ARTHRITIS & RHEUMATISM Volume 38
Number 6, June 1995, pp 795–798

A SELF-ADMINISTERED RHEUMATOID ARTHRITIS DISEASE ACTIVITY INDEX (RADAI) FOR EPIDEMIOLOGIC RESEARCH

Psychometric Properties and Correlation with Parameters of Disease Activity

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Objective. **To examine the psychometric properties and construct validity of a self-administered Rheumatoid Arthritis Disease Activity Index (RADAI).**

Methods. **Five items of the Rapid Assessment of Disease Activity in Rheumatology (RADAR) questionnaire were aggregated into the RADAI and assessed for their factor loading, internal consistency, and construct validity.**

Results. **In 55 patients with RA, the RADAI had a high internal consistency (Cronbach's alpha = 0.91) and correlated with physician's assessment of disease activity ($r = 0.54$, $P < 0.01$), the swollen joint count ($r = 0.54$, $P < 0.01$), and the C-reactive protein value ($r = 0.43$, $P < 0.01$).**

Conclusion. **The RADAI is a highly reliable and valid self-administered measure of disease activity for clinical, health services, and epidemiologic research. Its sensitivity to change in longitudinal studies needs further study.**

Two recent studies (1,2) show that patients with rheumatoid arthritis (RA) are reliable and accurate reporters of their signs and symptoms. Mason et al found high agreement between patients' and clinicians' ratings of a Rapid Assessment of Disease Activity in Rheumatology (RADAR) questionnaire (2). The questionnaire was sensitive to change and complemented the information from physical, social, and mental subscales of the Arthritis Impact Measurement Scales (3). This finding makes it possible to develop a self-administered method of assessing RA disease activity that could be more useful in clinical and epidemiologic research. Whereas for clinical practice reporting of individual items as used in the RADAR is highly informative, for practical and statistical reasons, a global score may be the preferred format in situations in which a face-to-face evaluation may not be possible, such as in clinical, health services, and epidemiologic studies.

In the present study, we sought to construct a self-administered Rheumatoid Arthritis Disease Activity Index (RADAI) that incorporated selected RADAR items and to test its reliability and validity. The specific aims were to 1) study the construct validity and psychometric properties of 5 RADAR items relevant to disease activity; 2) test the internal consistency and construct validity of a 4-item version that omits a question about pain in a series of joints (the most time-consuming item of the RADAR); and 3) test whether the addition of a self-administered articular index of swelling or tenderness in a mannequin format improves the psychometric properties of the instrument.

PATIENTS AND METHODS

Patients. We studied 55 consecutive patients with RA that fulfilled the 1987 classification criteria of the American College of Rheumatology (formerly, the American Rheumatism Association) (4). These patients attended the rheumatology outpatient clinic at the University Hospital Zurich.

Data collection and procedures. At a regularly scheduled visit, patients were asked to complete the self-report

Supported in part by NIH grant AR-36308. Dr. Stucki is a recipient of a fellowship of the Swiss National Science Foundation and grants from the EULAR and the Swiss Associations of Physical Medicine, Rehabilitation, and Rheumatology.

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Submitted for publication August 5, 1994; accepted in revised form January 4, 1995.

Table 1. The Rheumatoid Arthritis Disease Activity Index (RADAI) questionnaire, as derived from the RADAR questionnaire*

RADAI item	Mean ± SD in 55 RA patients
Numerical rating scale questions (0–10 scale)	
1. In general, how active has your arthritis been over the past 6 months?	4.4 ± 2.8
2. In terms of joint tenderness and swelling, how active is your arthritis today?	4.0 ± 2.9
3. How much arthritis pain do you feel today?	4.3 ± 2.9
Likert scale question (0–6 scale)	
4. Were your joints stiff when you woke up today? If yes, how long did this extra stiffness last?	1.5 ± 1.8
no = 0; <30 minutes = 1; 30 minutes to an hour = 2; 1–2 hours = 3; 2–4 hours = 4; >4 hours = 5; all day = 6	
Joint list question (sum score range 0–48; 8 joints or joint groups on both sides of the body, each graded 0–3)	
5. Please indicate the amount of pain you are having today in each of the joint areas listed below	10.8 ± 9.39
None = 0; mild = 1; moderate = 2; severe = 3	
Shoulders, elbows, wrists, fingers, hips, knees, ankles, and toes	

* RADAR = Rapid Assessment of Disease Activity in Rheumatology.

forms. Patients were then evaluated clinically, and laboratory tests were performed.

Measures. Self-report forms included German versions of the RADAR questionnaire (2) and the Physical Function Scale of the Health Assessment Questionnaire (HAQ) (5,6). In addition, patients were asked to mark all joints that were "swollen or tender" on a mannequin drawing, a procedure devised by Stewart et al (1).

The RADAR questionnaire contains 6 questions, 5 of which are relevant to disease activity (or disease process) (Table 1) and 1 to outcome. We did not consider the sixth question about functional limitation for inclusion in the RADAI because functional limitation measures both disease activity and outcome. Four disease activity questions ask about "arthritis activity over the past 6 months," "arthritis activity today," "arthritis pain today," and "morning stiffness today." Because of our patients' difficulty with the visual analog scales used in the original RADAR questionnaire, we used a numerical rating scale (NRS).

The fifth question includes a list of joints or joint groups, and the patients rate their joints according to pain severity (none, mild, moderate, or severe). In contrast to the RADAR questionnaire, we did not ask separately about hand knuckles, finger knuckles, the ball of the foot, and toe knuckles because in pretests, patients had difficulty differentiating hand and finger knuckles and did not understand "ball of foot joints." In the RADAI, patients rate their pain in the shoulders, elbows, wrists, fingers, hips, knees, ankles, and toes. Patients were asked about "pain," rather than about "pain/tenderness" as in the RADAR.

Joint tenderness was assessed separately, with the use of a mannequin (1). Patients were asked to mark "swollen or tender" joints, using the above list plus the metacarpophalangeal, proximal interphalangeal, and metatarsophalangeal joints.

The clinical evaluation, including swollen and tender joint count, grip strength (mean of both sides), and muscle strength (as a Muscle Strength Index [7]), was performed without knowledge of the results of the questionnaires. Laboratory assessment included the erythrocyte sedimentation rate (ESR), levels of C-reactive protein (CRP) and hemoglobin, and rheumatoid factor titer (Singer-Plotz method).

Overall disease activity was determined by the physician's global assessment (using an NRS from 0–10) and by physician-rated pooled indices (using a modified disease activity score [8] and the Mallya index [9]). To compute the modified disease activity score, we used the tender joint count (multiplied by 2) instead of the Ritchie articular index used by Van der Heijde et al (8). It is important to note that our algorithm does not provide the same score as the original disease activity score (8), and thus, it is not possible to directly compare the disease activity of populations characterized by the original (8) and by this modified disease activity score.

Statistical analysis. To study whether the 5 items represent a single underlying construct, we performed a factor analysis. The criterion for determining the number of factors was that the eigenvalue be >1.0. The internal consistency (reliability) of a scale consisting of the disease-related RADAR items was assessed with Cronbach's coefficient alpha. The RADAI was calculated as the mean of the standardized (Z) item scores.

To examine the construct validity of the RADAI, we studied its correlation with clinical and laboratory parameters used in assessing disease activity. Spearman's rank correlation coefficient was used because most variables were not normally distributed or had ordinal characteristics. We postulated that the RADAI would be associated with clinical and laboratory measures of disease activity (activity indices, swollen joint count, CRP, ESR). The RADAI was also compared with the HAQ, which measures a mixture of process and outcome but correlates highly with measures of disease activity (6). In contrast, we expected a weak relationship with hemoglobin and grip strength, which reflect disease activity over a period of time rather than at a given point in time (5,10,11).

To study the effect of omitting the pain rating for individual joints, which is the most time-consuming component of the RADAR questionnaire, we repeated the above analysis for 4 items (the 4 NRS from the RADAR). To examine whether the addition of a self-administered articular index of swelling and the use of a mannequin format increase internal consistency and construct validity, we used the same analytical strategy as outlined above.

RESULTS

We enrolled 55 patients in the study. Their age range was 27–82 years (mean ± SD 60.0 ± 14.6 years); 62% were female, and 63% had graduated from col-

Table 2. Correlation of the RADAR items and the RADAI instrument with clinical and laboratory parameters in 55 patients with RA*

Variable	Percentile values			Correlation with					
				RADAR items					RADAI instrument (mean of standardized [z] item scores)
	25th	50th	75th	Arthritis activity past 6 months	Arthritis activity today	Arthritis pain today	Morning stiffness today	Articular pain index	
Physician's global assessment of disease activity (0–10 scale)	2	3	4	0.40†	0.33‡	0.60†	0.46†	0.52†	0.54†
Modified disease activity score (ref. 8)	1.6	3.1	7.8	0.48†	0.42†	0.35‡	0.49†	0.49†	0.53†
Mallya Index (0–4 scale) (ref. 9)	1.8	2.3	2.7	0.62†	0.56†	0.62†	0.51†	0.48†	0.72†
Swollen joint count (range 0–80)	2	4	9	0.48†	0.47†	0.32‡	0.44†	0.32‡	0.54†
Tender joint count (range 0–68)	1	4	11.5	0.38†	0.33‡	0.27‡	0.42†	0.43†	0.44†
Grip strength (mean of both hands; kP/cm^2)	0.2	0.35	0.56	−0.39†	−0.31‡	−0.27‡	−0.35†	−0.22	−0.39†
Muscle Strength Index (%) (ref. 7)	34	40	51	−0.44†	−0.37†	−0.47†	−0.39†	−0.38†	−0.52†
CRP (mg/dl) (n = 40)	3	12	28	0.38‡	0.38‡	0.43†	0.39†	0.38‡	0.43†
ESR (mm/hour)	8	16	27	0.35†	0.21	0.26	0.03	0.04	0.24
Hemoglobin (mg/dl)	12.3	13.1	14.5	−0.33‡	−0.25	−0.31†	−0.12	−0.17	−0.31‡
Health Assessment Questionnaire (range 0–3) (ref. 5)	0.38	1.31	1.75	0.40†	0.41†	0.5†	0.46†	0.50	0.57†

* RADAR = Rapid Assessment of Disease Activity in Rheumatology; RADAI = Rheumatoid Arthritis Disease Activity Index; CRP = C-reactive protein; ESR = erythrocyte sedimentation rate.
† $P < 0.01$.
‡ $P < 0.05$.

lege or had professional training. All patients were Caucasian. The median disease duration was 5.1 years (25th percentile value 1.3; 75th percentile value 10.7). Ninety-three percent were treated with slow-acting drugs, 44% were taking corticosteroids, and 95% were taking nonsteroidal antiinflammatory drugs.

The results of the RADAI items from the RADAR questionnaire are shown in Table 1. Table 2 shows the correlation of individual RADAR items and the RADAI with clinical and laboratory parameters. As hypothesized, we found a strong association with physician-derived disease activity indices and the HAQ, and a significant, moderate correlation with CRP, whereas there was only a weak association with grip strength and hemoglobin, and a nonsignificant correlation with ESR. Compared with the individual RADAR items, the RADAI showed a higher correlation with most clinical and laboratory measures of disease activity (Table 2).

All items of the RADAI loaded on a single factor, which explained 74% of the variance of the scale items. The correlation between the individual items ranged from 0.42 (between morning stiffness and arthritis activity during the previous 6 months) to 0.90 (between the articular pain index and arthritis activity during the previous 6 months) (Table 3). Cronbach's coefficient alpha was 0.91, which indicates excellent reliability for group comparisons (12).

The internal consistency of a 4-item version omitting the joint list was 0.84, which is very good for group comparisons. The correlation with clinical and laboratory parameters was virtually identical to that of the 5-item RADAI.

The self-administered mannequin-format articular index of swelling or tenderness correlated with the physician-derived swollen joint count (intraclass correlation coefficient = 0.44, $P < 0.01$), the Mallya index (Spearman's r = 0.64, $P < 0.01$), CRP (r = 0.45, $P < 0.01$), and the HAQ (r = 0.58, $P < 0.01$). Agreement between patient and rheumatologist for individual joints or joint groups ranged from 63% (wrist joint) to 88% (elbow joint). However, addition of the self-administered articular index of swelling or tenderness to the 5-item version of the RADAI did not increase the internal consistency of the index ($\alpha = 0.90$) or the correlations with overall disease activity as measured by the physician (r = 0.50, $P < 0.01$), the Mallya Index

Table 3. Correlation among the 5 items of the self-report Rheumatoid Arthritis Disease Activity Index*

	Arthritis activity today	Morning stiffness today	Arthritis pain today	Articular pain index
Arthritis activity over past 6 months	0.76	0.42	0.67	0.90
Arthritis activity today	–	0.54	0.58	0.87
Morning stiffness today	–	–	0.44	0.73
Arthritis pain today	–	–	–	0.77

* All Spearman correlations are significant at $P < 0.01$.

($r = 0.74$, $P < 0.01$), CRP ($r = 0.44$, $P < 0.01$), and the HAQ ($r = 0.58$, $P < 0.01$).

DISCUSSION

This study demonstrates the internal consistency and validity of the RADAI, a self-administered questionnaire (based on 5 questions from the RADAR) that yields an index of rheumatoid arthritis activity. The RADAI and its 5 individual items had a high association with clinically assessed joint synovitis and the acute-phase response, which demonstrates that the RADAI measures disease activity. The high association among the items and the loading of all items on 1 factor indicate that the RADAI is a unidimensional measure of disease activity. In clinical or epidemiologic research, the articular pain index, which is time consuming and adds little or nothing to the measure, can be omitted from the RADAI. In contrast to the RADAR questionnaire, which requires individual analysis and interpretation of items, the RADAI provides a global score. This is advantageous for research purposes because a global score is a more stable estimate of disease activity, reduces sample size requirements, avoids the necessity of multiple comparisons, and can be used in covariate analyses.

When using the RADAI in conjunction with the HAQ, which also includes an assessment of pain, either pain scale can be used. Substituting the HAQ question about overall pain (without reference to arthritis) for the RADAR question about arthritis pain resulted in virtually identical psychometric properties of both the 4-item and the 5-item versions of the RADAI, with virtually identical correlations with clinical and laboratory parameters. Therefore, addition of only 3 items (arthritis activity over the previous 6 months, arthritis activity today, and morning stiffness) to the HAQ questionnaire would allow for calculation of the 4-item version of the RADAI.

Several limitations of the study require comment. First, the study population consisted of mostly well-educated patients from an urban population. Although the RADAR and the RADAI questionnaires performed well in this study group, the metric properties of the RADAI should be tested before using it in dissimilar populations. Second, the RADAI should not be a substitute for an expert clinical evaluation of disease activity in clinical practice. For clinical purposes, even the observed high reliability of 0.91 may not be sufficient to allow for the use of these scores in individual decision-making (12). Tentative addition of a self-administered articular index of joint swelling, which had a high level of agreement with the physician's assessment, did not improve the reliability of the RADAI. Third, although Mason et al have demonstrated the sensitivity of the individual RADAR items (2), it remains to be determined whether the RADAI is responsive to clinically meaningful change in disease activity.

In conclusion, the RADAI is a highly reliable and valid self-administered measure of disease activity for clinical, health services, and epidemiologic research. Its usefulness in longitudinal studies needs further assessment. Since the RADAI is a measure of activity in inflammatory arthritis, it might be useful in other forms of polyarthritis, but this, too, needs testing.

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