

The Rehabilitation Complexity Scale version 2: a clinimetric evaluation in patients with severe complex neurodisability

Lynne Turner-Stokes,^{1,2} Heather Williams,² Richard J Siegert¹

► See Editorial Commentary, p127

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¹King's College London, School of Medicine, Department of Palliative Care, Policy and Rehabilitation, London, UK
²Regional Rehabilitation Unit, Northwick Park Hospital, Harrow, UK

Correspondence to

Professor Lynne Turner-Stokes, Regional Rehabilitation Unit, Northwick Park Hospital, Watford Road, Harrow HA1 3UJ, UK;
lynne.turner-stokes@dial.pipex.com

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ABSTRACT

Objective To evaluate the clinimetric properties of the Rehabilitation Complexity Scale (RCS) in a neurorehabilitation inpatient sample.

Design Observational cohort analysis in a tertiary specialist setting.

Subjects 179 consecutive patients (mean age 44.5 years (SD 15 years), males:females 110:69) with complex neurological disabilities, mainly following acquired brain injury.

Methods Repeat RCS ratings of the level of care, nursing, therapy and medical interventions were examined for dimensionality, repeatability, consistency and responsiveness, and compared with the Northwick Park Nursing and Therapy Dependency Scales, the Functional Independence Measure (FIM) and Barthel Index, recorded at the start and end of treatment.

Results The test–retest reliability confirmed the RCS to be repeatable (κ 0.93 to 0.96) and moderately responsive to changes in levels of intervention over the course of the programme, suggesting the need for serial evaluation. Coefficient- α was 0.76 and item-total correlations all >0.50, with moderate to high loadings on the first principal component. Factor analysis revealed two clear factors ('Nursing/medical care,' and 'Therapies'). The RCS demonstrated good convergent and discriminant validity with the Northwick Park Nursing and Therapy Dependency Scales but some ceiling effect. FIM motor and Barthel scores correlated well with basic care and nursing scores (Spearman rho -0.65 to -0.79) but less well with therapy (rho -0.26) and medical (rho -0.28 to -0.33) scores.

Conclusion In this cohort, the RCS provided a reliable, valid and moderately responsive profile of rehabilitation interventions, separating into two main subscales. It usefully identified medical and therapy inputs not captured by the FIM and Barthel Index, which are commonly used to define case complexity in rehabilitation.

INTRODUCTION

Assessing the complexity of rehabilitation needs presents a considerable challenge throughout the world. In the US, Canada, Australia and many parts of Europe, classifications of rehabilitation complexity have relied on physical dependency (measured by the Functional Independence Measure (FIM)¹ or Barthel Index (BI)²) as a surrogate for rehabilitation needs.^{3,4} These classifications

may work reasonably well where patients are medically stable, and physical independence is the main target of intervention. However, they do not capture needs for medical or specialist nursing care; nor do they specifically address the need for cognitive, behavioural or other psychological interventions.

The Northwick Park nursing Dependency Scale (NPDS)^{5,6} and the equivalent Therapy Dependency Assessment tool (NPTDA)^{7,8} provide a detailed evaluation of requirements for basic care, nursing, therapy and medical needs, in terms of both the disciplines involved and the proportion of time spent on different rehabilitation activities (including cognitive/behavioural interventions and family support). A common underlying principle of these instruments is that they are designed to be applied either prospectively to measure 'needs' for care/intervention, or retrospectively to describe the level of intervention actually provided (ie, what the patient 'gets'),⁹ so that in future they could be applied as a framework for quantifying gaps in service provision. However, they are somewhat time-consuming to administer and may not be practical for routine application in services with a high throughput of cases.

The Rehabilitation Complexity Scale (RCS) has been similarly designed to provide a simple measure of the complexity of rehabilitation needs and/or interventions, which is timely to apply and takes account of basic care, specialist nursing, therapy and medical interventions. A preliminary exploration¹⁰ of the RCS (version 1) demonstrated that it is simple and practical for routine use across a range of specialist rehabilitation services. In a multicentre cross-sectional analysis,¹⁰ it showed clear differences between tertiary (or 'complex specialised') and secondary (or 'district specialist') rehabilitation services, on the basis of their relative proportions of complex cases (and the staffing levels to cope with them). Clinicians reported favourably on utility, content and face value but noted some ceiling effects for patients with very complex needs. The therapy subscale, which recorded total hours of therapy intervention,¹¹ was found to be difficult to rate prospectively. The instrument was revised to form the RCS version 2, in which the care, nursing and medical scales remain the same, but the therapy scale has been divided into two subscales reflecting (a) the number of therapy disciplines and (b) the overall intensity of treatment.

¹FIM is a trademark of the Uniform Data System for Medical Rehabilitation, a division of UB Foundation Activities,

¹⁰The RCS version 1 may be found in the original article Turner-Stokes.¹⁰

The term 'clinimetrics' was initially coined by Alvan Feinstein in the 1980s¹¹ in recognition of the fact that items within rating tools developed in clinical settings are often chosen for their clinical relevance, rather than their measurement or scaling properties. Scale development is therefore driven by clinical content, which is valued over unidimensionality—often the principal concern of psychometrics. Nevertheless, it is important to understand the extent to which a given instrument can be used as a 'measure,' as opposed to simply an 'assessment tool.'¹²

The items in the RCS were chosen for their content value, on the basis that needs for care, nursing, therapy and medical input are the principal 'causes' of case complexity which (together with length of stay) will ultimately determine the cost of providing a rehabilitation programme for a given individual. Item levels are broadly ordinal, but were designed to reflect clinically important features that may influence care planning, rather than being chosen for their interval qualities. Item scores are expected to be in some way cumulative, but it is pertinent to know whether they may reasonably be 'summed' to a total score as an overall indicator of caseload complexity and, if not, whether they can be grouped or should be reported individually.

The aim of the present paper is to report on the key clinimetric properties of the RCS version 2—that is, its reproducibility, validity, feasibility, responsiveness and interpretability¹³—and to investigate its performance in a sample of patients with highly complex rehabilitation needs. We also explored its dimensionality and relationship with the other rehabilitation dependency scales (the NPDS and the NPTDA), as well as with the BI and the FIM, in order to evaluate its potential as a measure of caseload complexity in complex neurological rehabilitation settings.

METHODS

Setting

The Regional Rehabilitation Unit at Northwick Park provides a tertiary postacute rehabilitation service for younger adults with severe complex neurological disabilities, including physical, cognitive, behavioural and/or communicative problems.¹⁴ The unit serves a wide catchment area in the South-East of England (population >5 million) to support people with complex rehabilitation needs that are beyond the scope of their local rehabilitation services. Set in an acute general hospital, it offers 24 h medical care and caters in particular for people who have ongoing medical problems, and cannot possibly be managed on an outpatient or domiciliary basis. This setting was chosen because it has a high proportion of patients with complex needs.

Sample

Data were collated for a total of 179 consecutive patients (110 males and 69 females) during a 30-month period between 1 June 2006 and 1 December 2008. Of these, 173 had data collected at discharge from the programme (the remaining six were short admissions only). Demographic details are given in table 1.

MEASURES

Rehabilitation Complexity Scale

The RCS is a 16-point measure with five items¹⁰ (see Appendix 1): basic care and support (C: range 0–3); nursing (N: 0–3); therapy (T), the number of therapy disciplines (TD: 0–3) and overall therapy intensity (TI: 0–3); medical (M: 0–3).

Northwick Park Dependency Scale

The NPDS is a measure of nursing needs/interventions specifically developed for rehabilitation settings.⁵ It is shown to be

Table 1 Demographic characteristics of the study population (n=179)

Mean age	44.5 years (SD=15, range 15–80)	
Male:female	110:69	
Mean length of stay	78 days (SD=64, range 12–469)	
Diagnosis	No	Percentage
Acquired brain injury	139	78
Cerebrovascular accident	88 (67%)	
Traumatic	26 (21%)	
Anoxic	14 (7%)	
Other, eg, inflammatory	11 (5%)	
Spinal cord injury	20	11
Peripheral nerve condition (eg, Guillain-Barré syndrome, critical illness neuropathy)	15	8
Other	5	3

a valid measure of nursing dependency^{15 16} and is used increasingly widely both in the UK and abroad.^{17 18} It has a total score ranging from 0 to 100 and is subdivided into two domains, Basic Care Needs (12 items, score range 0–65) and Special Nursing Needs (seven items, score range 0–35). Scoring levels reflect the number of carers and time taken to complete the task. It is translated by a computerised algorithm into a direct measure of care hours.¹¹

Northwick Park Therapy Dependency Assessment

The NPTDA is an equivalent scale to assess therapy needs/interventions in a neurological rehabilitation setting.^{7 8} It provides an ordinal score of therapy dependency (range 0–100) consisting of 26 items in two principal domains (direct and indirect intervention). Scoring levels reflect the number of therapists and approximate intervention times. Once again, a computerised algorithm translates this into an estimate of the total therapy hours, subdivided by discipline and by domain.⁷

APPLICATION OF MEASURES

In this evaluation, all three measures were applied retrospectively in respect of the levels of intervention provided. This application was chosen for its greater objectivity and precision, and also for comparability with the FIM and BI (see below). They were recorded as part of the unit's routine practice—RCS, NPDS and NPTDA ratings are rated at fortnightly intervals, based on the average of the preceding 2 week's interventions for each patient. NPDS scores were rated by their 'named nurse,' and NPTDA scores by the treating therapy team. RCS scores were recorded during the multidisciplinary ward round, by the treating team: C and N scales reported by the nurses, and M scale by the doctors. T scale scores were computed from routinely recorded therapy intervention times. RCS, NPTDA and NPDS ratings for start and end of treatment were chosen to represent the period corresponding as closely as possible to the FIM and BI ratings (see below).

Repeatability

The test–retest repeatability was tested during a 7-month period from June 2006 to January 2007.

RCS Care, nursing and medical subscale

C, N and M scores were rated for all current in-patients (usually n=18–20) by the treating clinical team at the beginning of each weekly ward-round meeting. At the end of the meeting (approximately 1.5–2 h later), RCS scores were again rated by the same clinical team, without reference to the first rating. The ward round thus acted as a distracter task. Over the 7-month period, 316 paired ratings were obtained.

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RCS Therapy subscale

T scores were extracted from computerised therapy records on this unit. During the same 6-month period, T scores for RCS version 1 based on total therapy hours of intervention per week were computed in parallel with T scores for RCS version 2 (TD (number of disciplines involved) plus TI (overall therapy intensity) (n=307 paired ratings)).

BI and FIM

The BI is a 10-item measure recorded on a range of 0–20.¹⁹ The FIM is an 18-item scale,¹ subdivided into a motor scale (13-items, range 7–91) and a cognitive scale (five items, range 5–35). FIM and BI scores were extracted²⁰ from the UK Functional Assessment Measure (UK FIM+FAM)²¹ which is routinely applied at the start (within 10 days of admission date) and at end (within the last 7 days) of the programme. In accordance with the manual,²² scores reflected the individual's observed level of dependence, not what they could or might do.

Data collection and clinimetric analyses

Deidentified data were extracted from the unit's computerised records. Analysis was undertaken using SPSS V.15 (SPSS, Chicago) or STATA V.8, using classical approaches within the framework recommended by Medical Outcomes Trust.²³

► Conceptual and measurement model

The conceptual model for development of the RCS is described briefly above.

► Dimensionality

The Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett test of sphericity were used to confirm suitability for factor analysis.²⁴ Dimensionality was examined using exploratory and confirmatory factor analysis. Exploratory factor analysis involved a principal-component analysis with

orthogonal (Varimax) rotation. Horn's method of Parallel Analysis was used as the objective criterion for how many factors to rotate.^{25–26} Confirmatory factor analysis was conducted on RCS data collected for the same patients, but at discharge (n=173), using the AMOS-16 structural equation software programme within SPSS V.15.

► Reliability

– Reproducibility (test–retest repeatability) was evaluated for individual items and total scores by testing agreement using quadratic-weighted Cohen κ statistics (STATA V.8).

– Internal consistency of the RCS was examined using Cronbach's α and item-total correlations in the reliability analysis module of SPSS V.15.

► Validity

Construct-related validity was evaluated using one set of ratings per patient at the start of treatment. In the absence of a clear gold standard against which to test criterion validity, concurrent convergent and discriminant validity were assessed through Spearman correlations with the NPDS and NPTDA scores.

► Relationship with other measures

Correlations with the FIM and BI were also examined to compare their potential to evaluate case complexity in this context.

► Responsiveness was evaluated by testing for significant differences between paired scores recorded at the start and end of the programme (Wilcoxon signed rank test).

RESULTS

Feasibility

In this study, the RCS took less than 1–2 min to administer by a team who was familiar with the scoring manual and used the score regularly in routine practice.

Table 2 Descriptive statistics for scores at the start and end of treatment

	Start of treatment (n=179)			End of treatment (n=173)			Wilcoxon signed rank test		
	Mean (SD)	Median (IQR)	Range	Mean (SD)	Median (IQR)	Range	z	p Value	Direction of change
Rehabilitation Complexity Scale scores									
Care (0–3)	1.4 (0.8)	1 (1 to 2)	0 to 3	1.0 (0.9)	1 (0 to 1)	0 to 3	–7.4	<0.001	↓
Nursing (0–3)	2.3 (0.7)	2 (2 to 3)	0 to 3	1.8 (0.9)	2 (1 to 3)	0 to 3	–7.3	<0.001	↓
Therapy disciplines (0–3)	2.6 (0.5)	3 (2 to 3)	2 to 3	2.8 (0.4)	3 (3 to 3)	1 to 3	–4.7	<0.001	↓
Therapy intensity (0–3)	2.2 (0.6)	2 (2 to 3)	1 to 3	2.4 (0.5)	2 (2 to 3)	1 to 3	–2.8	<0.01	↑
Medical (0–3)	2.1 (0.7)	2 (2 to 3)	0 to 3	1.5 (0.9)	2 (1 to 2)	0 to 3	–7.1	<0.001	↓
Total (0–15)	10.7 (2.2)	11 (9 to 12)	4 to 15	9.4 (2.6)	10 (7 to 11)	3 to 15	–6.8	<0.001	↓
NPDS scores									
Basic care needs	20.7 (13.3)	18 (11 to 31)	0 to 52	13.3 (13.7)	9 (3 to 21)	0 to 50	–8.9	<0.001	↓
Special nursing needs	4.6 (6.0)	5 (0 to 5)	0 to 25	3.3 (4.9)	0 (0 to 5)	0 to 25	–3.3	<0.001	↓
Total NPDS	25.3 (17.7)	22 (11 to 39)	0 to 72	16.6 (17.4)	11 (3 to 25)	0 to 65	–8.7	<0.001	↓
Estimated care hours per week	43.1 (18.4)	42 (32 to 60)	0 to 77	30.6 (20.4)	28 (14 to 42)	0 to 74	–8.7	<0.001	↓
NPTDA scores									
Total NPTDA	24.7 (7.7)	25 (19 to 30)	8 to 44	27.6 (7.5)	28 (23 to 33)	6 to 50	–4.4	<0.001	↑
Estimated total therapy hours per week	21.4 (8.9)	20 (16 to 26)	6 to 60	24.3 (8.8)	23 (19 to 29)	5 to 63	–4.2	<0.001	↑
FIM and BI									
BI (range 0–20)	8.7 (5.7)	9 (4 to 12)	0 to 20	14.2 (6.2)	16 (11 to 20)	0 to 20	–10.4	<0.001	↑
FIM motor	44.5 (22.9)	43 (27 to 61)	13 to 91	66.1 (24.7)	75 (54 to 85)	13 to 91	–10.6	<0.001	↑
FIM cognitive	23.1 (9.3)	24 (17 to 31)	5 to 35	25.9 (8.7)	28 (22 to 33)	5 to 35	–8.3	<0.001	↑

BI, Barthel Index; FIM, Functional Independence Measure (motor and cognitive subscales); IQR, Interquartile range; NPDS, Northwick park nursing dependency scale; NPTDA, Northwick Park Therapy Dependency Assessment.

Descriptive statistics

Table 2 shows the descriptive statistics for the RCS, NPDS, NPTDA, FIM and BI scores at the start and end of the programme. As expected for this complex group, RCS scores clustered at the top end of the scale, with a median of 11 (interquartile range 9–12). There was some evidence of a ceiling effect in the RCS scores, when compared with the more detailed Northwick Park Dependency Scales, particularly for the T score (see figure 1).

Dimensionality

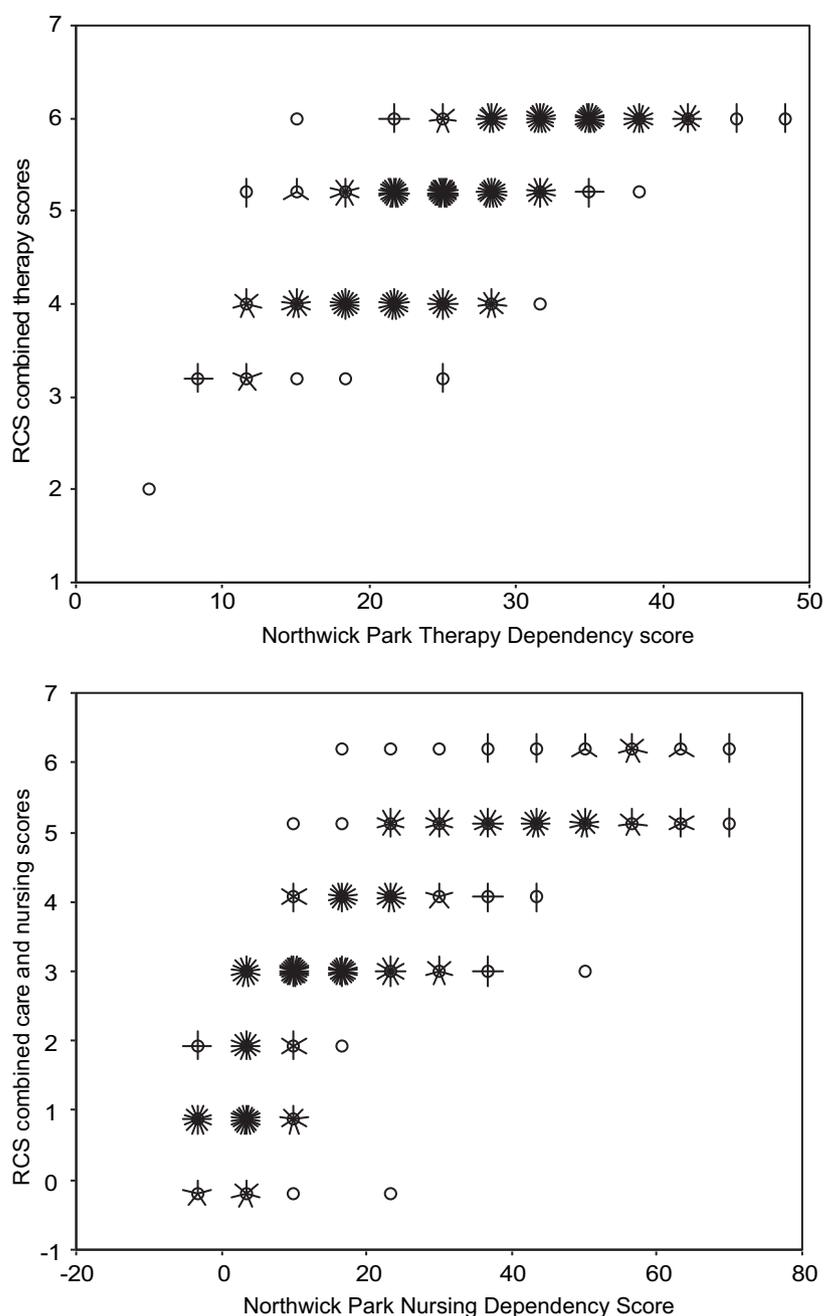
Table 3 shows the results of a principal-components factor analysis on the correlations of the RCS items. All five items loaded 'moderate' to 'high' on the first unrotated principal component with loadings ranging from 0.52 to 0.79. Only the first two components had eigenvalues >1, together accounting for 68% of the total variance in scores. Parallel analysis indicated

a two-factor solution, which was rotated using a Varimax procedure.

- ▶ The first factor appears to be 'Nursing/medical' care, which accounted for 44% of the variance. The C, N and M items all loaded high (0.65–0.88) on this factor and low (<0.15) on factor 2.
- ▶ The second factor appears to be 'Therapy,' accounting for 24% of the variance. The two therapy items (TD and TI) both loaded above 0.80 on this factor and low on factor 1.

Confirmatory factor analysis, conducted on RCS scores at discharge (n=173), examined both a one- and a two-factor model. The one-factor model, with all five RCS items loading on a single underlying factor, showed a relatively poor fit with a goodness of fit index=0.95, comparative fit index=0.92, an adjusted goodness of fit index=0.84, and $\chi^2=25.36$ (df=5, p=0.000). The two-factor model (factor 1: C, N and M items; factor 2 TD and TI) had an excellent fit with a goodness of fit

Figure 1 Sunflower plots. Each petal represents one pair of data. Data for both the start and end of the programme are included to ensure representation across the range of the scale. Comparison of the Rehabilitation Complexity Scale (RCS) therapy score with the Northwick Park Therapy Dependency Assessment (NPTDA) and the Northwick Park Dependency Scale (NPDS) shows significant ceiling effects for both the therapy and care/nursing scales, but particularly the former.



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Table 3 Results of principal-component factor analysis with orthogonal rotation on the correlations of the five Rehabilitation Complexity Scale items using start of treatment scores (n=179)

Rehabilitation Complexity Scale item	Unrotated principal-component loading		Varimax rotation orthogonal factor loading	
	Factor 1 Eigenvalue 2.2	Factor 2 Eigenvalue 1.2	Factor 1	Factor 2
Care	0.75	-0.37	0.83	0.09
Nursing	0.79	-0.40	0.88	0.08
Therapy disciplines	0.52	0.71	0.06	0.88
Therapy intensity	0.60	0.62	0.17	0.84
Medical	0.62	-0.23	0.65	0.14

index=1.0, comparative fit index=1.0, an adjusted goodness of fit index=0.98, and $\chi^2=1.92$ (df=4, p=0.750).

Reproducibility**Test-retest repeatability**

Weighted κ values for agreement between repeated RCS ratings (n=316 data pairs) were 0.93, 0.96 and 0.94 for the care, nursing and medical subscales respectively, which constitutes 'almost perfect' agreement according to the interpretation of Landis and Koch.²⁷ Agreement between T scores for versions 1 and 2 (TD+TI) (n=307 paired ratings) showed 'substantial' overall agreement (weighted κ 0.69). Although a small bias towards higher ratings for version 2 reached statistical significance at a numerical level (Wilcoxon z -8.3, p<0.001), this did not affect the median scores (which were five for both versions) nor agreement for the total RCS scores (weighted κ 0.92).

Internal consistency

The coefficient α for the 5-item RCS scale was 0.76. Item-total correlations were all moderate or high: C, 0.75; N, 0.78; TD, 0.51; TI 0.58 and M, 0.65.

Validity and relationship with other measures

In terms of convergent and discriminant validity, we expected to find a close relationship between the RCS care and nursing (C and N) items and the NPDS; and between the two therapy measures (RCS T score and NPTDA) but weaker correlations across the therapy/nursing divide.

Table 4 presents the correlations with the NPDS, NPTDA, BI and FIM scores. A threshold for significance of p<0.01 was adopted to allow for the multiple tests. The RCS total score

demonstrated moderately strong correlations with the NPDS and NPTDA (r=0.49 to 0.79, p<0.001). However, within the subscales, there were differential correlations. Only the T scale correlated with the NPTDA (r=0.72), while the NPDS correlated strongly with the C, and N items (0.70 to 0.80) and, to a lesser extent, with the M item (0.38) but only weakly with the T scale (0.26). These relationships suggest that the RCS T score reflects the needs for therapy intervention, and the RCS-C and -N scores reflect care and nursing needs, but that, as expected, these are relatively independent of each other.

Because BI and FIM are measures of independence (as opposed to dependency), negative correlations with the RCS, NPDS and NPTDA were expected, and indeed found. Table 4 demonstrates that, although the RCS showed an overall relationship with these scores (rho=-0.47 to -0.72), the FIM and BI were most closely related to the Care and Nursing items. By contrast, the Therapy score showed only modest associations with the BI and FIM Motor scales (rho=-0.26), but a stronger correlation with the FIM cognitive scale (rho=-0.44), a relationship reflected also in the NPTDA score. Meanwhile the M item showed little or no relationship with either the FIM or BI.

Responsiveness

We did not expect the RCS overall to change markedly during the programme, even though we anticipated that the relative components of care/nursing and therapy might change. Table 1 summarises the changes in RCS, NPDS and NPTDA scores between the start and end of treatment. Overall there was a small, but significant, reduction in RCS—principally reflecting the reduction in care, nursing and medical (C+N+M) needs (Wilcoxon z -9.0 p<0.001), while the therapy component (TD+TI) increased overall (Wilcoxon z -4.6, p<0.001). Figure 2 shows an example of a single case analysis of serial RCS measurements at fortnightly intervals, during a 5-month rehabilitation programme. Care and nursing needs gradually fell during the stay, but therapy needs followed a variable course as the interventions changed at different stages of the programme. Similar patterns were reflected also in the NPTDA/NPDS scores and hours of intervention.

DISCUSSION

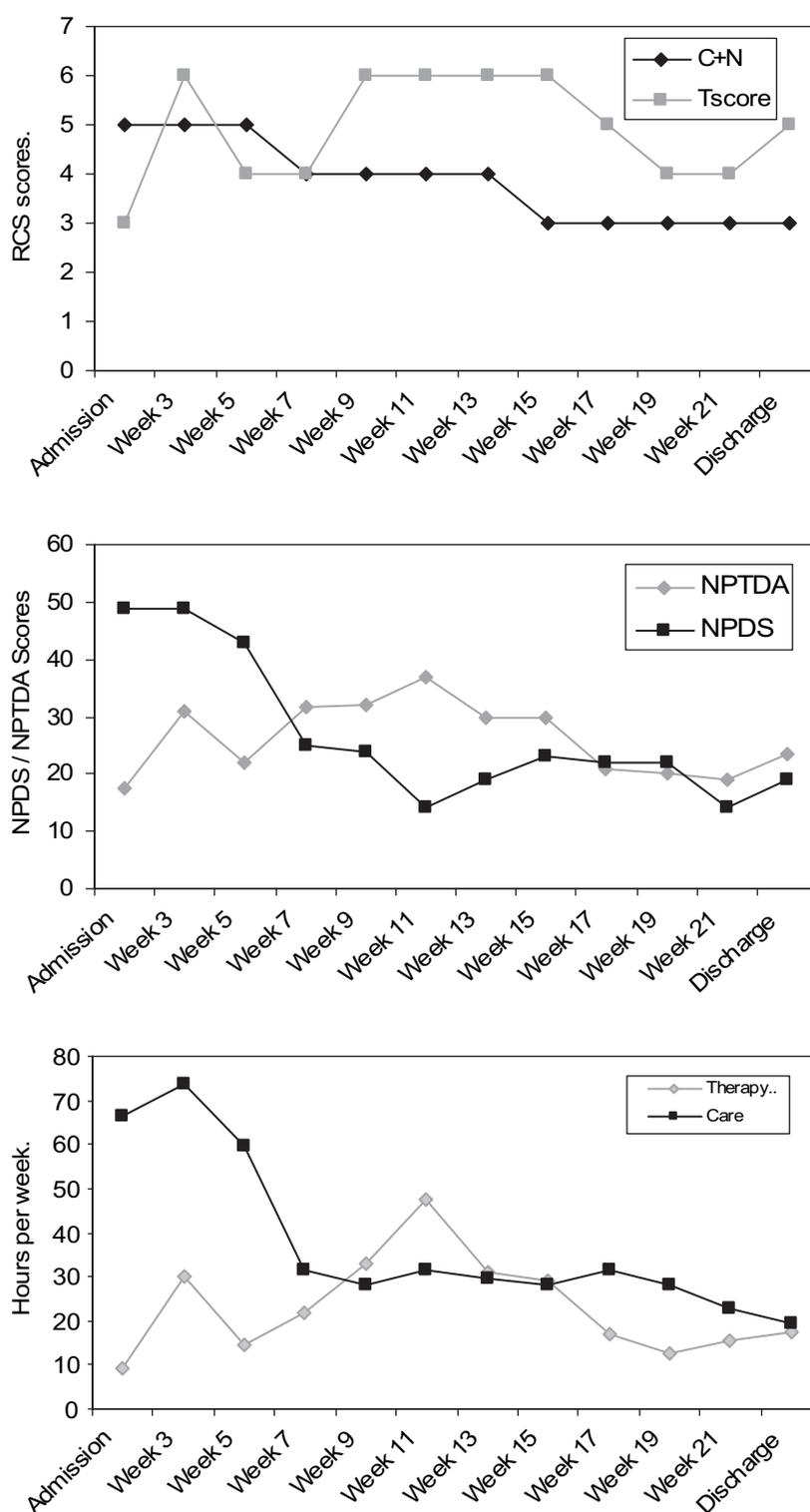
This evaluation represents a clinimetric analysis of the RCS within the context of a specific group of patients with severe complex neurodisability. Although a full psychometric analysis

Table 4 Spearman correlations between Rehabilitation Complexity Scale (RCS) items (n=179) and associations with the Northwick Park nursing and therapy dependency tools (NPDS and NPTDA), Barthel Index (BI), Functional Independence Measure (FIM) motor and cognitive scales at the start of treatment

	Care	Nursing	Therapy TD+TI	Medical	Total	NPDS	NPTDA
Rehab complexity scores							
Nursing	0.64*						
Therapy (therapy disciplines+therapy intensity)	0.18	0.23					
Medical	0.32†	0.44*	0.20				
Total RCS	0.72*	0.79*	0.64*	0.64*			
Northwick park dependency scores							
Total NPDS	0.80*	0.70*	0.26	0.38*	0.73*		
Total NPTDA	0.16	0.18	0.72*	0.19	0.49*	0.22	
Barthel and FIM scores							
BI	-0.76*	-0.65*	-0.26	-0.28†	-0.67*	-0.85*	-0.26
FIM motor	-0.79*	-0.69*	-0.26	-0.33†	-0.72*	-0.88*	-0.26
FIM cognitive	-0.33†	-0.33†	-0.44*	-0.17	-0.47*	-0.47*	-0.52*

Spearman rank correlation tests: *p<0.001, †p<0.01 (to account for multiple tests, the threshold for significance was taken as p<0.01—values above this are considered non-significant). NPTDA, Northwick Park Therapy Dependency Assessment.

Figure 2 Care and nursing interventions showing a gradual reduction over the course of the programme. Therapy interventions are more variable over time. While the Rehabilitation Complexity Scale (RCS) scores are 'blunter,' they follow a similar pattern to the more detailed scores and care hours.



was beyond the scope of this study, our findings are summarised under the Medical Outcomes Trust framework²³ in table 5.

The RCS was feasible to score regularly in routine practice, taking 1–2 min to administer by a team familiar with scoring. C, N and M scores were shown to be highly repeatable; and version 2 (which differs from version 1 only with respect to the T scores) gave equivalent results at a clinical level. The repeatability of the T scores has not been tested in this evaluation.

RCS scores changed differentially over the course of a 3–4-month stay—care, nursing and medical interventions reducing, and therapy scores increasing. While at first sight this might seem

surprising, it resonates with clinical experience that, as patients become less dependent on basic nursing and medical care for their survival and health, they become more active in therapies. The observed variability over time was reflected in other measures. This suggests that serial recording may be required to capture changes in rehabilitation needs and the interventions that are provided to meet them, throughout the course of the rehabilitation programme.

We found good evidence for convergent and discriminant validity of the RCS in relation to other measures of nursing and therapy dependency, although there was some potential for bias,

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Table 5 Clinimetric evaluation of the Rehabilitation Complexity Scale (RCS): summary of findings according to the medical outcomes trust framework

Attribute	Criteria	Evaluation
Conceptual and measurement model	Rationale for and description of the concept and the populations that the measure is intended to assess	
	Clinical content and design	<ul style="list-style-type: none"> ▶ RCS is a five-item ordinal scale, scored on a range of 0 to 15 ▶ Designed to provide a simple measure of the complexity of rehabilitation needs and/or interventions, which is timely to apply and takes account of basic care, specialist nursing, therapy and medical interventions ▶ In this evaluation, it was tested in the context of 'interventions provided'
	Dimensionality	Exploratory and confirmatory factor analyses showed strong evidence that the RCS has two distinct dimensions ('Nursing/medical care' and 'Therapy')
Reliability	Degree to which the instrument is free from random error	
	Internal consistency	Cronbach α 0.76 and item-total correlations (0.51 to 0.78) showed moderate internal consistency
	Reproducibility	Test-retest repeatability after 2 h using the ward-round as a distracter task: quadratic-weighted κ values were 0.93, 0.96 and 0.94 for the care, nursing and medical items, respectively, constituting excellent agreement; repeatability for therapy (TD and TI) items was not tested in this evaluation
Validity	Degree to which the instrument measures what it purports to measure	
	Content	RCS items C, N, T and M are the principal 'causes' of case complexity, which (together with length of stay) ultimately determine the cost of a rehabilitation episode
	Criterion-related	Not testable—no accepted gold standard currently exists
	Concurrent	Convergent and discriminant validity tested against Northwick Park Nursing and Therapy Dependency Scores: the RCS Care/Nursing scores correlated strongly with other measures of nursing dependency (r 0.70 to 0.80), while the T scores* correlated weakly (0.26); conversely, the T scores correlated with the therapy dependency (0.72)
Responsiveness	Ability to detect change over time where real changes occur	
	Change: admission to discharge	RCS scores changed significantly over the course of a 3–4-month stay, but the items changed in different directions: C, N and M interventions (C+N+M) reduced (Wilcoxon z -9.0 , $p < 0.001$), while therapy interventions (TD+TI) increased (Wilcoxon z -4.6 , $p < 0.001$)
Interpretability	Degree to which easily understood meaning can be assigned to the quantitative scores	
	Clinical meaning	RCS is recommended to be reported by item: eg, RCS 8=C2 N1 T4 M1, as the level descriptors provide a clinical description of needs/interventions that is useful for treatment planning; this evaluation also supports summation into two subscales: nursing medical care (C+N+M) and therapy (TD+TI)
Burden	Time, effort or other demands of administering the instrument	
	Time to administer	<ul style="list-style-type: none"> ▶ RCS is designed to be intuitive and requires minimal training ▶ In this study, it took less than 1–2 min to administer by a team who was familiar with the scoring manual and used the score regularly in routine practice
Alternative modes of administration		None currently available
Cultural and language adaptations		None currently available

*RCS T score=TD+TI.

C, care; M, medical; N, nursing; T, therapy; TD, therapy disciplines; TI, therapy intensity.

as scores were necessarily applied by the same treating team. Ceiling effects (especially in the therapy subscale) underline the need to use more detailed scales to measure complexity at the top end of the scale. Comparison with the FIM (motor) and Barthel Index suggests that these measures of physical disability provide a good indication of needs for care and nursing but are relatively poor indicators of needs for therapy or medical intervention. The closer relationship between the FIM cognitive score and level of therapy intervention is also expected in this group of patients with complex disability. As patients get back on their feet and become relatively independent for basic care activities, residual cognitive problems may still preclude the transition to home, but their needs for cognitive therapies (eg, psychology) may increase. This underlines the importance of including specific indicators of therapy and medical needs in the evaluation of rehabilitation complexity.

The RCS items were originally chosen for their clinical importance as the key determinants of cost of a rehabilitation episode. However, we wished to know whether they could be summed to a total score, as an overall indicator of caseload complexity. Item-total correlations and Cronbach α showed moderate internal consistency, suggesting that the five subscales are broadly cumulative. Nevertheless, exploratory and confirmatory factor analyses both showed strong evidence for two distinct dimensions ('Nursing/medical care' and 'Therapy').

This, together with the differential pattern of change over time, suggests that the Therapy items provide additional information with respect to rehabilitation complexity and should be recorded separately. Therefore, although our previous study¹⁰ demonstrated that a total RCS score had some discriminatory value in distinguishing services on the basis of caseload complexity, the findings presented here suggest that summation into two subscales is more appropriate. On the other hand, the four components each have differential impact for staffing requirements and between them provide a profile of rehabilitation needs. Separate reporting of item scores (eg, C2, N1, T3, M1) may therefore be required to facilitate clinical interpretation, in a manner analogous to the Glasgow Coma Scale.

In addition to those already mentioned, the authors recognise a number of limitations to this study:

1. It was confined to a single centre with a particularly complex group of patients undergoing neurological rehabilitation. While it was pertinent to evaluate use of the RCS in this group, because of the anticipated ceiling effects, the majority of patients in this cohort had severe physical disability. Further work is now required to evaluate the RCS as a measure of rehabilitation needs across a broader range of conditions and rehabilitation settings.
2. Our confirmatory factor analysis was undertaken on discharge scores from the same group of patients as the exploratory

factor analysis. Even though the two sets of scores were demonstrated to be significantly different, the results must be interpreted with caution, and further confirmatory analysis is required in different patient groups to confirm the factor structure of the RCS.

3. The relationship between rehabilitation needs and intervention is complex, and many clinicians feel frustrated by the lack of resources to meet all their patients' needs for rehabilitation. As noted above, the RCS, NPDS and NPTDA are designed to be applied either prospectively (to predict 'needs') or retrospectively (to describe the level of intervention provided) and so ultimately to quantify unmet need. In this study, we used retrospective application to reflect the actual rehabilitation intervention provided, in order to maximise objectivity and precision. Further evaluations are required, employing both prospective and retrospective designs, to establish the relationship between need and intervention, which was not addressed in this study.

In summary, the RCS is a new measure designed to evaluate complexity of rehabilitation needs/intervention. This study has provided evidence for its validity, reliability and responsiveness to change in patients with complex neurological disabilities. It provides a profile of rehabilitation needs, which could be used to distinguish case complexity in rehabilitation, and it includes areas of care that are missing from other routinely used instruments, such as the FIM and BI. Because of ceiling effects, however, caution should be exercised in its application to the most complex cases, where more detailed evaluation may be required using the NPDS and NPTDA.

It is anticipated that some further adjustment or adaptation may be needed to capture the various features that relate to complexity in different clinical settings—for example in neuropsychiatric units, recording the level of 'risk' of harm to self or others may be more relevant than the need for acute medical care. Further work is now warranted to explore the use of the RCS in different rehabilitation settings and with other patient groups.

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Copies of the Rehabilitation Complexity Scale, and indeed the NPDS and NPTDA, are available free of charge from the corresponding author.

Contributors LT-S had overall responsibility for the planning, conduct and reporting of the work described in the article. She was responsible for the analysis and drafting of the paper, and is responsible for the overall content as guarantor. HW was responsible for the day-to-day collation, management and validation of the data. She contributed to the analysis and manuscript preparation, as well as checking of figures and content. RJS was responsible for the clinimetric and statistical analysis, and provided intellectual input for the planning of the paper as well as selection of analytical techniques, and interpretation of data. He also contributed to drafting and manuscript preparation and checking. Other contributors: H Rose is the paramedical coordinator on the Regional Rehabilitation Unit clinical team at Northwick Park responsible for the day-to-day collection of therapy intervention data. S Harris heads the nursing team on the Regional Rehabilitation Unit at Northwick Park responsible for the day-to-day collection of nursing intervention data. A Thu is the consultant Rehabilitation Physician on the Regional Rehabilitation Unit at Northwick Park responsible for the day-to-day collection of medical intervention data. J Clark is the Academic Secretary to the Regional Rehabilitation Unit and responsible for the collection of scores and accurate data entry to ensure complete records.

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Competing interests Outcome measurement is a specific research interest of our centre. The RCS, NPDS and NPCNA were all developed through this department, but

are disseminated free of charge. Professor Turner-Stokes is lead author on the papers which describe their initial development and validation, as well as that of the UK version of the FIM+FAM. However, none of the authors has any personal financial interests in the work undertaken or the findings reported.

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Lynne Turner-Stokes, Heather Williams and Richard J Siegert

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