Sex (1 missing)	
Male	56 (81)
Female	12 (17)
Neurologic level	
Cervical	46 (67)
Thoracic	23 (33)
AIS	
A	18 (26)
B	17 (25)
C	13 (19)
D	21 (20)
Phase	
1A, 1B, 1C	4 (6), 17 (25), 15 (22)
2A, 2B, 2C	12 (17), 10 (14), 7 (10)
3A, 3B, 3C	2 (3), 1 (1), 1(1)
4	0
Age (y)	36±15; 30 (18, 77)
Time since SCI (y)	3.3±7.0; 1.5 (0.1, 53.4)

NOTE. Values are n (%) or mean ± SD; median (minimum, maximum).
Abbreviation: OSU, Ohio State University.