Validation of the Rivermead Post-Concussion Symptoms Questionnaire (RPQ) on Patients Injured in High Impact Car Accidents

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Abstract

Background: *The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) is used widely in clinical assessments. Its 16 items describe subjective neuropsychological symptoms. This study evaluates the criterion validity, convergent validity, and internal consistency of the RPQ in a sample of survivors of high impact motor vehicle accidents (MVAs).*

Method: *De-identified data on 65 post-MVA patients (mean age 38.1 years, SD=13.1; 24 men, 41 women) were available. Their data include scores on the Rivermead Post-Concussion Symptoms Questionnaire (RPQ), Subjective Neuropsychological Symptoms Scale (SNPSS), Insomnia Severity Index (ISI), Whetstone's and Steiner's measures of post-MVA driving anxiety, and the PCL-5 measure of PTSD. The data also included ratings of the worst pain, least pain, and of average pain (Items 3, 4, and 5 of the Brief Pain Inventory) and ratings of depression, anger, and of anxiety (Items 10 to 12 of the Whiplash Disability Questionnaire).*

Results: *The patients' average RPQ score was 45.5 (SD=9.8) and that of the normal controls 8.3 (13.2): the effect size corresponds to point biserial coefficient of .84, thus indicating a very satisfactory criterion validity. The convergent validity is also satisfactory (r=.79 to the SNPSS). Cronbach alpha coefficient for the full 16 item RPQ was excellent (.97) and would not be improved by evaluating separately the first 3 RPQ items and the next 13 items.*

Discussion and Conclusions: *We recommend that the RPQ be employed jointly with SNPSS in clinical assessments and research. The SNPSS includes important post-concussive symptoms missing in the RPQ as well as other subjective neuropsychological symptoms.*

Keywords: concussion, post-concussion syndrome, mTBI, whiplash syndrome

INTRODUCTION

The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) was developed in 1995 by King, Crawford, Wenden, Moss, and Wade[1]at the Rivermead Rehabilitation Centre in Oxford, UK. The RPQ is a measure of subjective post-concussive symptoms as reported by patients. In one study, the authors found a good test-retest reliability when the RPQ was re-administered within approximately 24 hours (Spearman coefficient of .91) and in another study, when re-administration followed within about 7 days (Spearman coefficient of .87). The RPQ is now

used very widely both in its English version and in its Spanish translation as a clinical measure of post-concussive symptoms in mild traumatic brain injury (mTBI). The clinical and research value of the RPQ may now also include its potential applications beyond the original target population of post-concussive patients: items listed describe subjective neuropsychological symptoms some of which also occur with multiple sclerosis,[2] Parkinson's or Huntington's disease,[3] and as residual symptoms in patients who have contracted covid19.[4,5,6]

A statistical study by Eyres's team in 2004 focused on internal characteristics of the scale.[7] Eyres's results suggested that the 16 item RPQ is not unidimensional, but could be considered as two separate scales: RPQ-3 consisting of the first 3 items (headaches, dizziness, nausea) and RPQ-13 consisting of the subsequent 13 items. The external construct validity was evaluated by correlations of the RPQ-3 and RPQ-13 to long term outcomes of the patients at follow up measured by the Rivermead Head Injury Follow Up Questionnaire and was found satisfactory (correlations of .62 for RPQ-3 and .83 for RPQ-13).[7]

A Montreal team led by de Guise also found significant correlation of the RPQ to outcomes as measured by the Mayo-Portland Adaptability Inventory-4 (MPAI-4) administered within 3 months: the correlation was .61.[8]

However, Asselstine's group in Thunder Bay in 2020 used yet another outcome measure and concluded that "While the RPQ is valid in assessing a patient's post-concussive symptoms following mTBI, it may not predict long-term physical or mental health in older adults."[9]

The RPQ items are descriptive of clinical symptoms typical for post-concussive patients: it seems to have an adequate content validity. In the case of the RPQ, the content validity is the extent to which its 16 items are descriptive of clinically important post-concussive symptoms.

It is generally assumed the RPQ would also demonstrate good criterion validity in statistical studies. The criterion validity of a new test or scale could be defined as the extent to which the test or scale indeed does what it was intended to do. In case of the RPQ, it requires that this questionnaire and

its individual items adequately differentiate post-concussive patients from normal controls. The present study examines the criterion validity of the 16 item RPQ by comparing the scores of patients injured in high impact motor vehicle accidents (MVAs) to those of normal controls, when evaluated cross-sectionally. Furthermore, the convergent validity of the RPQ is assessed by its correlation to other subjective neuropsychological symptoms within the post-concussion and whiplash spectrum, as quantified via the Subjective Neuropsychological Symptoms Scale (SNPSS).[10]

METHOD

De-identified archival data of 65 survivors of high impact motor vehicle accidents (24 men, 41 women) were available. Age ranged from 15 to 70 years, with an average of 38.1 years (SD=13.1). Data included scores on the Rivermead Post-Concussion Symptoms Questionnaire (see the list of all its 16 items in the left column of our Table 2),[1] Subjective Neuropsychological Symptoms Scale (SNPSS),[10] Insomnia Severity Index (ISI),[11] and the PCL-5[12] measure of PTSD developed by the U.S. National Center for PTSD. Scores were also available for the Whetstone Vehicle Anxiety Questionnaire[13] and for the Steiner's Automobile Anxiety Inventory (AAI).[14] Data also included ratings of the worst, least, and average pain (Items 3 to 5 of the Brief Pain Inventory)[15] and ratings of depression, anger, and anxiety (Items 10 to 12 of the Whiplash Disability Questionnaire).[16]

Patients also completed the Immediate Concussion Symptoms (ICS) scale[17] that evaluates retrospectively the symptoms experienced in the immediate aftermath of the MVA.

In their accident, 43 (66.2%) patients were drivers, 9 (13.8%) passengers, 12 (18.5%) pedestrians, and one drove a motorcycle. The accident involved a frontal/head-on collision in 15 cases (23.1%), side impact in 20 cases (30.8%), rear impact in 16 cases (24.6%), and combined impact in 14 cases (21.5%). Their MVA happened 7 to 146 weeks earlier (average=51.0 weeks, SD=34.0), but all patients still experienced active post-concussive symptoms at the time of this assessment. The patients' sample from this study partly overlaps with the sample used in the study of the SNPSS.[10]

In the present study, the patients' scores were

compared to de-identified data of 23 normal controls (11 men, 12 women) on the Rivermead Post-Concussion Symptoms Questionnaire (RPQ). Age ranged from 22 to 84 years, with an average of 45.0 years, SD=21.2. Their responses were also available to the Subjective Neuropsychological Symptoms Scale (SNPSS).

The normal controls did not differ significantly (p>.05, 2-tailed) from the patients with respect to age (point biserial r=.20) and gender proportions (phi coefficient=.10).The point biserial coefficients are a special case of the Pearson r calculated to evaluate the relationship of one continuous variable to a dichotomous variable.[18] The phi coefficients are a special case of the Pearson r calculated to evaluate the relationship of two dichotomous variables.[18]

RESULTS

Average Scores of the Patients on Clinical Measures

The average scores of the MVA patients and the normal controls are listed in Table 1.

Table1. *Means and SDs of MVA patients and of normal controls on clinical measures*

	Average score (SD)	
	MVA-patients	Normal controls
Rivermead Post-Concussion Symptoms Questionnaire (RPQ) [1] (data of 65 post-MVA patients and of 23 controls)	45.5 (9.8) Range: 24 to 63	8.3 (13.2) Range: 0 to 51
Subjective Neuropsychological Symptoms Scale (SNPSS)[10] (data of 65 post-MVA patients and of 22 controls)	20.7 (10.7) Range: 2 to 50	2.5 (4.8) Range: 0 to 21
The following data are from the **patients only**:	Average score (SD):	
Insomnia Severity Index[11] (N=65)	23.7 (3.8)Range: 15 to 28	
Brief Pain Inventory,[15] Items 3 to 5 (N=65):		
Ratings of worst pain	8.1 (1.2) Range: 6 to 10	
Ratings of least pain	4.3 (1.6)Range: 1.5 to 9	
Ratings of average pain	6.3 (1.3)Range: 2.5 to 9	
Whiplash Disability Questionnaire[16](N=65):		
Ratings of depression	8.2 (1.7)Range: 4 to 10	
Ratings of anger	8.4 (1.4)Range: 3 to 10	
Ratings of generalized anxiety	8.7 (1.5)Range: 4 to 10	
PCL-5 measure of PTSD[12] (N=27)	58.0 (13.2) Range: 36.5 to 79	

It is noteworthy that the lowest RPQ score among the patients was 24, whereas that of the normal controls was zero. A degree of overlap within the higher score range might be expected since some individuals within such normal samples could have a yet undiagnosed neurologic condition. However, the overall difference in mean scores between our post-MVA patients and normal controls was statistically significant and very large: the patients had approximately 5 times higher scores. The underlying trend corresponds to the point biserial coefficient of .84.

In this sample, the patients also significantly differed from normal controls in their SNPSS scores: the underlying point biserial coefficient was .65. The patients had approximately 8 times higher SNPSS scores.

Criterion Validity of the Rivermead Questionnaire

The criterion validity of similar questionnaires could be defined as the extent to which they indeed do what they were intended to do. Scores on the RPQ and on its individual items should adequately differentiate post-concussive patients from normal controls. Intuitively, it appears that the patients would score higher on the Rivermead as all RPQ items seem to have satisfactory content validity. However, statisticians would underscore the need to calculate the data to determine if the RPQ indeed has a satisfactory criterion validity.

The RPQ means for the patients and for controls are summarized in Table 2. The effect size for the total RPQ score corresponds to the Pearson point biserial coefficient of .84, i.e., the effect size is very satisfactory.

Table2. *Differences between post-MVA patients and normal controls on RPQ measures*

RivermeadPost-Concussion Symptoms Questionnaire (RPQ)[1] scores:	Average scores (SDs):		Correlation coefficient
	Post-MVA patients (N=65)	Normal controls (N=23)	
RPQ total score (based on all 16 items)	45.5 (9.8)	8.3 (13.2)	.84
RPQ-3 (score on the first 3 items)	7.4 (2.9)	1.2 (2.5)	.70
RPQ-13 (score on the next 13 items)	38.1 (7.5)	7.1 (10.9)	.85
Individual RPQ Items:			
Headaches	3.0 (1.0)	0.6 (1.1)	.73
Dizziness	2.5 (1.1)	0.3 (0.8)	.67
Nausea and/or Vomiting	1.9 (1.5)	0.3 (0.8)	.47
Noise Sensitivity (phonosensitivity)	3.1 (1.0)	0.4 (0.8)	.77
Sleep Disturbance	3.6 (0.6)	0.9 (1.4)	.81
Fatigue	3.6 (0.6)	0.7 (1.4)	.84
Irritability	3.5 (0.8)	0.6 (1.0)	.84
Feeling Depressed or Tearful	3.4 (0.7)	0.7 (1.2)	.82
Feeling Frustrated or Impatient	3.6 (0.6)	1.0 (1.3)	.81
Forgetfulness, Poor Memory	3.0 (1.3)	0.7 (1.1)	.65
Poor Concentration	3.2 (0.9)	0.7 (1.2)	.77
It Takes Longer to Think	3.1 (0.9)	0.5 (1.1)	.78
Blurred Vision	1.6 (1.5)	0.0 (0.2)	.48
Light Sensitivity (photosensitivity)	2.4 (1.4)	0.4 (0.8)	.56
Double Vision (diplopia)	0.8 (1.2)	0.1 (0.5)	.29
Restlessness	3.0 (1.1)	0.5 (1.0)	.73

Note: all correlations in this table are significant at p<.001, 2-tailed, except for double vision which is significant at p=.007, 2-tailed.

The average values on individual RPQ items suggest that the post-concussive symptoms of injured motorists were within the moderate to severe range on 11 of the 16 RPQ items (mean scores from 3.0 to 3.6).

The least frequent symptoms were those of diplopia, blurred vision, and nausea.

The significant trend on all variables in Table 2 indicates a satisfactory overall criterion validity of the RPQ. The percent of persons endorsing each post-concussive symptom as present in the mild, or moderate, or severe form, are listed in Table 3.

Table3. *Proportions of persons reporting post-concussive symptoms*

	% reporting either mild, moderate, or severe symptoms	
Rivermead Post-Concussion Symptoms Questionnaire (RPQ)[1] - Individual RPQ Items:	Post-MVA patients (N=65)	Normal controls (N=23)
Headaches	93.8%	17.4%
Dizziness	80.0%	8.7%
Nausea and/or Vomiting	63.1%	8.7%
Noise Sensitivity (phonosensitivity)	93.8%	13.0%
Sleep Disturbance	100%	30.4%
Fatigue	98.5%	21.7%
Irritability	96.9%	21.7%
Feeling Depressed or Tearful	98.5%	21.7%
Feeling Frustrated or Impatient	100%	30.4%
Forgetfulness, Poor Memory	89.2%	26.1%
Poor Concentration	96.9%	21.7%
It Takes Longer to Think	98.5%	13.0%
Blurred Vision	49.2%	0%
Light Sensitivity (photosensitivity)	72.3%	17.4%
Double Vision (diplopia)	27.7%	4.3%
Restlessness	92.3%	21.7%

Convergent Validity of the RPQ

Convergent validity represents the extent to which the scores of a new scale correlate with other scales or measures with which the new scale is theoretically expected to correlate. In the case of the RPQ, positive correlations were expected with scores on the Subjective Neuropsychological Symptoms Scale (SNPSS). Indeed, the correlation between the two measures was high, r=.79 (p<.001).

The SNPSS scale evaluates both typical post-concussive symptoms that are not included in the RPQ (tinnitus, impaired balance, syndrome of word finding difficulty) and whiplash symptoms (tingling, numbness, reduced feeling, and reduced muscular control in the limbs, hand tremor, impaired bladder or bowel control, stutter, difficulty articulating words). [10] Motorists injured in high impact MVAs typically experience both the post-concussion symptoms and whiplash symptoms. Thus, the correlation of the RPQ with SNPSS indicates satisfactory convergent validity.

Correlations of RPQ to other Clinical Variables

The correlations are listed in Table 4.

Table4. *Correlations of the RPQ to other clinical variables and data*

	Pearson correlation	p values (2-tailed)
Age in years, N=88	-.28	.008
Gender, N=88	.19	.084, n.s.
N of weeks since MVA (patients only, N=65)	-.18	.144, n.s.
N of prior serious MVAs associated with injuries (patients only, N=65)	.22	.079, n.s.
Ratings on Items 3 to 5 of the Brief Pain Inventory[15] (patients only, N=65) *Worst pain* *Least pain* *Average pain*	.45 .33 .38	p<.001 p=.007 p=.002
Insomnia Severity Index[11] (patients only, N=65)	.45	p<.001
PCL-5[12] scores for PTSD (patients only, N=27)	.76	p<.001
Ratings on Items 10 to 12 on the Whiplash Disability Questionnaire[16] (patients only, N=65) *Depression* *Anger* *Generalized Anxiety*	.60 .60 .70	p<.001 p<.001 p<.001
Whetstone Vehicle Anxiety Questionnaire[13] (patients only, N=53)	.54	p<.001
Steiner's Automobile Anxiety Inventory (AAI) [14] (patients and controls, N=69)	.88	p<.001

Legend: n.s.=not significant, p<.05, 2-tailed

The RPQ scores failed to correlate with gender, number of previous MVAs, and number of weeks since the MVA: all patients in this sample were still experiencing active post-MVA symptoms requiring therapeutic attention.

Older persons in this sample reported slightly less post-concussive symptoms (r=.28), however, this correlation was weak and would account for only 7.8% of variance in the RPQ scores of this particular sample.

The correlations to PTSD severity, ratings of depression, and ratings of pain were all significant and in the direction consistent with the clinical impression: patients with more post-concussive symptoms experienced higher levels of pain, depression, anger, anxiety, PTSD, and insomnia. Patients with more post-concussive symptoms also obtained higher scores on measures of post-MVA driving anxiety. These various correlations suggest a satisfactory convergent validity of the RPQ.

Internal Consistency of the RPQ

Cronbach alpha coefficient of internal consistency calculated on the 16 item RPQ was .97, thus indicating an excellent internal consistency of the scale. The deletion of any of the 16 items led to only a negligible change in Cronbach alpha of the remaining 15 item scale: all coefficients (before rounding) ranged from .966 to .971.

The correlations of each item to the remaining 15 items were also inspected. The weakest of these were correlations involving double vision (.47), blurred vision (.59), and nausea (.69). The highest were those involving slow speed of thinking (.91), fatigue (.90), impaired sleep (.89), and impaired concentration (.89).

As mentioned, many clinicians score the first 3 RPQ items as a separate scale (labelled RPQ-3) scored independently from a scale based on the remaining 13 RPQ items (labelled RPQ-13). However, examined separately, the internal consistency of the first 3 items (RPQ-3) failed to lead to a higher Cronbach alpha than the .97 obtained for the full RPQ: the coefficient for the RPQ-3 was .86.

Removing the first 3 RPQ items, i.e., the RPQ-3 scale, to separately examine the internal consistency of the RPQ-13 scale alone did not improve the Cronbach alpha: the coefficient for the RPQ-13 was .96.

Immediate Symptoms of Concussion Versus the Post-Concussion Syndrome

We examined correlations of the RPQ to scores on the Immediate Concussion Symptoms (ICS) scale. [17] The ICS relies on retrospective recall by the patients, of the presence or absence of 6 symptoms of cerebral concussion in the immediate aftermath of vehicular collision: feeling dizzy, dazed, stunned, confused, disoriented, and loss of consciousness. The 5 first items of the ICS scale (i.e., all except the loss of consciousness) are scored as follows: 0=absent, 1=present. If the patient lost consciousness, these first 5 items are scored on the basis of symptoms as they were experienced within the very first minutes upon regaining consciousness. The loss of consciousness (LOC) is scored as follows: 0=no loss of consciousness,1=not certain, 2=brief loss of consciousness, 3=loss of consciousness lasting more than 5 minutes.

As shown in Table 5, the correlations of the RPQ to our patients' retrospective recall of which concussion symptoms they experienced in the immediate aftermath of their accident were not statistically significant and some (those relating to feeling stunned or confused) were in the opposite direction than clinically expected. Perhaps this is due to inaccuracies in recall of past symptoms or to individual differences in the patterns or speed of the recovery process from neuropsychological symptoms listed in the ICS. The only exception to these non-significant trends was the significant correlation of RPQ to "feeling dizzy," however, the correlation coefficient is too small (.26), i.e, too weak to be of theoretical or clinical significance as it would explain only 6.8% of the variance in RPQ scores.

Table5. *Correlations of RPQ to recalled immediate symptoms of cerebral concussion*

Immediate Concussion Symptoms scale (ICS),[17] scores of patients only, N=62	Pearson correlations	P level, 2-tailed
Total ICS score	.17	p=.199, n.s.
Feeling dazed	.08	p=.516, n.s.
Feeling stunned	-.07	p=.571, n.s.
Feeling confused	-.07	p=.617, n.s.
Feeling disoriented	.14	p=.290, n.s.
Feeling dizzy	.26	p=.039
Loss of consciousness	.16	p=.211, n.s.

Legend: n.s.=not significant, p<.05, 2-tailed

The ICS scale was designed for a descriptive clinical assessment of the immediate symptoms of concussion, preferably within the first few hours or days after the concussion, to maximize the accuracy of recall. As noted, the present sample of post-MVA patients was assessed rather late, on average, 51.0 weeks (SD=34.0) after the MVA.

DISCUSSION

The results indicate a very satisfactory criterion validity of the Rivermead Post-Concussion Symptoms Questionnaire (RPQ). An adequate convergent validity of the RPQ is suggested by its correlations to the SNPSS and to several clinical variables, including pain,

insomnia, PTSD, depression, generalized anxiety, and driving anxiety.

The data from our particular sample of injured motorists and normal controls also indicate an excellent internal consistency of the full 16 item RPQ and suggest that there is no statistical reason predicated on the internal consistency data alone to split the questionnaire into the RPQ-3 and RPQ13 in clinical studies, unless pursuing some distinct area of interest.

It appears advantageous in clinical assessments and in research involving patients with post-concussion syndrome such as motorists injured in high impact MVAs, to administer the RPQ jointly with the Subjective Neuropsychological Symptoms Scale (SNPSS). The SNPSS includes important post-concussive symptoms that are missing in the RPQ, specifically tinnitus, impaired balance, and the syndrome of word finding difficulty. If the internal consistency coefficient is re-calculated with the 16 RPQ items plus those 3 post-concussive items from the SNPSS, the resulting Cronbach alpha coefficient for the 19 item RPQ is .97, i.e., the same as the one calculated for the 16 item RPQ alone.

When the 3 new items are added to the 16 item RPQ, the correlations of each of these 3 to the remaining 18 items are significant: .64 for tinnitus, .71 for impaired balance, and .71 for word finding difficulty. Removal of any of these 3 items does not change the remaining alpha coefficient: it remains .97.

Conclusions

The RPQ has a satisfactory criterion validity and convergent validity. In addition to patients with post-concussive syndrome, we recommend the joint use of the 16 item RPQ and the SNPSS in studies of neurologic conditions such as multiple sclerosis, Parkinson's disease, and accidental exposure to neurotoxins. Each of these two scales measures a different (non-overlapping) group of subjective neuropsychological symptoms that needs to be investigated.

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