Research Report

Rating Scale, Standard Gamble, and Time Trade-off for People With Traumatic Spinal Cord Injuries

Background and Purpose. The rating scale (RS), standard gamble (SG), and time trade-off (TTO) for people with traumatic spinal cord injuries (SCIs) have not been reported. This study compared psychometric performances of these preference-based measures among people with SCIs in Taiwan. Subjects and Methods. In total, 187 subjects from a nationwide registry of people with traumatic SCIs were interviewed by telephone. Score distributions, interrater reliability, discriminant ability, and convergent validity for the RS, SG, and TTO were compared. Results. The mean (median) values of the RS, SG, and TTO were 0.67 (0.70), 0.64 (0.75), and 0.53 (0.50), respectively, and their corresponding intraclass correlation coefficients for intrarater and interrater test-retest reliability were .92 and .89, .78 and .73, and .91 and .78. Compared with the SG and TTO, the RS had fewer floor and ceiling values as well as percent changes, more missing observations, a larger effect size, and better discrimination ability. The results of Spearman correlation and factor analysis showed that the SG strongly converged with the TTO (r=.65, and in a single common factor), but they weakly converged with the RS (r=.33 with the SG and r=.27 with the TTO). In the linear regression models, the RS was significantly associated with neurological severity, employment, educational level, and self-care ability; the SG was associated with neurological severity and employment; and the TTO was associated only with neurological severity. Discussion and Conclusion. The RS generally performed better than the SG and TTO among people with traumatic SCIs; however, the underlying construct measured by the RS differed considerably from those measured by the SG and TTO. [Lin MR, Hwang HF, Chung KP, et al. Rating scale, standard gamble, and time trade-off for people with traumatic spinal cord injuries. *Phys Ther.* 2006;86:337–344.]

Key Words: *Health-related quality of life, Preference, Rating scale, Spinal cord injury, Standard gamble, Time trade-off.*

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Physical therapists, like other clinicians, make implicit and individual decisions every day, based on their experiences with different patients and on the needs of an individual patient.[1] These clinical decisions often are subjective and difficult to quantify. However, when identifying and incorporating specific patients' needs as assessed by the health-related quality of life (QOL), including their health profile and preference-based measures,[2] the efficiency and objectivity of clinical judgments can be substantially improved.[3,4]

Because improvements in early postinjury care have eliminated or minimized many of the complications that typically occur in people with traumatic spinal cord injuries (SCIs), the health-related QOL outcomes among those surviving with such injuries have become an important concern.[5,6] Health profile measures often are applied to assess the impact of traumatic SCIs, according to functioning and well-being in multiple domains.[7–15] However, these measures have difficulty capturing the total clinical picture of traumatic SCIs or other chronic diseases and integrating components of related medical treatments.[2,3] Furthermore, they do not relate health states to death in order to allow comparisons across patient populations.

Preference-based measures summarize a broad range of relevant outcomes among people with SCIs into an overall health-related QOL outcome, called "utility" or "preference."[16] An individual preference is reflected as a single number along a continuum that usually extends from 0, anchored as death, to 1, anchored as full health.[16,17] In medical decision analyses and cost-effectiveness analyses for optimal treatment choices, an individual's preferences for a health state or condition of interest can be included. Furthermore, quality-adjusted life years (QALYs) can be further calculated by the preference times for each year of life to incorporate the effects of both QOL and quantity of life.[18,19] For example, experts draw different conclusions on whether or not thrombolysis can be recommended for people with acute ischemic stroke because of a problem of weighing the improvement in functional ability against the risk of increased mortality. By including a patient's preference, thrombolysis with a tissue plasminogen activator gave an additional 0.13 QALYs over standard supportive care for an "average" patient with stroke; it was further identified that the thrombolysis should be restricted to patients who assign low preferences of $<0.6\sim0.7$ to major post-stroke disability to increase the gain as well as the margin of safety.[20]

Three commonly used preference-based measures are the rating scale (RS), the standard gamble (SG), and the time trade-off (TTO).[21,22] The RS provides a simple technique for assigning a numerical value for a certain health state. The SG reveals an individual's preference by offering a choice between 2 alternatives: living in a health state with certainty or taking a gamble on a new intervention for which the outcome is uncertain. The SG has attracted attention because it is based on the axioms of utility theory proposed by von Neumann and Morgenstern.[23] The TTO offers a choice of living defined as a fixed length of time in full health or a variable length of time in an alternative state that is less desirable such as with an SCI.

These preference-based QOL measures have not been reported for people with SCIs. In addition to describing

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the preferences among people with traumatic SCIs in Taiwan, this study also compared psychometric performances of the RS, SG, and TTO, including score distributions, test-retest reliability, discriminant ability, and convergent validity.

Method

Subjects and Procedure

Potential subjects were identified from a nationwide registry, which consisted of 809 traumatic SCI cases collected by the Head and Spinal Cord Research Group of the Neurological Society in Taiwan during the 4-year period from July 1, 1992, to June 30, 1996.[24] As adopted from Kraus and colleagues,[25] *traumatic spinal cord injury* was defined as an acute, traumatic lesion of the spinal cord resulting in any degree of sensory or motor deficit or paralysis, including injury to the nerve roots or cauda equina. The registry was developed by reviewing medical records of 113 hospitals in Taiwan considered by the Head and Spinal Cord Research Group to have the ability to manage traumatic SCIs, and included patients who had not been transferred from other hospitals and who were coded with the rubric numbers of the *International Classification of Disease* [26] as 806.0 to 806.9 and 968.0 to 968.9. In addition to the neurological severity of injury (incomplete tetraplegia, complete tetraplegia, incomplete paraplegia, and complete paraplegia) using the classification of the American Spinal Cord Injury Association,[27] patient demographics (age and sex), time since injury, and cause of injury (motor vehicle crash, fall, and "other") also were recorded in the registry.

We used national identification numbers and names to search mortality data from 1992 to 2001 in the Department of Health, Executive Yuan, Republic of China, and 64 people in the SCI registry were matched. Of those remaining in the registry, there were telephone numbers for 603 people. Of the 142 people who did not have telephone numbers recorded in the registry and those who could not be reached by their original telephone numbers, 10 people were identified and contacted by searching the member lists of national and local SCI associations. These telephone numbers were used to conduct telephone interviews. When a subject agreed to participate in the study during the first call, we asked him or her to provide a time session of approximately 30 to 40 minutes within 1 week for our telephone interview. In the interview, 3 preference-based QOL measures—the RS, SG, and TTO—were administered; current information on education, marital status, and employment also was collected. Before the interview, a questionnaire was mailed to each subject to provide better comprehension of the questions in order to shorten the interview time.

As a result, 187 subjects were interviewed, 370 could not be reached by existing telephone numbers, 40 had died, 1 was in a vegetative state, and 15 declined to be interviewed. Compared with all people in the SCI registry, the 187 respondents did not significantly differ in age (45.6 versus 42.9 years), sex (76% versus 81% men), time since injury (7.8 versus 7.4 years), cause of injury (58% versus 57% motor vehicle crashes), neurological severity (40% versus 35% complete lesion), or associated injuries (43% versus 47% being positive). Verbal consent was obtained from all participants.

Instruments

With the aid of the previously mailed questionnaires, the RS method asked subjects to rate their current state of health on a 0-to-100 scale (ie, a 100-point thermometer), with 0 representing death during the study and 100 representing full health. Then the subjects told the interviewers what rating they chose. The RS value was the raw score divided by 100.

The SG method asked subjects to imagine that they would live in their current health states for an average life expectancy of people in Taiwan's general population of 25 years (ie, 25 years for people at age 43 years) (the average age of people in the SCI registry was used to estimate the life expectancy based on Taiwan's general population).[28] They then were told that a hypothetical new treatment was available that could improve their QOL to full health. However, the treatment had a risk of immediate death. The probability of full health was varied until the subject expressed indifference between the alternatives and the preference score of his or her SCI was equal to the probability. For instance, if a subject was indifferent between 25 years with SCI for sure and a gamble with a probability of 0.7 of full health for 25 years and a complementary probability of 0.3 $(1 - 0.7)$ of immediate death, the preference of his or her SCI was equal to 0.7.

In the TTO method, subjects were told that they would live in their current health states for an average life expectancy of 25 years. Furthermore, subjects were asked to choose between 2 alternatives: living the entire duration in the specified health state or living for a shorter interval in which health would always be perfect. The length of the interval was varied until the subject expressed indifference about the decision. The duration was used to estimate the TTO score of the health state. For instance, if a subject was indifferent to 25 years with SCI and 15 years in full health, the preference of his or her SCI was equal to 0.6 (15/25).

Table 1.
Distribution and Test-Retest Reliability of Scores for the Rating Scale, the Standard Gamble, and the Time Trade-off

Instrument	$\bar{X}$	SD	Median	Percentage of Floor Values	Percentage of Ceiling Values	Percentage of Missing Values	Intrarater Reliability ICC[a]	Interrater Reliability ICC
Rating scale	0.67	0.19	0.70	0.0	0.9	6.0	.92	.89
Standard gamble	0.64	0.34	0.75	3.6	9.8	3.8	.78	.73
Time trade-off	0.53	0.34	0.50	10.8	15.3	5.1	.91	.78

[a] ICC=intraclass correlation coefficient.

Data Analysis

Score distribution. Distributions of the mean and median values, the percentages of floor and ceiling values (number of subjects who had a floor or ceiling value divided by the number of respondents), and the percentage of missing values (number of subjects who had difficulty responding divided by 187) for each preference-based measure were calculated. Furthermore, the normality of the preference scores was tested using the Shapiro-Wilk method.[29]

Test-retest reliability. A random sample of 20 subjects was selected to assess their original responses within 2 weeks. Seven of 10 subjects completed the retest for the assessment of intrarater test-retest reliability, and 6 of another 10 subjects did so for the assessment of interrater test-retest reliability. The intraclass correlation coefficients for both types of test-retest reliability were calculated.[30] The *intraclass correlation coefficient*, defined as an estimate of the proportion of the total measurement variability among subjects, combines information on both the linear correlation and the systematic differences between repeated tests.[30]

Discriminant validity. The ability of these 3 preference-based measures to discriminate among groups based on 9 sociodemographic and medical characteristics (age, time since injury, sex, education, marital status, employment, neurological severity, cause of injury, and level of ability for self-care) was tested using the Mann-Whitney test[31] because these preference scores were not normally distributed. These selected characteristics have been reported to be associated with QOL among people with SCIs.[7–15] For these characteristics, effect sizes were calculated by the difference in each preference score between subgroups divided by the standard deviation of scores among all people with SCIs. An effect size of 0.2 to 0.5 was considered to be small, 0.5 to 0.8 to be moderate, and 0.8 or greater to be large.[32]

Convergent validity. Factor analysis and Spearman correlation were used to test the convergence among the 3 preference-based measures. Factor analysis examined whether the 3 measures converged, with moderate or strong factor loadings ($\geq$0.4),[33] onto a single common factor. Convergence indicates that the 3 measures have same underlying construct. Two criteria, factor eigenvalues greater than 1 and scree test, were used to select the number of common factors.[34] Furthermore, it was assumed that those measures that were conceptually related would be relatively strongly correlated, whereas those measures with less in common would show weaker correlations.

A linear regression model was used to determine factors associated with each preference score in order to understand differences among underlying constructs of the 3 measures. We used Statistical Analysis Software, version 8.02,* for all statistical analyses.

Results

Of the 187 subjects, the age at injury and time since injury, on average ($\pm$SD), were 42.9$\pm$17.3 and 7.4$\pm$2.0 years, respectively. Of these subjects, 48 (26%) had incomplete tetraplegia, 28 (15%) had complete tetraplegia, 73 (39%) had incomplete paraplegia, and 38 (20%) had complete paraplegia. Furthermore, 151 (81%) of them were male, 23 (12%) had an education level of senior high school or above, 96 (51%) had an education level of junior high school, and 68 (36%) had an education level of elementary school or no formal education, 54 (29%) were single/divorced/widowed, 101 (54%) were unemployed, and 99 (53%) could care for themselves independently. Cause of injury was associated with motor vehicle crashes for 106 subjects (57%), with falls for 62 subjects (33%), and with "other" for 19 subjects (10%).

As shown in Table 1, the median of each preference score was not equal to the mean, and the Shapiro-Wilk test for normality produced a P value of less than .05 for all preference scores (ie, these scores were not normally distributed). The percentage of the minimum possible values ranged from 0% for the RS to 10.8% for the TTO. Similarly, the percentage of the maximum possible values ranged from 0.9% for the RS to 15.3% for the

* SAS Institute Inc, PO Box 8000, Cary, NC 27511.

Table 2.
Discriminant Ability of Scores for the Rating Scale, the Standard Gamble, and the Time Trade-Off With Respect to Sociodemographic and Medical Characteristics of Subjects

Characterisic	Statistic	Rating Scale	Standard Gamble	Time Trade-off
Age at injury (y)				
≤43	Mean	0.69	0.64	0.53
>43	Mean	0.66	0.63	0.52
	P	.189	.880	.918
	Effect size	0.18	0.02	0.04
Sex				
Male	Mean	0.67	0.63	0.50
Female	Mean	0.71	0.68	0.61
	P	.182	.440	.057
	Effect size	−0.23	−0.13	−0.32
Education				
Junior high school or below	Mean	0.65	0.64	0.51
Senior high school or above	Mean	0.72	0.64	0.55
	P	.011	.876	.372
	Effect size	−0.36	0.02	−0.13
Marital status				
Single/divorced/widowed	Mean	0.65	0.59	0.50
Spouse present	Mean	0.68	0.66	0.54
	P	.317	.209	.415
	Effect size	−0.15	−0.18	−0.12
Employment status				
Yes	Mean	0.75	0.70	0.56
No	Mean	0.61	0.59	0.49
	P	.000	.011	.105
	Effect size	0.82	0.32	0.21
Time since injury (y)				
≤7.6	Mean	0.69	0.65	0.53
>7.6	Mean	0.65	0.63	0.52
	P	.093	.698	.765
	Effect size	0.23	0.05	0.04
Level of injury				
Tetraplegia	Mean	0.66	0.60	0.50
Paraplegia	Mean	0.69	0.68	0.55
	P	.236	.096	.204
	Effect size	−0.16	−0.23	−0.17
Cause of injury				
Motor vehicle crash	Mean	0.68	0.65	0.52
Other	Mean	0.65	0.62	0.55
	P	.193	.543	.517
	Effect size	0.19	0.09	−0.10
Self-care ability				
Yes	Mean	0.74	0.73	0.58
No	Mean	0.61	0.55	0.47
	P	.000	.000	.009
	Effect size	0.74	0.53	0.35

TTO. The percentages of missing value ranged from 3.8% for the SG to 6.0% for the RS. The intraclass correlation coefficients for intrarater and interrater test-retest reliability were .92 and .89 for the RS, .78 and .73 for the SG, and .91 and .78 for the TTO, respectively.

The ability of the 3 preference-based QOL measures to discriminate between groups with respect to the 9 sociodemographic and medical characteristics is shown in Table 2. The RS significantly discriminated between groups regarding 3 characteristics (education, employment, and self-care), the SG discriminated between groups regarding 2 characteristics (employment and self-care), and the TTO discriminated between groups regarding 1 characteristic (self-care). Furthermore, the effect size was small or greater for 5 characteristics on the RS (ie, sex, education, time since injury, employment, and self-care ability) and for 3 characteristics on both the SG (ie, employment, level of injury, and self-care ability) and the TTO (ie, sex, employment, and self-care ability).

The factor loadings of the RS, SG, and TTO onto the first common factor were 0.09, 0.59, and 0.61, respectively, indicating that the RS was not convergent in the same dimension as the SG and TTO. Spearman correlation coefficients were .33 between the RS and the SG, .27 between the RS and the TTO, .65 between the SG and the TTO.

Results of the linear regression analyses are shown in Table 3. After adjusting for other variables, the RS scores of subjects who had complete paraplegia and complete tetraplegia were 0.14 and 0.13 points lower, respectively, than those of subjects who had incomplete paraplegia. Moreover, subjects who were employed, had higher educational levels, and had self-care ability had larger RS scores than those of their counterparts. Compared with the SG scores of subjects who had incomplete paraplegia, the SG scores of subjects who had complete paraplegia and incomplete tetraplegia were 0.34 and 0.12 points lower, respectively. In addition, the SG scores among employed subjects were 0.11 points larger than those of unemployed subjects. Compared with the TTO scores of subjects with incomplete paraplegia, the TTO scores of subjects with complete paraplegia and complete tetraplegia were 0.26 and 0.19 points lower, respectively.

Table 3.
Results of Linear Regression Model Analysis: Adjusted Relative Differences (RDs) and 95% Confidence Intervals (CIs) of Scores for the Rating Scale, the Standard Gamble, and the Time Trade-off

Characteristic	Rating Scale RD (95% CI)	Standard Gamble RD (95% CI)	Time Trade-off RD (95% CI)
Intercept	0.68	0.67	0.59
Neurological severity			
Incomplete paraplegia (reference group)	0.0	0.0	0.0
Complete paraplegia	−0.14 (−0.23, −0.05)	−0.34 (−0.51, −0.16)	−0.26 (−0.43, −0.08)
Incomplete tetraplegia	−0.02 (−0.07, 0.03)	−0.12 (−0.22, −0.03)	−0.07 (−0.16, 0.03)
Complete tetraplegia	−0.13 (−0.21, −0.05)	−0.15 (−0.31, 0.01)	−0.19 (−0.35, −0.04)
Employment (yes/no)	0.09 (0.05, 0.14)	0.11 (0.02, 0.20)	
Education			
Elementary or below (reference group)	0.0		
High school	0.02 (−0.03, 0.07)		
College or above	0.09 (0.02, 0.16)		
Self-care ability (yes/no)	0.07 (0.02, 0.11)		

Discussion

This study provides preference-based QOL scores among people with traumatic SCI, with the RS, on average, giving the highest score, followed by the SG and the TTO. Compared with the other 2 measures, the RS produced fewer floor and ceiling values, more reliability, a larger effect size, and better discrimination ability, as well as more missing observations. Furthermore, similar to the results in other patient groups,[35–37] the SG scores in our study converged strongly with the TTO scores, and they converged weakly with the RS scores. This study further revealed that the factors associated with the RS differed greatly from those associated with the SG and the TTO.

Because the RS method can easily be self-administered, whereas the SG and TTO methods considerably depend on the judgment, motivations, and cognition of subjects,[38] it is often appealing as an alternative to the SG and TTO methods for collecting health state preferences from large populations such as patients in clinical trials.[35] Despite having displayed better psychometric properties and being easier to administer, the meaning of preferences using the RS method in which no alternative choice is available may differ from those of the other 2 measures in which an alternative choice is available. Furthermore, contrary to the findings of studies of other patient groups,[39,40] the preference derived from the RS in our study was uncommonly higher than those derived from the SG and TTO. One possible explanation is that people with traumatic SCIs are more willing to trade off their life or life years than are other patient groups, because the 2 methods use death as the reference health state. That is, people with SCI might be more likely than other patient groups to risk ending up dead rather than choosing to remain in a less-than-perfect heath state.[41] Alternatively, subjects' time preference may have confounded the results (ie, people with SCI might be more willing to trade off their life or life years for the longer life expectancy of 25 years of this study than for the commonly used 10 years and shorter life expectancy).[35,37,39,42,43]

Differences between the SG and the TTO methods often are attributed to the subjects' risk attitude for the hypothetically new treatment. Specifically, subjects are familiarized with having risk aversion in the SG method and risk neutrality in the TTO method.[16,21,44] Recently, an additional 3 factors—probability weighting (eg, people may underweight moderate and high probabilities or the distant future while overweighting low probabilities or the near future), loss aversion (ie, people are more sensitive to losses than to gains), and contingent weighting (ie, people tend to pay more attention to the probabilities or durations and relatively less attention to health outcomes)—also have been identified.[45] The current study further revealed that the SG scores increased by 0.11 point when the subjects were employed, implying a possible relationship between employment status and risk attitudes among people with SCI. Additionally, the longer life expectancy of 25 years may not have the same effect for the ST and TTO methods, and subjects seemed to be more willing to trade off their life years than to risk their life for full health.

There are several limitations to the study. First, generalizing these results to all people with SCIs needs to be done in a mindful way, because a substantial number of people in the SCI registry could not be reached for participation in the study. Despite no statistically significant differences being detected in any characteristics recorded in the registry, more nonparticipants tended to have complete paraplegia or tetraplegia, and they were

marginally older, possibly indicating a poorer health status than those participating in the study. Furthermore, of the 187 study subjects, those who had difficulty responding to the preference-based measurement were older and had complete lesions. As a result, the preferences of people with SCI may have been underestimated in this study. In addition, we had no choice but to conduct the interviews by telephone because our subjects lived nationwide and their physical health was such that it was inconvenient for them to leave their homes for personal interviews. Nevertheless, a recent study[46] showed that telephone interviews yielded similar preferences on the SG and TTO compared with personal interviews. Finally, the responsiveness (ie, the ability of an instrument to detect clinically important changes over time) was not evaluated in the study and needs to be further compared among the 3 measures.

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