Short Musculoskeletal Function Assessment Questionnaire: Validity, Reliability, and Responsiveness*

BY MARC F. SWIONTKOWSKI, M.D.†, RUTH ENGELBERG, PH.D.‡, DIANE P. MARTIN, PH.D.‡, AND JULIE AGEL, M.A.†, SEATTLE, WASHINGTON

Investigation performed at Harborview Medical Center, Seattle

Abstract

Background: **A short questionnaire on functional status was designed for use in community-based outcome studies and in the management of individual patients who have musculoskeletal disease. As most musculoskeletal care is delivered in community practices, short, validated instruments are necessary to perform clinical studies on the effectiveness of treatment in this setting.**

Methods: **A forty-six-item questionnaire was created as an extension of the work to develop the longer, 101-item Musculoskeletal Function Assessment (MFA) questionnaire. The Short Musculoskeletal Function Assessment (SMFA) questionnaire consists of the dysfunction index, which has thirty-four items for the assessment of patient function, and the bother index, which has twelve items for the assessment of how much patients are bothered by functional problems. The SMFA questionnaire was evaluated for reliability, validity, and responsiveness in a population of 420 patients who had a musculoskeletal disease or injury.**

Results: **The SMFA questionnaire demonstrated excellent internal consistency and stability, with most values greater than 0.90. Content validity for the dysfunction and bother indexes was supported with very little skew (less than 1.00), few ceiling effects (less than 5 percent), and no floor effects. Convergent validity was supported with significant correlations between the SMFA dysfunction and bother indexes and the physicians' ratings of patient function (for example, activities of daily living, recreational and leisure activities, and emotional function [rho $\geq$ 0.40]) and standard clinical measures (for example, grip strength and walking speed [$r \geq 0.40$]). Convergent and discriminant construct validity of the SMFA indexes were demonstrated ($p < 0.01$) in comparisons with clinical, demographic, Short Form-36 (SF-36), and life-change data. The responsiveness of the SMFA questionnaire to change over time was demonstrated with standardized response means ranging from moderate (0.76) to large (–1.14) for patients who had changes in health status.**

Conclusions: **The SMFA questionnaire may be used for clinical assessments of the impact of treatment in groups of patients who have musculoskeletal disease or injury. It also may be used in clinical settings to provide reliable and valid assessments of the health status of an individual patient.**

The present study describes the development of the Short Musculoskeletal Function Assessment (SMFA), a two-part, forty-six-item, self-reported health-status questionnaire, which can be completed in about ten minutes. The SMFA is designed to detect differences in the functional status of patients who have a broad range of musculoskeletal disorders that are commonly seen in community practices. It also allows patients to evaluate how bothered they are by functional problems.

The purpose of a functional assessment tool is to provide a standardized measure of the actual physical limitations of the patient. This tool then can be used to compare the patient with herself or himself over time as well as with other patients who have similar musculoskeletal disorders. Patient function also can be compared with function in the general population.

In a well planned clinical experiment, functional assessment tools can be used to evaluate the effectiveness of treatments as well as health-care policies. When there is one general assessment tool that is applicable to all forms of musculoskeletal disease, the administrative burden of making the assessment is greatly reduced. Office staff need to learn only one set of procedures, not multiple sets according to the type of disease or injury.

The SMFA questionnaire is based on the longer, 101-item Musculoskeletal Function Assessment (MFA) questionnaire, which also was developed by our team. The MFA questionnaire has been shown to be reliable, valid, and responsive[12,44]. It has demonstrated validity and responsiveness that are equal to or better than those of other disease-specific and generic health-status

*No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. Funds were received in total or partial support of the research or clinical study presented in this article. The funding sources were the National Institute of Child Health and Human Development, the American Academy of Orthopaedic Surgeons, and the Orthopaedic Trauma Association.

†Department of Orthopaedic Surgery, University of Minnesota, Box 492, Delaware Street N.E., Minneapolis, Minnesota 55455. E-mail address for Dr. Swiontkowski: swion001@tc.umn.edu. Please address requests for reprints to Dr. Swiontkowski.

‡Department of Health Services, Harborview Medical Center, University of Washington, Box 357660, 325 Ninth Avenue, Seattle, Washington 98195.

instruments[45]. Because of the length and detail of the MFA questionnaire, it has been most useful in research rather than in clinical settings[7]. Thus, we developed the SMFA questionnaire as a shorter alternative to the MFA questionnaire. In the present study, we describe the reliability, validity, and responsiveness of the SMFA questionnaire in a sample of patients who had musculoskeletal injuries and disorders.

Materials and Methods

Short Musculoskeletal Function Assessment Questionnaire

The SMFA questionnaire contains two parts: the dysfunction index and the bother index (Appendix). The dysfunction index has thirty-four items for assessment of the patients' perceptions of their functional performance: twenty-five items assess the amount of difficulty that patients have when performing certain functions, and nine items assess how often the patients have difficulty when performing certain functions. The items are grouped into four categories: daily activities, emotional status, function of the arm and hand, and mobility. (Descriptive and validity analyses of the dysfunction index categories are available from us.) Each item has a 5-point response format, ranging from 1 point for good function to 5 points for poor function. The bother index has twelve items that allow patients to assess how much they are bothered by problems in broad functional areas, such as recreation and leisure, sleep and rest, work, and family. The 5-point response format ranges from 1 point (not at all bothered) to 5 points (extremely bothered).

The scores on the dysfunction index and the bother index are calculated by summing the responses to the items and then transforming the scores so that they range from zero to 100, with use of the formula[70]: ([actual raw score – lowest possible raw score]/possible range of raw score) × 100. Higher scores indicate poorer function. For the dysfunction index, unanswered items within a category are replaced with the individual's mean score for that category, as long as more than 50 percent of the items in that category have been answered[70]. Substitution with the mean is not appropriate for the bother index as each item addresses a unique functional area.

The forty-six items selected for the SMFA questionnaire were identified from analyses of baseline and follow-up data on 327 patients who had responded to the MFA questionnaire[12,41]. Items that were retained met three criteria: (1) they were determined by the research team to be clinically and conceptually important[28,69]; (2) they were stable, with percent agreement statistics from test-retest data that were greater than 0.80 and kappa values that were greater than 0.70[28,65]; and (3) they were moderately endorsed (patients responded with the item that was true for them) at baseline and follow-up evaluations, with exclusion of items that had very low endorsement (10 percent or less, with some exceptions to provide items for seriously disabled patients), very high endorsement (80 percent or more), or missing endorsements (5 percent or more)[25]. The retained items represent what we consider to be the shortest form that is feasible while maintaining statistical integrity. Another change from the MFA was the replacement of that questionnaire's dichotomous yes-or-no response format with a 5-point Likert-type response format. We believed this to be necessary because the SMFA has fewer items but was designed to be evaluative as well as discriminative. Thus, we thought it necessary to increase the variability in the scores by providing more response choices[17,20,28]. We also added two new composite questions that combine the MFA questions concerning housework. Finally, the categories in the SMFA questionnaire were assessed with use of principal component factor analytic procedures with baseline data. A pilot evaluation was carried out to assess the SMFA for readability, clarity, ease of use, and appropriateness with a sample of twenty-six patients from a university medical center and a community orthopaedic practice.

Characteristics of the Patients

The 420 patients who were included in the study were at least eighteen years old and had an acute fracture or soft-tissue injury of an extremity or the spine, a repetitive-motion disorder, osteoarthritis, or rheumatoid arthritis. Patients were excluded if they had a head injury; a fracture of the spine with a residual neurological deficit; a neuromuscular disease; an amputation secondary to a systemic disease; a history of a stroke or cardiovascular disease with an acute episode in the preceding three months; end-stage renal disease, cancer, or acquired immunodeficiency syndrome; a serious psychiatric or cognitive limitation; or an inability to speak or understand English. Twenty-four patients were excluded from the analyses of the bother index because they had incomplete data on either the baseline (fourteen patients) or the follow-up (ten patients) questionnaire.

Patients were selected from eighteen sites across the United States. Four sites were university-based clinics, seven were private orthopaedic clinics not located in the state of Washington, and seven were private orthopaedic clinics located in the state of Washington.

Study Protocol

Patients who had an acute fracture or soft-tissue injury were recruited by letter either during hospitalization or at the time of the first office visit. Patients who had a repetitive-motion disorder (for example, tendinitis, bursitis, or a nerve compression syndrome), osteoarthritis, or rheumatoid arthritis were recruited by letter at the time of the office visit. Recruitment continued until we had enrolled approximately 500 patients. Consent forms were mailed with the first questionnaire. Recruitment and study protocols were approved by the University of Washington Human Subjects Review Board.

The SMFA was self-administered at two points in time. The time-frames were selected on the basis of previous research on patients who had an acute fracture or soft-tissue injury[33,39-41,48,54], a repetitive-motion disorder[53,58], osteoarthritis, or rheumatoid arthritis[13,73]. A questionnaire was mailed to the 211 patients who had an acute fracture or soft-tissue injury at three and six months after the injury. The 209 patients who had a repetitive-motion disorder, osteoarthritis, or rheumatoid arthritis completed the survey at the time of the enrollment visit and again three months later.

Analyses

On the basis of functional characteristics associated with injuries and disorders, the patients were divided into clinical groups for analyses: acute fractures or soft-tissue injuries involving the lower extremities; acute fractures or soft-tissue injuries involving the upper extremities; acute fractures or soft-tissue injuries involving both the upper and the lower extremities; repetitive-motion disorders involving the lower extremities (for example, patellar tendinitis or a chronic tear of the meniscus); repetitive-motion disorders (for example, carpal tunnel syndrome or chronic instability of the shoulder) or osteoarthritis involving the upper extremities; osteoarthritis involving the lower extremities; rheumatoid arthritis involving the upper extremities, lower extremities, or both; acute fractures or soft-tissue injuries about the spine; and chronic conditions of the spine (that is, those with a duration of more than three months).

Reliability

Reliability, assessed both as stability and as internal consistency, was evaluated for the dysfunction and bother indexes for all patients, regardless of clinical group. Stability, defined as the consistency of scores over time "among respondents who are assumed not to have changed,"[59] was assessed with use of intraclass correlation coefficients with test-retest data[11,20]. A quota sample of 150 patients returned a retest baseline questionnaire that they had completed one to two weeks (mean and standard deviation, 7.8 ± 1.62 days) after completion of the baseline questionnaire. Seventy-two of these patients had an acute fracture or soft-tissue injury, and seventy-eight had a repetitive-motion disorder, osteoarthritis, or rheumatoid arthritis.

Internal consistency, defined as the comparability of items within the SMFA questionnaire, was assessed with use of Cronbach's alpha with baseline and follow-up data to verify the makeup of the categories. We expected correlations and alpha values to be greater than 0.70, the standard for adequate reliability for questionnaire development and group comparisons[24,57].

Validity

Validity, defined as the ability of an instrument to measure what it is intended to measure, was examined by means of content and construct validity[3,59,65].

Content validity is present when "the domain of the instrument is appropriate relative to its intended use."[59] Questionnaires that demonstrate content validity should have few missing responses, use the full range of scores with little skew (the amount of asymmetry in the distribution of scores), and have few ceiling (best possible score) or floor (poorest possible score) effects. On the SMFA questionnaire, a ceiling score of 0 points is the best possible score. The questionnaire is unable to measure any additional improvement in function, even though patients may still improve. At the other end of the scale, a floor score of 100 points is the worst possible score that the SMFA can measure but, again, there is no limit to patients' actual deterioration in function. We examined content validity for the dysfunction and bother indexes across all clinical groups with use of data collected at the three-month mark for the group that had a traumatic injury and at the time of the first office visit for the other groups (baseline). We expected less than 5 percent of the responses to be missing, the score ranges to include most values (that is, from 0 to 100 points), the distributions of the scores to have skew values of less than 1.00 (symmetrical distribution of the data — skew values between –3.00 and +3.00 are considered reflective of a normal distribution), and less than 5 percent of the patients to have a ceiling score of 0 points (best function) or a floor score of 100 points (poorest function). Because of the functional characteristics associated with clinical groups, we expected more limited score ranges (50 to 60 percent of available scores) and more skewed distributions (a skew value of less than 3.00)[65] when examining SMFA scores by clinical groups. Because of the severity of illness in the patients who had rheumatoid arthritis, we expected higher mean scores and more limited score ranges for this clinical group.

Construct validity is present when there is a relationship between the questionnaire and various hypotheses. It is possible to demonstrate either convergent construct validity or discriminant construct validity. Construct validity is also demonstrated when "the health measure relates to other measures in ways consistent with plausible hypotheses."[65] These other measures may include clinical measures of patient function[1,2,9,49,61,67,72], demographic data (for example, age, gender, education, race, marital status, income, health insurance, disability compensation, or legal action)[4,27,29,31,37,39,50,52,60,63,64,66], or other health-status questionnaires[70].

Convergent construct validity must correlate the scales being measured in a positive fashion. Also, similar measures must correlate significantly with the new health-status questionnaire to demonstrate convergent construct validity[36].

Discriminant construct validity must correlate the scales being measured in a negative fashion. In addition, groups that are known to differ from each other on the basis of their group membership should differ signifi-

TABLE I
VALIDATION SOURCES FOR COMPARISON WITH THE SMFA QUESTIONNAIRE*

Validation Measure	Instrument	No. of Patients Who Had Validation Data	Result
Physicians' ratings† *(points)*	Physician assessment form	263	
Mobility of upper extemities		206	1.8 ± 2.3
Mobility of lower extremities		241	3.4 ± 2.6
Ability to carry out activities of daily living		262	3.2 ± 2.3
Ability to carry out recreational and leisure activities		253	5.1 ± 2.8
Emotional coping and adjustment		256	2.5 ± 2.3
Clinical measures‡			
Walking speed *(m/sec.)*	25 or 50-meter timed course	90	0.91 ± 0.29 (74)
Grip strength *(kgF)*	Jamar dynamometer	49	23.07 ± 17.07 (65)
Range of motion — continuous *(degrees)*	Goniometer		
Flexion of shoulder		29	156 ± 24
Extension of shoulder		25	46 ± 22
Flexion of elbow		29	144 ± 19
Extension of elbow		28	–0.07 ± 15
Flexion of wrist		22	68 ± 17
Extension of wrist		22	62 ± 22
Flexion of hip		48	120 ± 17
Extension of hip		47	12 ± 18
Flexion of knee		82	128 ± 18
Extension of knee		79	–0.27 ± 6
Flexion of ankle		52	11 ± 6
Extension of ankle		51	43 ± 16
Range of motion — categorized§	Goniometer		
Shoulder		25	4.0
Elbow		28	14.3
Wrist		22	13.6
Hip		47	42.6
Knee		79	8.9
Ankle		52	28.8
SF-36 health-status questionnaire#	Additional questionnaire included with SMFA	420	
Physical functioning		416	54.0 ± 28.4
Physical role functioning		411	33.9 ± 40.4
Bodily pain		410	47.9 ± 23.0
Vitality		416	50.1 ± 21.1
General health		408	68.7 ± 22.1
Social functioning		408	67.1 ± 28.8
Emotional role functioning		405	62.2 ± 42.2
Mental health		415	69.1 ± 19.5
Demographic data	Supplementary questions in SMFA instrument	420	See Table VI

*SMFA = Short Musculoskeletal Function Assessment.
†The ratings ranged from 0 to 10 points, with 0 points indicating best function and 10 points, poorest function. The results are given as the mean and the standard deviation.
‡The results are given as the mean and the standard deviation, with the percentage of those who had a poor result in parentheses.
§The categories were normal, functional, or poor range of motion. The results are given as the percentage of patients who had a poor range of motion.
#The results are given as the mean score and the standard deviation, with 0 points indicating poor health and 100 points, excellent health.
SF-36 = Short Form-36.

cantly from each other with regard to the scores of the new health-status questionnaire to demonstrate discriminant construct validity[37].

The convergent construct validity of the SMFA was measured against four separate studies: ratings of patient function by an orthopaedist, clinical measures of patient function, the Short Form-36 (SF-36) subscales, and the demographic characteristics of the patients.

For the first evaluation of validity, the orthopaedic surgeons subjectively assessed the functional status of the patients with use of a rating form developed for validation of the MFA[12]. Ratings were completed for 263 patients who had visits that corresponded with the baseline administration of the SMFA (Table I). The orthopaedists rated patient function with respect to the mobility of the upper and lower extremities, the ability to carry out the activities of daily living as well as recreational and leisure activities, and emotional coping and

adjustment. Scores were assigned on the basis of an 11-point scale, with 0 points indicating the best function and 10 points, the poorest function.

For the second evaluation of validity, the physician or a member of the clinical staff carried out several clinical measurements during visits that corresponded with the administration of the baseline questionnaire. These measurements were of self-selected walking speed and grip strength or range of motion, or both, of the affected extremity.

Ninety patients who had an injury or disorder of the lower extremity performed a test to determine their self-selected walking speeds at locations that had either a twenty-five or a fifty-meter walking course (Table I). In order to accommodate the variation in distances at the locations, speeds were standardized as meters per second. The walking speed was considered to be poor if it was more than one standard deviation slower than reported norms, adjusted for age and gender[30,35,43,62].

The grip strength of forty-nine patients who had an injury or disorder of the upper extremity was measured with use of the Jamar dynamometer (J. A. Preston, Jackson, Mississippi), according to the recommendations of the American Society of Hand Therapists[47] (Table I). Grip strength that was more than one standard deviation less than normal, adjusted for age and gender, was rated as poor[46,47].

The range of motion of the affected extremity of patients who had a single injury or disorder was measured, with use of a goniometer, according to the recommendations of the American Academy of Orthopaedic Surgeons[15] (Table I). Range-of-motion scores were reported as continuous variables and were also categorized as normal, functional, or poor with use of reported estimates defining normal and minimum functional ranges for the joint measured[56]. Values for flexion and extension were combined to create a single score.

For the third evaluation of validity, all patients completed the SF-36 questionnaire. This generic, self-administered health-status questionnaire has thirty-six multiple-choice items grouped into eight subscales: physical functioning, role limitations due to physical health problems (physical role functioning), bodily pain, vitality, general health, social functioning, role limitations due to emotional problems (emotional role functioning), and mental health[70]. This test was administered as a way to assess convergent construct validity — that is, to use as a so-called yardstick with which to compare changes in the scores on the SMFA. In order to facilitate the validity analyses, SF-36 scales were reversed to correspond with SMFA scores (the higher the SF-36 scale value, the greater the dysfunction of the patient).

For the fourth evaluation of validity, the patients answered questions about race, gender, age, education, marital status, health insurance, employment, income, disability compensation, legal action, changes in life due to illness, and health status. These data demonstrated

TABLE II
DEMOGRAPHIC CHARACTERISTICS OF THE PATIENTS WHO RESPONDED TO THE SMFA QUESTIONNAIRE

Characteristics	SMFA Sample* (N = 420)
Clinical groups	
Acute fracture or soft-tissue injury of lower extremity	108 (26)
Acute fracture or soft-tissue injury of upper extremity	72 (17)
Acute fracture or soft-tissue injury of both upper and lower extremities	14 (3)
Repetitive-motion disorder of lower extremity	79 (19)
Repetitive-motion disorder and osteoarthritis of upper extremity	53 (13)
Osteoarthritis of lower extremity	44 (10)
Rheumatoid arthritis	8 (2)
Acute fracture or soft-tissue injury about spine	17 (4)
Chronic condition of spine	25 (6)
Female	239 (57)
Age *(yrs.)*	48.9 ± 15.99 (18-89)
Race†	
White	380 (91)
Other	36 (9)
Level of education completed‡	
≤8th grade	8 (2)
High school	141 (34)
Some college	170 (41)
Bachelor's or more advanced degree	99 (24)
Living alone	80 (19)
Current employment status	
Working full-time	158 (38)
Working part-time because of health	12 (3)
Working part-time, not health-related	27 (6)
Employed but on sick leave	34 (8)
Retired	86 (20)
Unemployed	54 (13)
Homemaker	39 (9)
Other or no response	10 (2)
Injured at work§	37 (18)
Annual income	
<$20,000	122 (29)
$20,000-$50,000	171 (41)
>$50,000	100 (24)
Other or no response	27 (6)
Change in income	
Decreased	124 (30)
No change	288 (69)
Increased	4 (1)
No response	4 (1)
Health insurance#	
Managed care	57 (14)
Private	257 (61)
Medicare	96 (23)
Medicaid	22 (5)
Government programs (state and federal)	28 (7)
Other insurance	19 (5)
No insurance	42 (10)
Don't know	6 (1)
Receiving disability compensation	83 (20)
Involved in litigation	49 (12)

*All values, except for age, are given as the number of patients, with the percentage in parentheses. Age is given as the mean and the standard deviation, with the range in parentheses. SMFA = Short Musculoskeletal Function Assessment.
†N = 416 for this category.
‡N = 418 for this category.
§N = 211 for this category.
#N > 420 because of multiple endorsements, but the percentages are based on 420.

TABLE III
CONTENT VALIDITY: DESCRIPTIVE STATISTICS FOR THE SMFA QUESTIONNAIRE*

SMFA Indexes	No. of Items	Score† *(points)*	Range *(points)*	Skew	Cronbach's Alpha (T1/T2)‡	Intraclass Correlation Coefficient§	Missing Data *(percent)*	Patients Who Had a Score of 0 Points *(percent)*
Dysfunction index	34							
All patients (n = 420)		27.33 ± 16.93	0-87	0.70	0.95/0.96	0.93	17.9	0.5
Acute fracture or soft-tissue injury of lower extremity (n = 108)		28.28 ± 16.62	1-67	0.54				0.0
Acute fracture or soft-tissue injury of upper extremity (n = 72)		22.79 ± 15.50	2-63	0.87				0.0
Acute fracture or soft-tissue injury of both upper and lower extremities (n = 14)		48.69 ± 18.97	18-87	0.56				0.0
Repetitive-motion disorder of lower extremity (n = 79)		21.68 ± 15.74	0-64	0.99				2.5
Repetitive-motion disorder or osteoarthritis of upper extremity (n = 53)		21.74 ± 15.27	1-71	1.69				0.0
Osteoarthritis of lower extremity (n = 44)		29.18 ± 10.77	1-54	–0.12				0.0
Rheumatoid arthritis (n = 8)		50.84 ± 15.25	30-71	0.06				0.0
Acute fracture or soft-tissue injury about spine (n = 17)		40.10 ± 16.74	1-63	–0.76				0.0
Chronic condition of spine (n = 25)		34.56 ± 15.12	10-73	0.66				0.0
Bother index#	12							
All patients (n = 396)		31.22 ± 20.84	0-94	0.75	0.92/0.95	0.88	3.3	2.5
Acute fracture or soft-tissue injury of lower extremity (n = 101)		31.79 ± 21.95	0-90	0.76				3.0
Acute fracture or soft-tissue injury of upper extremity (n = 68)		26.72 ± 18.86	0-77	0.58				4.4
Acute fracture or soft-tissue injury of both upper and lower extremities (n = 14)		46.88 ± 16.89	15-71	–0.54				0.0
Repetitive-motion disorder of lower extremity (n = 78)		24.55 ± 20.40	0-85	1.38				3.8
Repetitive-motion disorder or osteoarthritis of upper extremity (n = 49)		30.49 ± 20.11	2-92	1.12				0.0
Osteoarthritis of lower extremity (n = 41)		31.40 ± 14.29	6-88	1.47				0.0
Rheumatoid arthritis (n = 4)		56.25 ± 20.90	44-88	1.96				0.0
Acute fracture or soft-tissue injury about spine (n = 16)		41.67 ± 24.06	0-81	–0.14				6.3
Chronic condition of spine (n = 25)		43.75 ± 20.10	10-94	0.31				0.0

*SMFA = Short Musculoskeletal Function Assessment.
†The values are given as the mean and the standard deviation.
‡T1 = baseline value and T2 = follow-up data.
§Based on the test-retest data (n = 150).
#The size of sample is smaller because of missing responses to the bother index.

that the study group was a heterogeneous population of patients. It also allowed us to test validity against factors such as employment status and legal action, which are thought to have a potential impact on recovery for some individuals[12].

Physicians' ratings of patient function, clinical measures of patient function, and SF-36 subscales were analyzed with use of correlations. Pearson's correlation (r) measures were used with the clinical measures and SF-36 subscales. Spearman's rho correlations, with a significance level of $r_s \geq 0.40$, were used with the physicians' ratings to accommodate the skewed distribution of these ratings[65]. The Spearman rho (r_s) statistic measures the extent to which two sets of ranked data are in agreement or disagreement with each other. A value of 1.00 indicates perfect agreement; a value of –1.00 indicates perfect disagreement. Relationships between the SMFA indexes and the demographic characteristics of the pa-

tients were examined with analysis of variance tests ($p < 0.01$) and Scheffé's tests for pairwise comparisons ($p < 0.05$). All analyses were performed with baseline data, unless otherwise noted, and included all clinical groups.

Discriminant construct validity was examined, with use of baseline data, for patients who differed by overall health status and by life changes because of illness. The perception of overall health status was assessed with the SF-36 item: "In general, would you say your health is excellent/very good/good/fair/poor?" We expected that patients who had different levels of health status would have significantly different scores on the SMFA indexes. We tested this hypothesis with analysis of variance ($p < 0.01$) and Scheffé's tests for pairwise comparisons ($p < 0.05$).

Life changes due to illness were assessed with the item: "How much has your injury or arthritis changed your life — not at all/a little/somewhat/quite a bit/completely?" This item was used to evaluate, with use of receiver operating characteristic analysis[5], the ability of the SMFA to discriminate between patients who had and those who did not have functional problems. (The principles and methods of receiver operating characteristic analysis have been previously described[45].) With a receiver operating characteristic curve, the patients who were correctly identified by the question as having the disease were plotted on the y axis (sensitivity) and the patients who were incorrectly classified as having the disease were plotted on the x axis (1 – specificity). Patients were classified as not having a functional problem if they answered "not at all" or "a little" to the life-change question. Patients were classified as having a functional problem if they answered "quite a bit" or "completely" to the life-change question. We expected the specificity, sensitivity, and areas under the curve for the SMFA indexes at baseline to be greater than 0.70. A value of 1.00 for the area under the curve indicates that patients have been correctly classified, with the level of their dysfunction equal to their response to the life-change question.

Responsiveness

Responsiveness, or the ability of the questionnaire to detect clinical change[14,18,19,34], was assessed with the question: "How is your health now compared to when you completed this survey before — much worse/worse/about the same/better/much better?" Patients who reported that their health was "worse" or "much worse" or "better" or "much better" were expected to show significant changes (increases or decreases) in the follow-up scores on the SMFA. Changes between the baseline and follow-up scores on the dysfunction and bother indexes, across all clinical groups, were examined with use of paired t tests ($p < 0.01$).

Additionally, responsiveness was assessed with use of standardized response mean statistics. The standardized response mean is calculated as the mean change in score divided by the standard deviation of individuals' changes in score. On the basis of the recommendation by Guyatt et al.[20] that the data from subjects with stable responses be used as the denominator of the standardized response mean, we used the standard deviation of the changes in the scores for the patients who reported that their health was "about the same." With use of the standards established by Cohen for small (more than 0.2), moderate (more than 0.5), and large (more than 0.8) effects[8], we expected standardized response means to range from small to large for patients who reported that their health had changed.

Results

Characteristics of the Patients

The mean age of the 420 patients was forty-nine years (range, eighteen to eighty-nine years) (Table II). Two hundred and thirty-nine patients (57 percent) were women, thirty-six (9 percent) were nonwhite, and 149 (35 percent) had completed twelve years of education or less. Eighty-three patients (20 percent) were receiving disability compensation. Two hundred and eleven patients (50 percent) had an acute fracture or soft-tissue injury, 132 patients (31 percent) had a repetitive-motion disorder, and seventy-seven patients (18 percent) had osteoarthritis, rheumatoid arthritis, or a chronic condition of the spine. Of the 211 patients who had an acute fracture or soft-tissue injury, four had associated arterial injuries, twelve had associated nerve injuries, and twenty had at least one open (type-III[16]) fracture.

The ninety-four patients who did not complete a second survey were similar to the 420 respondents in terms of gender, number of comorbidities, number of disorders, procedures or treatments (for example, operative procedures, medications, physician visits, and physical therapy), severity or type of acute fracture or soft-tissue injury, severity of repetitive-motion disorder, and number of involved joints for patients who had osteoarthritis or rheumatoid arthritis. However, the nonrespondents were significantly ($p < 0.05$) younger than the respondents (44.70 ± 14.96 years [mean and standard deviation] compared with 48.93 ± 15.99 years), and they had fewer complications (0.01 ± 0.10 compared with 0.05 ± 0.22) and fewer bilateral injuries (1.25 ± 0.45 compared with 1.72 ± 0.45). In addition, the nonrespondents who had osteoarthritis or rheumatoid arthritis had less severe disease ratings than did the respondents who had those disorders (1.67 ± 0.69 compared with 2.66 ± 0.96)[6]. (The severity of the osteoarthritis or rheumatoid arthritis was determined on the basis of data in the medical record, specifically the type of medications prescribed, a history of operative procedures, and the number of involved joints.)

Reliability

The dysfunction and bother indexes demonstrated excellent reliability (Table III). The intraclass correla-

TABLE IV

CONVERGENT VALIDITY: CORRELATIONS AMONG PHYSICIANS' RATINGS, CLINICAL MEASURES, AND THE SMFA INDEXES*

SMFA Indexes	Physicians' Ratings†		Clinical Measures	
	Function	Spearman's Rho	Function	Pearson's r
Dysfunction index	Physical function: mobility of lower extremities	0.36	Walking speed	0.49‡
	Physical function: mobility of upper extremities	0.10	Grip strength	0.45‡
	Activities of daily living	0.42‡	Range of motion	
	Recreational and leisure activities	0.46‡	Shoulder	–0.10
	Emotional function	0.43‡	Elbow	0.13
			Wrist	0.47‡
			Hip	0.31
			Knee	0.14
			Ankle	0.45‡
Bother index	Physical function: mobility of lower extremities	0.29		
	Physical function: mobility of upper extremities	0.20	Walking speed	0.43‡
	Activities of daily living	0.41‡	Grip strength	0.40‡
	Recreational and leisure activities	0.46‡	Range of motion	
	Emotional function	0.43‡	Shoulder	–0.04
			Elbow	0.10
			Wrist	0.22
			Hip	0.34
			Knee	0.10
			Ankle	0.30

*SMFA = Short Musculoskeletal Function Assessment.

†Physicians' ratings were assigned on an 11-point scale, with 0 points indicating best function and 10 points, poorest function. The values are given for the 263 patients for whom data were available.

‡Rho or r ≥ 0.40, which indicated a positive and significant correlation.

tion coefficients, which measured stability, were 0.93 for the dysfunction index and 0.88 for the bother index. Cronbach's alpha values for baseline and follow-up data, which measured internal consistency, were, respectively, 0.95 and 0.96 for the dysfunction index and 0.92 and 0.95 for the bother index.

Content Validity

The dysfunction and bother indexes, when examined across clinical groups, displayed good score ranges (0 to 87 points and 0 to 94 points, respectively), distributions with little skew (0.70 and 0.75, respectively), no floor effects, and few ceiling effects (0.5 percent and 2.5 percent, respectively) (Table III). Missing responses were more frequent (17.9 percent) than expected for the dysfunction index. This discrepancy was due to a single item, the sexual activity question, which had an 11 percent rate of missing responses. No other item in the dysfunction index had a rate of missing responses of more than 3 percent. The bother index had a missing-response rate of 3.3 percent.

The content validity of the SMFA, examined according to clinical group, was supported, with some exceptions (Table III). All clinical groups, with the exception of patients who had rheumatoid arthritis, used 50 percent or more of the response scale. None of the distributions were skewed more than 3.0[65], and none of the clinical groups received a floor SMFA score (that is, 100, the poorest score for function). Ceiling effects, with more than 5 percent of the patients receiving a score of 0 points (no dysfunction), occurred only on the bother index for the patients who had an acute fracture or soft-tissue injury about the spine, 6.3 percent of whom had a ceiling score. As expected, patients who had rheumatoid arthritis had the highest mean score and the smallest range of scores on the SMFA indexes.

Convergent Construct Validity

Convergent construct validity of the SMFA indexes was demonstrated for most of the hypothesized relationships. The SMFA indexes were found to be significantly and positively related to the physicians' ratings for the activities of daily living, recreational and leisure activities, and emotional function (rho ≥ 0.40); they were not found to be significantly related to the physicians' ratings of mobility of the lower extremities or mobility of the upper extremities, with the numbers available (Table IV). For the clinical measures of patient function, both SMFA indexes were found to be significantly correlated with walking speed and grip strength and the dysfunction index alone was found to be correlated with range of motion of the ankle and wrist (rho or r ≥ 0.40); the indexes were not found to be significantly related to any of the other range-of-motion measures (Table IV). The SMFA indexes were found to be significantly related to all comparable SF-36 subscales (p = 0.000) (Table V). With regard to the demographic characteristics, we found that patients scored significantly higher (poorer) if they were from a minority group, had less education, were unemployed, were receiving public health insurance or disability compensation, or were involved in litigation (p = 0.00 or 0.01); scores did not vary significantly by age, gender, or marital status (Table VI).

TABLE V
CONSTRUCT VALIDITY: CORRELATIONS BETWEEN THE SF-36 SUBSCALES AND THE SMFA INDEXES*

SMFA Indexes	SF-36 Subscales	Pearson's r†
Dysfunction index	Physical functioning	0.78
	Physical role functioning	0.59
	Bodily pain	0.66
	Vitality	0.55
	Social functioning	0.71
	Emotional role functioning	0.47
	Mental health	0.51
Bother index	Physical functioning	0.68
	Physical role functioning	0.60
	Bodily pain	0.70
	Vitality	0.55
	Social functioning	0.70
	Emotional role functioning	0.50
	Mental health	0.58

*SF-36 = Short Form-36 and SMFA = Short Musculoskeletal Function Assessment.
†P = 0.000 for all.

Discriminant Construct Validity

The dysfunction and bother indexes were found to vary significantly according to the health status of the patient ($p < 0.01$). On the dysfunction index, the seventy-four patients who reported poor or fair health status scored significantly higher (greater dysfunction) (40.27 ± 17.37 points) than the 153 patients who reported good health status (30.25 ± 15.40 points). The patients who reported good health status scored significantly higher than the 190 patients who reported very good or excellent health status (20.20 ± 14.09 points). Scores on the bother index followed the same pattern. The sixty-seven patients who reported poor or fair health status scored significantly higher (more bothered) (49.91 ± 22.21 points) than the 145 patients who reported good health status (33.42 ± 18.02 points). The patients who reported good health status scored significantly higher than the 181 patients who reported very good or excellent health status (22.95 ± 17.29 points). Three patients who did not answer the question were excluded from this analysis.

Receiver operating characteristic analyses[10,22,23,42,51,55,68,71] of the SMFA indexes resulted in values of greater than 0.70. For the 319 responses on the dysfunction index, the values for sensitivity and specificity were 0.90 and 0.84, respectively, and the area under the curve was 0.94. For the 308 responses on the bother index, the values for sensitivity and specificity were 0.87 and 0.84, respectively, and the area under the curve was 0.94.

Responsiveness

Changes in the dysfunction and bother indexes from baseline to follow-up were significantly different ($p < 0.01$) for patients who reported that their health was "worse" or "much worse" and for those who reported that their health was "better" or "much better" (Table VII). Standardized response means for patients who reported health changes ranged from 0.76 (patients who reported "better" or "much better" health on the bother index) to –1.14 (patients who reported "worse" or "much worse" health on the dysfunction index). Of the four standardized response means for patients who reported change, two indicated large effects (that is, values greater than 0.8) and two indicated moderate effects (that is, values greater than 0.5).

Discussion

Our findings support the reliability, validity, and responsiveness of the Short Musculoskeletal Function Assessment (SMFA) in a sample of patients who had musculoskeletal disorders.

The SMFA has the versatility to function as a measure of a patient's change over time, as a measure of a group of patients who have a similar disease, and as a measure of the direct impact of functional limitation on individual patients.

In the area of reliability, the dysfunction index demonstrated values for stability and internal consistency that warrant its use in the evaluation of health status in groups of patients and for making clinical decisions about individuals[38]. Similar to the dysfunction index, the bother index demonstrated values for internal consistency that make it appropriate for use with groups of patients and with individual patients. The stability value of the bother index (0.88) was just slightly less than the criteria of 0.90 for individual applications, suggesting that it may not be stable enough for use in guiding clinical decisions for individual patients.

In the area of validity, the SMFA indexes demonstrated good content validity (that is, the scores spanned the full range of values, with few floor or ceiling effects and with distributions showing little skew). Convergent construct validity, assessed with physicians' ratings of patient function, clinical measures of patient function, SF-36 subscales, and demographic characteristics of the patients, was supported with few exceptions. Discriminant construct validity, assessed for groups of patients who had different levels of health status, was supported without exception.

Although physicians' ratings of mobility of the upper and lower extremities were not found to be significantly related to the SMFA indexes, these ratings were significantly and positively correlated with specific SMFA categories. Ratings of mobility of the upper extremities were shown to be significantly related to the category of arm and hand function (rho = 0.57), and ratings of mobility of the lower extremities were found to be significantly related to the mobility category (rho = 0.56). In short, because the scores on the SMFA indexes are summary scores that describe function in a number of areas, it is not surprising that assessments of specific functional areas are not as strongly related to the summary SMFA indexes as they are to specific categories.

TABLE VI
CONSTRUCT VALIDITY: DEMOGRAPHIC HYPOTHESES AND THE SMFA*

Demographic Hypothesis†	SMFA Dysfunction Index			SMFA Bother Index		
	Hypothesis Confirmed	No. of Patients (Percent)	Score on Dysfunction Index‡ *(points)*	Hypothesis Confirmed	No. of Patients (Percent)	Score on Bother Index‡ *(points)*
Age (n = 420/396)	No			No		
18-44 yrs.		180 (43)	27.13 ± 17.27		173 (44)	32.07 ± 22.15
≥45 yrs.§		240 (57)	27.48 ± 16.71		223 (56)	30.57 ± 19.78
Gender (n = 420/396)	No			No		
Female§		239 (57)	28.31 ± 18.18		222 (56)	31.86 ± 22.28
Male		181 (43)	26.03 ± 15.08		174 (44)	30.40 ± 18.87
Race (n = 416/393)	Yes, p = 0.01			Yes, p = 0.01		
White		380 (91)	26.70 ± 16.68		359 (91)	30.44 ± 20.45
Nonwhite§		36 (9)	34.01 ± 18.42		34 (9)	39.77 ± 23.33
Education# (n = 418/394)	Yes, p = 0.00**			Yes, p = 0.00**		
<8th grade§		8 (2)	30.69 ± 15.17		8 (2)	41.67 ± 19.00
8th grade through high school§		141 (34)	31.68 ± 18.72		131 (33)	35.91 ± 22.43
Some college		170 (41)	27.78 ± 15.77		161 (41)	31.70 ± 20.50
Bachelor's or more advanced degree		99 (24)	19.91 ± 13.76		94 (24)	22.81 ± 16.49
Marital status (n = 416/392)	No			No		
Married		256 (62)	26.21 ± 16.91		245 (63)	29.88 ± 20.21
All other§		160 (38)	28.99 ± 16.88		147 (38)	33.46 ± 21.99
Health insurance (n = 414/390)	Yes, p = 0.00**			Yes, p = 0.00**		
Private		239 (58)	22.74 ± 14.11		232 (59)	26.71 ± 18.21
Public or don't know or no insurance§		175 (42)	33.50 ± 18.42		158 (41)	38.12 ± 22.69
Disability compensation (n = 413/389)	Yes, p = 0.00			Yes, p = 0.00		
No		330 (80)	23.63 ± 15.10		313 (80)	27.04 ± 19.12
Yes§		83 (20)	41.15 ± 16.44		76 (20)	47.29 ± 19.58
Income†† (n = 393/373)	Yes, p = 0.00**			Yes, p = 0.00**		
>$50,000		100 (25)	22.29 ± 14.71		98 (26)	25.13 ± 17.88
$20,000-$50,000		171 (44)	25.82 ± 15.59		163 (44)	28.53 ± 17.78
<$20,000§		122 (31)	34.26 ± 18.41		112 (30)	40.92 ± 23.42
Legal action (n = 413/389)	Yes, p = 0.00**			Yes, p = 0.00**		
No		364 (88)	25.60 ± 15.82		343 (88)	28.77 ± 19.33
Yes§		49 (12)	38.66 ± 19.50		46 (12)	47.42 ± 23.30
Current employment status‡‡ (n = 412/388)	Yes, p = 0.00			Yes, p = 0.00		
Employed		199 (48)	20.77 ± 14.03		192 (49)	25.05 ± 18.49
Unemployed, not health-related		114 (28)	26.97 ± 16.20		105 (27)	28.53 ± 18.86
Unemployed, health-related§		99 (24)	39.96 ± 15.48		91 (23)	46.06 ± 19.49

*SMFA = Short Musculoskeletal Function Assessment.
†The numbers of patients are given as the sample size for the dysfunction index/sample size for the bother index.
‡The values are given as the mean and the standard deviation.
§Group expected to have higher (worse) scores.
#For both indexes, a significant difference was found between the patients who had completed eight to twelve years of education and those who had a bachelor's or more advanced degree.
**Kruskal-Wallis nonparametric test.
††For both indexes, a significant difference was found between the patients whose income was more than $50,000 and those whose income was less than $20,000. A significant difference was also detected between patients whose income was between $20,000 and $50,000 and those whose income was less than $20,000.
‡‡For both indexes, a significant difference was found between the patients who were employed and those who were unemployed because of health-related reasons. A significant difference was also detected between patients who were unemployed for non-health-related reasons and those who were unemployed for health-related reasons.

The failure to find a relationship between the SMFA indexes and range-of-motion measures is somewhat more difficult to explain, although it has been reported by other investigators who have used range-of-motion measures as criteria for assessing health-status measures[6,21,26]. Patients may assess range of motion as a dichotomous variable ("I have enough motion to do what I need to do" or "I do not have enough motion"), whereas orthopaedists think of range of motion as a continuous variable. There are problems associated with finding so-called gold standards that are truly equivalent with the constructs measured by the health-status instruments.

TABLE VII

RESPONSIVENESS OF THE SMFA ACCORDING TO THE PATIENTS' REPORTS OF CHANGES IN HEALTH STATUS*

SMFA Indexes	SMFA Score†		Difference Between Scores		P Value‡	Standardized Response Mean§
	Baseline	Follow-up	Mean	Standard Deviation		
Dysfunction index						
Worse or much worse health (n = 31)	34.27 ± 18.80	44.52 ± 17.45	–10.25		0.000	–1.14
Health about the same (n = 159)	24.09 ± 15.93	22.83 ± 16.80	1.26	8.96	0.079	0.14
Better or much better health (n = 227)	28.49 ± 17.00	18.83 ± 15.19	9.66		0.000	1.08
Bother index						
Worse or much worse health (n = 27)	45.52 ± 24.67	56.79 ± 24.07	–11.27		0.006	–0.79
Health about the same (n = 153)	27.49 ± 19.85	27.03 ± 21.53	0.46	14.29	0.689	0.03
Better or much better health (n = 213)	31.92 ± 20.13	21.06 ± 19.05	10.86		0.000	0.76

*The change in health status from the baseline evaluation to the time of follow-up was assessed with the question: "How is your health now compared to when you completed this survey before?" SMFA = Short Musculoskeletal Function Assessment.

†The values are given as the mean and the standard deviation.

‡The changes in the baseline and follow-up scores were evaluated for significance with use of paired t tests.

§The value is calculated as the difference between the baseline and follow-up scores divided by the standard deviation of the mean score of patients whose health status remained stable.

Criteria chosen for validation of health-status instruments are often complementary rather than substitutive[6,9,32], and this lack of equivalence may explain the failure to find significant relationships. Additional validation studies with other patient samples may clarify this finding as well as the finding that the SMFA indexes did not vary significantly with regard to patient age, gender, or marital status.

Lastly, the SMFA demonstrated very good responsiveness. Patients who reported a change in functional status displayed significant changes on the SMFA dysfunction and bother indexes ($p < 0.01$). These changes, evaluated with a standardized measure, ranged from moderate to large.

The present study is limited by a number of factors. First, because of small numbers in some of our clinical groups (such as patients who had rheumatoid arthritis, acute fracture or soft-tissue injury with involvement of both upper and lower extremities, or acute or chronic conditions involving the spine), additional testing is needed to confirm the stability and generalizability of our findings. Second, the time-frame used to test the SMFA was narrow. We do not know how well the SMFA will perform for patients with acute problems who may have more dysfunction because of immobilization or how well it will perform for patients who are seen more than six months after injury. Third, we do not know how useful the SMFA is in the management of an individual patient. In the current study, we assessed only groups of patients over time.

There are a number of issues to consider when choosing between the longer MFA questionnaire and the shorter SMFA questionnaire. For investigators who are interested in more detailed functional information and whose patients may have more time to complete the questionnaire, the long-form MFA may be useful, as it provides more categories and, in some areas, a fuller range of scores. For clinicians who are interested in a short questionnaire that can be completed at the clinic visit and that provides an overall assessment of major areas of patient function, the shorter SMFA may be the better choice. As a measure of patient change over time, the SMFA can be used during follow-up examinations to demonstrate individual differences in function. This change can be measured by individual question, category, or total score or by all of these. As a measure of disease in patients, the SMFA can be used to allow large groups of clinicians to successfully pool disease-specific data in order to provide a better measure of the severity of the disease or the effectiveness of treatment. The bother index of the SMFA can be used to assess the impact of limitation of function on the individual. A patient can endorse only the question, "How often does your leg lock or give-way?" with "some of the time," noting no other dysfunction in the questionnaire; for the initial evaluation with the SMFA, this patient would have a moderate individual question score and a low category and total score. However, because the patient is constantly worried about whether or not a given activity might cause the knee to lock, he or she might have chosen to answer "extremely bothered" for two items in the bother index — that is, use of the legs and problems with recreational activities. This flexibility in the use of the SMFA adds to the broad spectrum of applications for which it may be appropriate. In this situation, the patient is able to indicate that there is a moderately frequent occurrence of one specific dysfunction, with no other functional problems, but this one dysfunction is

extremely bothersome in two facets of life. The usefulness of the SMFA in the management of individual patients is currently being studied.

As both the thirty-four functional items comprising the dysfunction index and the twelve items comprising the bother index demonstrated validity, reliability, and responsiveness, a clinician may choose either index, depending on his or her needs. For example, if a physician is most interested in an inventory of the kinds of activities that are difficult for the patient to perform, the dysfunction index might be preferable to the bother index. The dysfunction index may also be suitable for tracking and monitoring patients, as it has shown reliability and stability that is adequate for individual applications. If the physician is most interested in how troubled the patient is by his or her current functional limitations, the bother index may be a better choice. Also, because there are fewer items on the bother index and these items are broader and more comprehensive, the bother index items may be more easily completed during a clinic visit.

Whether they are used separately or in combination, the SMFA indexes constitute a promising short-form, self-reported questionnaire that is quickly completed and may be used in clinical settings to provide valid, reliable, and responsive assessments of health status for patients who have musculoskeletal disorders.

NOTE: The authors thank the following individuals and clinics for their participation in the present study: Clem Jones, M.D., San Francisco, California; Mark Meier, M.D., Orthopaedic Associates, Boise, Idaho; Kevin Maddox, Hugh Selznick, M.D., and Sheila Cellan, Pocatello Orthopaedics and Sports Medicine Institute, Pocatello, Idaho; David Brokaw, M.D., and Timothy Weber, M.D., Orthopaedics Indianapolis, Indianapolis, Indiana; James Hughes, M.D., and Philip Kregor, M.D., University of Mississippi, Jackson, Mississippi; Robert Snider, M.D., and Sheri Dodd, Orthopaedic Surgeons, P.S.C., Billings, Montana; Tom Sculco, M.D., and Tracie Dugas, Hospital for Special Surgery, New York, N.Y.; David Teague, M.D., University of Oklahoma, Oklahoma City, Oklahoma; David Noall, M.D., and Lily Nigo, Portland Orthopaedic Clinic, P.C., Portland, Oregon; Michael Christie, M.D., and Melanie Capps, Vanderbilt University, Nashville, Tennessee; Steven Ratcliffe, M.D., Northwest Orthopaedic Physicians, P.S., Bellevue, Washington; Michael Thorpe, M.D., Bellingham, Washington; David Bishop, M.D., Enunclaw, Washington; John Hendrickson, M.D., Martin Tullus, M.D., and Susan Cero, M.D., Valley Orthopaedic Associates, Renton, Washington; James Crutcher, M.D., and Martin Mankey, M.D., Orthopaedic Physician Associates, Seattle, Washington; Jon Keeve, M.D., and Leanne Mason, Northwest Orthopaedic and Fracture Clinic, Spokane, Washington; and Edward Farrar, M.D., and Deborah DeChand, Wenatchee Orthopaedics, Wenatchee, Washington.

Appendix

SHORT MUSCULOSKELETAL FUNCTION ASSESSMENT

Instructions

We are interested in finding out how you are managing with your injury or arthritis this week. We would like to know about any problems you may be having with your daily activities because of your injury or arthritis.

Please answer each question by putting a check in the box corresponding to the choice that best describes you.

These questions are about how much difficulty you may be having this week with your daily activities because of your injury or arthritis.

	Not at All Difficult	A Little Difficult	Moderately Difficult	Very Difficult	Unable To Do
1. How difficult is it for you to get in or out of a low chair?	☐	☐	☐	☐	☐
2. How difficult is it for you to open medicine bottles or jars?	☐	☐	☐	☐	☐
3. How difficult is it for you to shop for groceries or other things?	☐	☐	☐	☐	☐
4. How difficult is it for you to climb stairs?	☐	☐	☐	☐	☐
5. How difficult is it for you to make a tight fist?	☐	☐	☐	☐	☐
6. How difficult is it for you to get in or out of the bathtub or shower?	☐	☐	☐	☐	☐
7. How difficult is it for you to get comfortable to sleep?	☐	☐	☐	☐	☐
8. How difficult is it for you to bend or kneel down?	☐	☐	☐	☐	☐
9. How difficult is it for you to use buttons, snaps, hooks, or zippers?	☐	☐	☐	☐	☐
10. How difficult is it for you to cut your own fingernails?	☐	☐	☐	☐	☐
11. How difficult is it for you to dress yourself?	☐	☐	☐	☐	☐
12. How difficult is it for you to walk?	☐	☐	☐	☐	☐
13. How difficult is it for you to get moving after you have been sitting or lying down?	☐	☐	☐	☐	☐
14. How difficult is it for you to go out by yourself?	☐	☐	☐	☐	☐
15. How difficult is it for you to drive?	☐	☐	☐	☐	☐

16. How difficult is it for you to clean yourself after going to the bathroom?	☐	☐	☐	☐	☐
17. How difficult is it for you to turn knobs or levers (for example, to open doors or to roll down car windows)?	☐	☐	☐	☐	☐
18. How difficult is it for you to write or type?	☐	☐	☐	☐	☐
19. How difficult is it for you to pivot?	☐	☐	☐	☐	☐
20. How difficult is it for you to do your usual physical recreational activities, such as bicycling, jogging, or walking?	☐	☐	☐	☐	☐
21. How difficult is it for you to do your usual leisure activities, such as hobbies, crafts, gardening, card-playing, or going out with friends?	☐	☐	☐	☐	☐
22. How much difficulty are you having with sexual activity?	☐	☐	☐	☐	☐
23. How difficult is it for you to do light housework or yard work, such as dusting, washing dishes, or watering plants?	☐	☐	☐	☐	☐
24. How difficult is it for you to do heavy housework or yard work, such as washing floors, vacuuming, or mowing lawns?	☐	☐	☐	☐	☐
25. How difficult is it for you to do your usual work, such as a paid job, housework, or volunteer activities?	☐	☐	☐	☐	☐

These next questions ask how often you are experiencing problems this week because of your injury or arthritis.

	None of the Time	A Little of the Time	Some of the Time	Most of the Time	All of the Time
26. How often do you walk with a limp?	☐	☐	☐	☐	☐
27. How often do you avoid using your painful limb(s) or back?	☐	☐	☐	☐	☐
28. How often does your leg lock or give-way?	☐	☐	☐	☐	☐
29. How often do you have problems with concentration?	☐	☐	☐	☐	☐
30. How often does doing too much in one day affect what you do the next day?	☐	☐	☐	☐	☐
31. How often do you act irritable toward those around you (for example, snap at people, give sharp answers, or criticize easily)?	☐	☐	☐	☐	☐
32. How often are you tired?	☐	☐	☐	☐	☐
33. How often do you feel disabled?	☐	☐	☐	☐	☐
34. How often do you feel angry or frustrated that you have this injury or arthritis?	☐	☐	☐	☐	☐

These questions are about how much you are bothered by problems you are having this week because of your injury or arthritis.

	Not at All Bothered	A Little Bothered	Moderately Bothered	Very Bothered	Extremely Bothered
35. How much are you bothered by problems using your hands, arms, or legs?	☐	☐	☐	☐	☐
36. How much are you bothered by problems using your back?	☐	☐	☐	☐	☐
37. How much are you bothered by problems doing work around your home?	☐	☐	☐	☐	☐
38. How much are you bothered by problems with bathing, dressing, toileting, or other personal care?	☐	☐	☐	☐	☐
39. How much are you bothered by problems with sleep and rest?	☐	☐	☐	☐	☐
40. How much are you bothered by problems with leisure or recreational activities?	☐	☐	☐	☐	☐

41. How much are you bothered by problems with your friends, family, or other important people in your life?	☐	☐	☐	☐	☐
42. How much are you bothered by problems with thinking, concentrating, or remembering?	☐	☐	☐	☐	☐
43. How much are you bothered by problems adjusting or coping with your injury or arthritis?	☐	☐	☐	☐	☐
44. How much are you bothered by problems doing your usual work?	☐	☐	☐	☐	☐
45. How much are you bothered by problems with feeling dependent on others?	☐	☐	☐	☐	☐
46. How much are you bothered by problems with stiffness and pain?	☐	☐	☐	☐	☐

References

1. **Anderson, J. J.; Felson, D. T.; Meenan, R. F.;** and **Williams, H. J.:** Which traditional measures should be used in rheumatoid arthritis clinical trials. *Arthrit. and Rheumat.,* 32: 1093-1099, 1989.
2. **Bellamy, N.; Buchanan, W. W.;** and **Grace, E.:** Double-blind randomized controlled trial of isoxicam vs. piroxicam in elderly patients with osteoarthritis of the hip and knee. *British J. Clin. Pharmacol.,* 22 (Supplement 2): 149S-155S, 1986.
3. **Benirschke, S. K.; Melder, I.; Henley, M. B.; Routt, M. L.; Smith, D. B.; Chapman, J. R.;** and **Swiontkowski, M. F.:** Closed interlocking nailing of femoral shaft fractures: assessment of technical complications and functional outcomes by comparison of a prospective database with retrospective review. *J. Orthop. Trauma,* 7: 118-122, 1993.
4. **Benson, J.,** and **Clark, F.:** A guide for instrument development and validation. *Am. J. Occup. Ther.,* 36: 789-800, 1982.
5. **Berwick, D. M.; Murphy, J. M.; Goldman, P. A.; Ware, J. E., Jr.; Barsky, A. J.;** and **Weinstein, M. C.:** Performance of a five-item mental health screening test. *Med. Care,* 29: 169-176, 1991.
6. **Bijlsma, J. W.; Huiskes, C. J.; Kraaimaat, F. W.; Vanderveen, M. J.;** and **Huber-Bruning, O.:** Relation between patients' own health assessment and clinical and laboratory findings in rheumatoid arthritis. *J. Rheumatol.,* 18: 650-653, 1991.
7. **Catalano, L. W., III; Cole, R. J.; Gelberman, R. H.; Evanoff, B. A.; Gilula, L. A.;** and **Borrelli, J., Jr.:** Displaced intra-articular fractures of the distal aspect of the radius. Long-term results in young adults after open reduction and internal fixation. *J. Bone and Joint Surg.,* 79-A: 1290-1302, Sept. 1997.
8. **Cohen, J.:** *Statistical Power Analysis for the Behavioral Sciences.* New York, Academic Press, 1977.
9. **Deyo, R. A.; Inui, T. S.; Leininger, J. D.;** and **Overman, S. S.:** Measuring functional outcomes in chronic disease: a comparison of traditional scales and a self-administered health status questionnaire in patients with rheumatoid arthritis. *Med. Care,* 21: 180-192, 1983.
10. **Deyo, R. A.:** Measuring functional outcomes in therapeutic trials for chronic disease. *Controlled Clin. Trials,* 5: 223-240, 1984.
11. **Deyo, R. A.; Diehr, P.;** and **Patrick, D. L.:** Reproducibility and responsiveness of health status measures. Statistics and strategies for evaluation. *Controlled Clin. Trials,* 12 (Supplement 4): 142S-158S, 1991.
12. **Engelberg, R.; Martin, D. P.; Agel, J.; Obremsky, W.; Coronado, G.;** and **Swiontkowski, M. F.:** Musculoskeletal Function Assessment instrument: criterion and construct validity. *J. Orthop. Res.,* 14: 182-192, 1996.
13. **Fitzpatrick, R.; Ziebland, S.; Jenkinson, C.; Mowat, A.;** and **Mowat, A.:** A comparison of the sensitivity to change of several health status instruments in rheumatoid arthritis. *J. Rheumatol.,* 20: 429-436, 1993.
14. **Fortin, P. R.; Stucki, G.;** and **Katz, J. N.:** Measuring relevant change: an emerging challenge in rheumatologic clinical trials. *Arthrit. and Rheumat.,* 38: 1027-1030, 1995.
15. **Greene, W. B.,** and **Heckman, J. D.** [editors]: *The Clinical Measurement of Joint Motion.* Rosemont, Illinois, American Academy of Orthopaedic Surgeons, 1994.
16. **Gustilo, R. B.; Mendoza, R. M.;** and **Williams, D. N.:** Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. *J. Trauma,* 24: 742-746, 1984.
17. **Guyatt, G. H.; Bombardier, C.;** and **Tugwell, P. X.:** Measuring disease-specific quality of life in clinical trials. *CMAJ,* 134: 889-895, 1986.
18. **Guyatt, G.; Walter, S.;** and **Norman, G.:** Measuring change over time: assessing the usefulness of evaluative instruments. *J. Chronic Dis.,* 40: 171-178, 1987.
19. **Guyatt, G. H.; Deyo, R. A.; Charlson, M.; Levine, M. N.;** and **Mitchell, A.:** Responsiveness and validity in health status measurement: a clarification. *J. Clin. Epidemiol.,* 42: 403-408, 1989.
20. **Guyatt, G. H.; Kirshner, B.;** and **Jaeschke, R.:** Measuring health status: what are the necessary measurement properties? *J. Clin. Epidemiol.,* 45: 1341-1345, 1992.
21. **Guyatt, G. H.; Feeny, D. H.;** and **Patrick, D. L.:** Measuring health-related quality of life. *Ann. Intern. Med.,* 118: 622-629, 1993.
22. **Hanley, J. A.,** and **McNeil, B. J.:** The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology,* 143: 29-36, 1982.
23. **Hanley, J. A.,** and **McNeil, B. J.:** A method of comparing the areas under receiver operating characteristic curves derived from the same cases. *Radiology,* 148: 839-843, 1983.
24. **Helmstadter, G. C.:** *Principles of Psychological Measurement.* New York, Appleton-Century-Crofts, 1964.
25. **Juniper, E. F.; Guyatt, G. H.;** and **King, D. R.:** Comparison of methods for selecting items for a disease-specific quality of life questionnaire: importance versus factor analysis. *Qual. Life Res.,* 3: 52-53, 1994.
26. **Kantz, M. E.; Harris, W. J.; Levitsky, K.; Ware, J. E., Jr.;** and **Davies, A. R.:** Methods for assessing condition-specific and generic functional status outcomes after total knee replacement. *Med. Care,* 30 (Supplement 5): MS240-MS252, 1992.
27. **Katz, J. N.; Harris, T. M.; Larson, M. G.; Krushell, R. J.; Brown, C. H.; Fossel, A. H.;** and **Liang, M. H.:** Predictors of functional outcomes after arthroscopic partial meniscectomy. *J. Rheumatol.,* 19: 1938-1942, 1992.

28. **Kirshner, B.,** and **Guyatt, G.:** A methodological framework for assessing health indices. *J. Chronic Dis.*, 38: 27-36, 1985.
29. **Landsman, I. S.; Baum, C. G.; Arnkoff, D. B.; Craig, M. J.; Lynch, I.; Copes, W. S.;** and **Champion, H. R.:** The psychosocial consequences of traumatic injury. *J. Behav. Med.*, 13: 561-581, 1990.
30. **Leiper, C. I.,** and **Craik, R. L.:** Relationships between physical activity and temporal-distance characteristics of walking in elderly women. *Phys. Ther.*, 71: 791-803, 1991.
31. **Lerner, R. K.; Esterhai, J. L., Jr.; Polomono, R. C.; Cheatle, M. C.; Heppenstall, R. B.;** and **Brighton, C. T.:** Psychosocial, functional, and quality of life assessment of patients with posttraumatic fracture nonunion, chronic refractory osteomyelitis, and lower extremity amputation. *Arch. Phys. Med. and Rehab.*, 72: 122-126, 1991.
32. **Liang, M. H.:** Evaluation of function and health status in rheumatic diseases in clinical research and office practice. *Postgrad. Adv. Rheumatol.*, III-VIII: 1-10, 1988.
33. **Liang, M. H.; Fossel, A. H.;** and **Larson, M. G.:** Comparisons of five health status instruments for orthopedic evaluation. *Med. Care*, 28: 632-642, 1990.
34. **Liang, M. H.:** Evaluating measurement responsiveness. *J. Rheumatol.*, 22: 1191-1192, 1995.
35. **Lord, S. R.; Lloyd, D. G.;** and **Li, S. K.:** Sensori-motor function, gait patterns and falls in community-dwelling women. *Age and Ageing*, 25: 292-299, 1996.
36. **McHorney, C. A.:** Methodological and psychometric issues in health status assessment across populations and applications. In *Advances in Medical Sociology.* Vol. 5, pp. 281-304. Greenwich, Connecticut, JAI Press, 1994.
37. **McHorney, C. A.; Ware, J. E., Jr.; Lu, J. F.;** and **Sherbourne, C. D.:** The MOS 36-Item Short-Form Health Survey (SF-36): III. Tests of data quality, scaling assumptions, and reliability across diverse patient groups. *Med. Care*, 32: 40-66, 1994.
38. **McHorney, C. A.,** and **Tarlov, A. R.:** Individual-patient monitoring in clinical practice: are available health status surveys adequate? *Qual. Life Res.*, 4: 293-307, 1995.
39. **MacKenzie, E. J.; Siegel, J. H.; Shapiro, S.; Moody, M.;** and **Smith, R. T.:** Functional recovery and medical costs of trauma: an analysis by type and severity of injury. *J. Trauma*, 28: 281-297, 1988.
40. **MacKenzie, E. J.; Burgess, A. R.; McAndrew, M. P.; Swiontkowski, M. F.; Cushing, B. M.; deLateur, B. J.; Jurkovich, G. J.;** and **Morris, J. A., Jr.:** Patient-oriented functional outcome after unilateral lower extremity fracture. *J. Orthop. Trauma*, 7: 393-401, 1993.
41. **MacKenzie, E. J.; Cushing, B. M.; Jurkovich, G. J.; Morris, J. A., Jr.; Burgess, A. R.; deLateur, B. J.; McAndrew, M. P.;** and **Swiontkowski, M. F.:** Physical impairment and functional outcomes six months after severe lower extremity fractures. *J. Trauma*, 34: 528-539, 1993.
42. **McNeil, B. J.,** and **Hanley, J. A.:** Statistical approaches to the analysis of receiver operating characteristic (ROC) curves. *Med. Decision Making*, 4: 137-150, 1984.
43. **Marks, R.; Quinney, H. A.;** and **Wessel, J.:** Proprioceptive sensibility in women with normal and osteoarthritic knee joints. *Clin. Rheumatol.*, 12: 170-175, 1993.
44. **Martin, D. P.; Engelberg, R.; Agel, J.; Snapp, D.;** and **Swiontkowski, M. F.:** Development of a musculoskeletal extremity health status instrument: the Musculoskeletal Function Assessment instrument. *J. Orthop. Res.*, 14: 173-181, 1996.
45. **Martin, D. P.; Engelberg, R.; Agel, J.;** and **Swiontkowski, M. F.:** Comparison of the Musculoskeletal Function Assessment questionnaire with the Short Form-36, the Western Ontario and McMaster Universities Osteoarthritis Index, and the Sickness Impact Profile health-status measures. *J. Bone and Joint Surg.*, 79-A: 1323-1335, Sept. 1997.
46. **Mathiowetz, V.; Weber, K.; Volland, G.;** and **Kashman, N.:** Reliability and validity of grip and pinch strength evaluations. *J. Hand Surg.*, 9A: 222-226, 1984.
47. **Mathiowetz, V.; Kashman, N.; Volland, G.; Weber, K.; Dowe, M.;** and **Rogers, S.:** Grip and pinch strength: normative data for adults. *Arch. Phys. Med. and Rehab.*, 66: 69-74, 1985.
48. **Maurette, P.; Masson, F.; Nicaud, V.; Cazaugade, M.; Garros, B.; Tiret, L.; Thicoipe, M.;** and **Erny, P.:** Posttraumatic disablement: a prospective study of impairment, disability, and handicap. *J. Trauma*, 33: 728-736, 1992.
49. **Meenan, R. F.; Anderson, J. J.; Kazis, L. E.; Egger, M. J.; Altz-Smith, M.; Samuelson, C. O., Jr.; Willkens, R. F.; Solsky, M. A.; Hayes, S. P.; Blocka, K. L.; Weinstein, A.; Guttadauria, M.; Kaplan, S. B.;** and **Klippel, J.:** Outcome assessment in clinical trials. Evidence for the sensitivity of a health status measure. *Arthrit. and Rheumat.*, 27: 1344-1352, 1984.
50. **Meenan, R. F.; Kazis, L. E.;** and **Anderson, J. J.:** The stability of health status in rheumatoid arthritis: a five-year study of patients with established disease. *Am. J. Pub. Health*, 78: 1484-1487, 1988.
51. **Metz, C. E.:** Basic principles of ROC analysis. *Sem. Nucl. Med.*, 8: 283-298, 1978.
52. **Morris, J. A., Jr.; Sanchez, A. A.; Bass, S. M.;** and **MacKenzie, E. J.:** Trauma patients return to productivity. *J. Trauma*, 31: 827-833, 1991.
53. **Mossberg, K. A.,** and **McFarland, C.:** Initial health status of patients at outpatient physical therapy clinics. *Phys. Ther.*, 75: 1043-1053, 1995.
54. **Mossey, J. M.; Mutran, E.; Knott, K.;** and **Craik, R.:** Determinants of recovery 12 months after hip fracture: the importance of psychosocial factors. *Am. J. Pub. Health*, 79: 279-286, 1989.
55. **Murphy, J. M.; Berwick, D. M.; Weinstein, M. C.; Borus, J. F.; Budman, S. H.;** and **Klerman, G. L.:** Performance of screening and diagnostic tests. Application of receiver operating characteristic analysis. *Arch. Gen. Psychiatry*, 44: 550-555, 1987.
56. **Norkin, C. C.,** and **White, D. J.:** *Measurement of Joint Motion: A Guide to Goniometry.* Ed. 2. Philadelphia, F. A. Davis, 1985.
57. **Nunnally, J. C.:** *Psychometric Theory.* New York, McGraw-Hill, 1978.
58. **Patrick, D. L.; Deyo, R. A.; Atlas, S. J.; Singer, D. E.; Chapin, A.;** and **Keller, R. B.:** Assessing health-related quality of life in patients with sciatica. *Spine*, 20: 1899-1909, 1995.
59. **Perrin, E. B.; Aronson, N. K.; Alonso, J.; Burnam, A.; Lohr, K. H.; Patrick, D. L.;** and **Roberts, J.:** Instrument review criteria. *Med. Outcomes Trust Bull.*, 3: I-IV, 1995.
60. **Pincus, T.,** and **Callahan, L. F.:** Formal education as a marker for increased mortality and morbidity in rheumatoid arthritis. *J. Chronic Dis.*, 38: 973-984, 1985.
61. **Pincus, T.; Callahan, L. F.; Brooks, R. H.; Fuchs, H. A.; Olsen, N. J.;** and **Kaye, J. J.:** Self-report questionnaire scores in rheumatoid arthritis compared with traditional physical, radiographic, and laboratory measures. *Ann. Intern. Med.*, 110: 259-266, 1989.
62. **Richard, R.; Weber, J.; Mejjad, O.; Polin, D.; Dujardin, F.; Pasquis, P.;** and **Le Loet, X.:** Spatiotemporal gait parameters measured using the Bessou gait analyzer in 79 healthy subjects. Influence of age, stature, and gender. *Rev. rhumat., English Ed.*, 62: 105-114, 1995.
63. **Salaffi, F.; Cavalieri, F.; Nolli, M.;** and **Ferraccioli, G.:** Analysis of disability in knee osteoarthritis. Relationship with age and psychological variables but not with radiographic score. *J. Rheumatol.*, 18: 1581-1586, 1991.

64. **Stewart, A. L.; Hays, R. D.;** and **Ware, J. E., Jr.:** The MOS short-form general health survey. Reliability and validity in a patient population. *Med. Care*, 26: 724-735, 1988.
65. **Stewart, A. L.,** and **Ware, J. E., Jr.:** *Measuring Functioning and Well Being: The Medical Outcome Study Approach.* Durham, North Carolina, Duke University Press, 1992.
66. **Straaton, K. V.; Maisiak, R.; Wrigley, J. M.;** and **Fine, P. R.:** Musculoskeletal disability, employment, and rehabilitation. *J. Rheumatol.*, 22: 505-513, 1995.
67. **Tugwell, P.; Bombardier, C.; Buchanan, W. W.; Goldsmith, C.; Grace, E.; Bennett, K. J.; Williams, H. J.; Egger, M.; Alarcon, G. S.; Guttadauria, M.; Yarboro, C.; Polisson, R. P.; Szydlo, L.; Luggen, M. E.; Billingsley, L. M.; Ward, J. R.;** and **Marks, C.:** Methotrexate in rheumatoid arthritis. Impact on quality of life assessed by traditional standard-item and individualized patient preference health status questionnaires. *Arch. Intern. Med.*, 150: 59-62, 1990.
68. **Vida, S.:** A computer program for non-parametric receiver operating characteristic analysis. *Computer Meth. and Prog. Biomed.*, 40: 95-101, 1993.
69. **Wallston, K. A.; Brown, G. K.; Stein, M. J.;** and **Dobbins, C. J.:** Comparing the short and long versions of the Arthritis Impact Measurement Scales. *J. Rheumatol.*, 16: 1105-1109, 1989.
70. **Ware, J. E., Jr.; Snow, K. K.; Kosinski, M.;** and **Gandek, B.:** *SF-36 Health Survey: Manual and Interpretation Guide.* Boston, The Health Institute, New England Medical Center, 1993.
71. **Weinstein, M. C.; Berwick, D. M.; Goldman, P. A.; Murphy, J. M.;** and **Barsky, A. J.:** A comparison of three psychiatric screening tests using receiver operating characteristic (ROC) analysis. *Med. Care,* 27: 593-607, 1989.
72. **Wolfe, F.:** Clinical, laboratory, and radiographic assessments. *Curr. Opin. Rheumatol.*, 5: 138-145, 1993.
73. **Wright, J. G.,** and **Young, N. L.:** The patient-specific index: asking patients what they want. *J. Bone and Joint Surg.*, 79-A: 974-983, July 1997.