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PREDICTORS OF CHANGES IN OBSERVED DEXTERITY DURING ONE YEAR IN PATIENTS WITH RHEUMATOID ARTHRITIS

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SUMMARY

Objective. To determine which disease-related variables predict loss of dexterity in patients with rheumatoid arthritis (RA).

Methods. A random sample of 94 RA patients was measured twice 1 yr apart. Dexterity, or hand-related disability, was measured with the Sequential Occupational Dexterity Assessment (SODA). The SODA measures dexterity in activities of daily life based on the observation of standardized tasks. Impairment of the hands, disease activity, pain and self-reported functioning were additionally assessed.

Results. After 1 yr, observed dexterity was significantly decreased. Change in dexterity was predicted by impairment of the hands at baseline. Changes in dexterity were related to changes in grip strength, disease activity indicators, self-care, depressive mood and cheerful mood. An increase in the number of swollen joints was most strongly correlated with a decrease in dexterity, even after controlling for impairment at baseline.

Conclusion. It was concluded that even in patients with longer disease duration, observed dexterity declines gradually.

KEY WORDS: Rheumatoid arthritis, Dexterity, Activities of daily life, SODA, Hand function.

RHEUMATOID arthritis (RA) is a chronic disease which mainly affects the joints. The joints of the hand and wrist are usually impaired in most patients with RA. This impairment of the hand may result in disability in performing activities of daily life (ADL). This loss of hand-related ability, or dexterity, may result in dependency, one of the most important stressors of the disease [1–3].

An important aim of treatment in RA is the prevention of impairment of the joints in the hand and the resulting disability [4]. Most often, evaluation of treatment of the hand in RA is limited to measurements of certain conventional parameters like range of motion of thumb, fingers and wrist, grip strength, and Larsen score based on radiographic images [5, 6]. These conventional assessments measure impairment of one individual hand. Impairment is defined by the World Health Organization as the consequence of a disease at the organ level. As such, impairment is distinguished from disability: the consequence of the disease on functional performance and activity in daily life [7]. In assessing the impact of RA on the hands, research has shown that conventional measurements are related to, but not identical to, hand function in daily life [6, 8]. For the patient, disability in daily life may be of more importance than the level of impairment [9]. Therefore, the use of standardized tests to evaluate the effect of treatment on ADL is recommended [10].

A number of tests have been developed to measure the functional performance of the hand [11]. Examples are the Jebsen test [12] and the Purdue pegboard test [13]. The Jebsen hand function test is a series of standardized tasks representative of hand functioning in daily life. The Purdue pegboard test measures fine finger motion in manipulating small objects. A major disadvantage of these tests is that they do not measure bimanual dexterity. In most ADL, dexterity depends on the combined action of both hands. Therefore, it is unclear in what way these unimanual tests are related to bimanual ADL. This is especially the case in a symmetrical disease like RA. Because both hands are generally impaired in RA, dexterity in RA should be measured bimanually.

One way to circumvent this problem is to use self-report assessments. A number of scales, like the Arthritis Impact Measurement Scales (AIMS) [14] and the Health Assessment Questionnaire (HAQ) [15], have separate scales to measure dexterity. The problem with these scales is that they do not measure dexterity in controlled conditions. Comparisons cannot be made, especially when it is unclear whether aiding tools are used to perform a certain task. Recently, a new test was developed to measure observed bimanual hand function in ADL under controlled conditions. The Sequential Occupational Dexterity Assessment (SODA) measures hand function in daily life with a set of 12 standardized tasks deemed important for daily life by patients [6, 16].

The aim of this study is to identify those variables which predict changes in dexterity. For this purpose, a group of 94 patients was followed during 1 yr. Impairment of the hand, disease activity, pain, self-reported functioning and dexterity were assessed at the beginning and end of this period. Measurements at the start of the study will be used to predict subsequent changes in dexterity. Finally, changes in dexterity will be related to changes in grip strength, disease activity and self-reported functioning.

MATERIALS AND METHODS

Patients

A group of 109 patients with classic or definitive RA, according to the revised 1987 American

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Rheumatism Association (ARA) criteria [17], were randomly selected from the out-patient departments of the Sint Maartenskliniek and the Department of Rheumatology of the University Hospital in Nijmegen. This study is part of a 4 yr longitudinal study for which we needed complete data from 80 patients for statistical purposes. We estimated that at least 105 patients were needed at entry of the study to reach this number in the final wave of data collection.

After 1 yr, eight patients dropped out of the study for reasons unrelated to the study (two patients died, three patients moved to other parts of the country and three patients refused to cooperate further in the study). Of the remaining 101 patients, seven were excluded from the study because they had undergone hand surgery in between both measurements. As a result, data from 94 patients were available for the study.

Measurements

Demographic variables. For all participants in the study, gender, age and duration of the disease were assessed.

Disease activity. Three variables are used as indicators of disease activity: erythrocyte sedimentation rate (ESR) according to Westergren (mm in 1st h), the number of painful joints and the number of swollen joints. The short 28-joint-count version of the Ritchie score was used. Studies have shown that these three variables are good indicators of general disease activity [18].

Impairment of the hand. For each hand, the range of motion of the joints was assessed [19]. Range of motion of the wrist was assessed by measuring the extension, flexion, pronation, supination, radial and ulnar deviation in grades. Mobility of each finger was assessed by measuring the minimal distance to the middle of the palmar wrist crease. In a similar way, the minimal distance between the thumb and the middle of the first palmar crease of the little finger was measured. For each hand, the number of the following deformities was counted: boutonniere, swan-neck, hand scoliosis, ulnar deviation, deformity of the thumb and median nerve compression. The Jamar dynamometer was used to measure grip strength in kilograms. For each hand, grip strength was measured three times. The average score for each hand is used. Radiographic abnormalities in the hand were assessed according to the Larsen score [20].

Dexterity. Dexterity was measured with the SODA. The SODA measures bimanual functional abilities in ADL. The test is developed to measure differences in dexterity within the RA population. The SODA is a test of 12 standardized tasks which measure dexterity without interference from impairment of the elbow and shoulder. Separate scores for each individual hand are made for six tasks. The therapist rates the performance on the test on 18 scales ranging from 0 (unable to perform the task) to 6 (able to perform the standardized task without difficulty). The range of scores on the SODA is thus 0–108. A higher score means greater dexterity. The SODA was shown to be both reliable and valid. Internal consistency expressed in Cronbach's alpha $= 0.91$; test–retest reliability $r = 0.93$. For a full description of the construction, validity and content of the test, see van Lankveld *et al*. [6]. The 12 tasks of the SODA are described in Table I.

TABLE I
Tasks of the SODA

Writing a sentence
Picking up an envelope
Picking up coins
Holding the receiver of a telephone to one ear
Unscrewing a tube of toothpaste
Squeeze toothpaste on a toothbrush
Handling spoon and knife
Buttoning a blouse
Unscrewing a large bottle
Pouring water in a glass
Washing hands
Drying hands

Self-reported functioning. All patients completed a Dutch health status questionnaire, the 'Invloed van Reuma op Gezondheid en Leefwijze' (IRGL). The IRGL, partly derived from the AIMS [14], measures physical, psychological and social aspects of health status in patients with RA. The reliability and validity of the IRGL scales are satisfactory [21]. The scale 'self-care' is used as a measure of self-reported dexterity.

Pain. Pain was assessed with three measures. In addition to the IRGL pain scale, general pain was also assessed with a visual analogue scale (VAS). Pain was also assessed separately during the performance of SODA. After each task, the patient was asked whether performing this task was painful or not. Summing the number of painful tasks resulted in the SODA pain score (score ranges from 0 to 12).

Procedure

After giving their informed consent, patients were scheduled for sequential visits to a rheumatologist and a research occupational therapist on the same day. Measurements made at the beginning of the study are referred to as baseline measurements. One year after the first assessment, patients were contacted again to be scheduled for a second measurement. Reasons for drop-out were documented.

All measurements were made by the same occupational therapist and rheumatologist. All measurements were made at time 1 and 2, except for range of motion of thumb, fingers and wrist, counting of deformities, and Larsen score. These variables were only assessed at baseline.

Statistical methods

Data were analysed using SPSS statistical procedures. Computations are based on the variables available using pairwise deletion of missing data. To reduce the number of impairment variables in the analyses, the separate measurements for the left and right hand on each impairment variable are summed. Correlations

TABLE II
Baseline characteristics of patients participating in the study (range)

Ratio female/male	63%/37%
Age (yr)	56.34 (20–78)
Duration of the disease	13.33 (1–47)
Ratio right/left-handed	90%/10%
Larsen score	
Left	21.65 (0–92)
Right	22.27 (0–54)
Number of deformities	
Left	0.60 (0–4)
Right	0.69 (0–4)

between measurements of each hand showed a strong symmetry in this sample (range of motion for fingers $0.46 < r < 0.62$; range of motion of wrist $0.63 < r < 0.79$; number of deformities $r = 0.74$; Larsen score $r = 0.89$; grip strength $r = 0.92$). The changes in average score between time 1 and time 2 were tested using two-tailed T-tests for paired samples. Relationships between variables are expressed in Pearson correlations (r). Confidence intervals of 95% are given for significant Pearson correlations. Multiple correlations (MR) were computed using regression analysis.

RESULTS

In Table II, descriptive characteristics of the patients at baseline are given for the 94 patients selected for analysis. Larsen score and number of deformities are given for the right and left hand separately.

Most of the patients in the sample are middle-aged females. Most patients are right-handed. It should be noted that the average duration of the disease in this sample is high. On average, 13 yr have passed since diagnosis.

Table III shows the average scores on ESR, number of painful joints, number of swollen joints, grip strength for each hand separately, SODA, SODA pain, self-reported functioning and general pain at time 1 and 2. Differences between both assessments were tested using T-tests for pairwise comparisons.

The only significant change between time 1 and time 2 was found in observed dexterity. SODA score at baseline is 84.76 (S.D. = 19.57) with a range from 14 to 108. The correlation with SODA score after 1 yr was $r = 0.76$ ($P < 0.001$). The average SODA score fell to 78.45 (S.D. = 20.2). This is a significant decrease in dexterity in 1 yr (mean difference = –6.29, T-test for pairwise comparisons: $T = 4.48$, d.f. = 93, $P < 0.001$). Pairwise comparison of average scores on ESR, number of painful joints, number of swollen joints, grip strength, mobility, self-care, IRGL pain, VAS pain and SODA pain showed that none of these variables changed between the two assessments.

In Table IV, correlations are given between disease-related variables at baseline and SODA at baseline, as well as change in SODA score between both measurements. The first column of Table IV shows Pearson correlations between demographic variables, impairment variables, disease activity, pain, self-reported

TABLE III
Changes in disease-related variables between time 1 and 2 (S.D.)

	Time 1	Time 2
ESR	32.43 (18.02)	31.20 (19.41)
Painful joints	7.35 (6.05)	6.80 (6.16)
Swollen joints	5.80 (5.10)	5.72 (4.04)
Grip strength		
Left	11.00 (9.26)	11.65 (9.01)
Right	11.72 (10.23)	11.58 (9.55)
SODA	84.76 (19.65)	78.45 (20.20)**
SODA pain	3.33 (3.92)	3.60 (3.52)
IRGL mobility	16.66 (6.17)	16.76 (5.98)
IRGL self-care	22.59 (6.23)	22.20 (6.65)
IRGL pain	15.57 (4.21)	15.09 (4.00)
VAS pain	34.63 (24.70)	30.83 (22.16)

**$P < 0.001$.

'self-care' and SODA score at baseline. Confidence intervals at 95% for significant correlations are given in parentheses. The second column shows the correlation between the same variables and change in SODA score. SODA change score was calculated by computing the difference between both SODA scores (SODA2 − SODA1). The distribution of SODA change scores was normal (Kolgoromov–Smirnov goodness of fit test, K-S $Z = 0.59$, $P = 0.87$). A positive score on SODA change reflects an increase in bimanual dexterity. Individual variables within each block of impairment variables, disease activity variables and pain variables are highly intercorrelated. Therefore, MR were computed between these sets of variables and SODA and SODA change.

Dexterity assessed with SODA at baseline is not related to gender or age. Duration of the disease is weakly related to SODA score. Patients with longer disease duration tend to have a lower SODA score. The set of impairment variables is significantly related to SODA at baseline (multiple $R = 0.69$). This means that 48% of the variation on SODA is explained by the impairment measurements of the hands. A high Larsen score, high number of deformities of the hand, and low range of motion of the thumb and fingers are related to poor performance on the SODA. Grip strength and range of motion of the wrist are positively related to SODA score. Multiple regression was performed to determine which impairment variables contributed independently to the variation in SODA score. To this end, all impairment variables were entered in a stepwise regression analysis with SODA as dependent variable. Grip strength, range of motion of thumb and the number of deformities each made an independent contribution to the explanation of variation on SODA (multiple $R = 0.62$).

The number of painful joints is the only indicator of disease activity which is negatively related to SODA. ESR and the number of swollen joints are unrelated to SODA.

Pain was assessed with three different measures. Each pain measure has a negative correlation with SODA score. High levels of pain, either general level

TABLE IV
Correlations between demographic, impairment, disease activity, pain, self-report dexterity assessments at baseline, and SODA at baseline and SODA change. For the last four blocks of variables, multiple correlations are given

	SODA		SODA change	
	r	95% CI	*r*	95% CI
Demographic variables				
Age	0.06		−0.11	
Gender	−0.07		−0.08	
Disease duration	−0.21*	(−0.40, −0.01)	−0.13	
Impairment				
Larsen score	−0.28*	(−0.46, −0.08)	−0.30**	(−0.47, −0.10)
Grip strength	0.46**	(0.29, 0.61)	0.10	
Deformities†	−0.36**	(−0.52, −0.17)	−0.29**	(−0.47, −0.09)
ROM thumb	−0.38**	(−0.54, −0.19)	−0.21*	(−0.40, −0.01)
Index finger	−0.30**	(−0.47, −0.10)	−0.30**	(−0.47, −0.10)
Middle finger	−0.32**	(−0.49, −0.13)	−0.16	
Ring finger	−0.34**	(−0.51, −0.15)	−0.15	
Little finger	−0.37**	(−0.53, −0.18)	−0.15	
ROM wrist				
Extension	0.36**	(0.17, 0.52)	0.09	
Flexion	0.30**	(0.10, 0.47)	0.11	
Abduction	0.36**	(0.17, 0.52)	0.14	
Adduction	0.23*	(0.03, 0.41)	0.12	
Pronation	0.37**	(0.18, 0.53)	0.04	
Supination	0.28**	(0.08, 0.46)	0.07	
Multiple correlation	0.69**		0.53*	
Disease activity				
ESR	−0.04		−0.01	
No. of painful joints	−0.56**	(−0.68, −0.40)	0.06	
No. of swollen joints	−0.05		0.13	
Multiple correlation	0.56**		0.14	
Pain				
Pain (IRGL)	−0.39**	(−0.55, −0.20)	0.24*	(0.04, 0.42)
Pain (VAS)	−0.53**	(−0.66, −0.37)	0.11	
Pain during SODA	−0.54**	(−0.67, −0.38)	0.20*	(0.00, 0.39)
Multiple correlation	0.58**		0.26	
Self-reported dexterity	0.64**	(0.50, 0.75)	−0.09	

$*P < 0.05$; $**P < 0.01$; *r*, Pearson correlation; CI, 95% confidence interval.
†Boutonniere, swan-neck, hand scoliosis, ulnar deviation, deformity of the thumb and median nerve compression.

of pain or pain during SODA, are related to low SODA score. These relationships remained significant after controlling for grip strength, range of motion of thumb and number of deformities (partial correlations: IRGL pain $r = -0.36$, $P < 0.01$; VAS pain $r = -0.42$, $P < 0.01$; pain during SODA $r = -0.52$, $P < 0.01$). Pain during SODA has the strongest partial correlation with SODA score. Pain during SODA was the only pain variable selected in a stepwise regression analysis with SODA as dependent variable controlling for grip strength, range of motion of thumb, and number of deformities (multiple R increase 0.12, $P < 0.001$).

Because the IRGL scale ‘self-care’ measures self-reported dexterity, the strong relationship with SODA ($r = 0.64$) is expectedly high.

Change in SODA score is unrelated to gender, age and duration of disease at baseline. Impairment of the hands at baseline is related to successive change in SODA score (multiple $R = 0.53$, $P < 0.05$). Larsen score, number of deformities, and range of motion of thumb and index finger have significant individual correlations with SODA change score. Grip strength and range of motion of the wrist at baseline are unrelated to SODA change. Stepwise regression analyses were carried out with the individual impairment variables at baseline as independent variables and SODA change as dependent variable. Larsen score, and range of motion of thumb and index finger each made an independent contribution to variation in change in SODA score. Disease activity at baseline, assessed with ESR and number of painful and swollen joints, is unrelated to successive change in SODA score. The multiple correlation of the three pain scores combined on SODA change is not significant. However, two of the three pain measures have weak correlations with successive changes in SODA score. Both general pain measured with the IRGL and SODA pain at baseline are related to an increase in dexterity. When controlling for Larsen score and range of motion of thumb and index finger, these relationships were not significant.

TABLE V
Correlations between changes in disease activity, grip strength, self-report measures and change in SODA score

	SODA T2 – T1	
Changes in	*r*	95% CI
ESR	−0.18	
Number of painful joints	−0.29**	(−0.47, −0.09)
Number of swollen joints	−0.35**	(−0.52, −0.16)
Grip strength	0.24*	(0.04, 0.42)
Self-care	0.24*	(0.04, 0.42)
Pain IRGL	−0.24*	(−0.42, −0.04)
Pain VAS	−0.13	
SODA pain	−0.31**	(−0.48, −0.11)
Depressive mood	−0.24*	(−0.42, −0.04)
Cheerful mood	0.22*	(0.02, 0.41)

*$P < 0.05$; **$P < 0.01$; *r*, Pearson correlation; CI, 95% confidence interval.

In Table V, Pearson correlations are given between change scores in ESR, number of painful joints, number of swollen joints, grip strength, self-care, pain, psychological functioning and change in SODA score. For each variable, change scores were computed by subtracting the score at baseline from the score after 1 yr.

Changes in dexterity assessed with SODA are related to changes in three of the four objective measurements: number of painful joints, number of swollen joints and grip strength. The observed decrease in dexterity is related to an increase in disease activity, measured by the number of painful and swollen joints, and a decrease in grip strength. Partial correlations between changes in observed variables and changes in SODA score were computed controlling for Larsen score, and range of motion of thumb and index finger at baseline. Partial correlations between changes in these four observed variables and change in SODA are significant (ESR −0.23, $P < 0.05$; number of painful joints −0.24, $P < 0.05$; number of swollen joints −0.33, $P < 0.01$; grip strength 0.25, $P < 0.05$). The direction of these partial correlations shows that an increase in disease activity is related to a decrease in SODA score. Additional regression analyses were computed to determine which variable is most strongly related to change in SODA score. Larsen score and range of motion of thumb and index finger at baseline were first entered in the equation with SODA change as dependent variable (multiple $R = 0.48$, $P < 0.01$). Next, change in ESR, number of painful joints, number of swollen joints and grip strength were entered in a stepwise regression. Together, they explained an additional 12% of the variation in SODA change (F change = 3.46, $P < 0.05$). Stepwise selection procedure resulted in the selection of change in number of swollen joints as the sole variable explaining an additional proportion of variation in SODA change (multiple R increase = 0.08, $P < 0.01$).

Changes in SODA are related to changes in a number of self-reported measurements. A decrease in SODA score is related to a decrease in self-reported dexterity assessed with the IRGL scale 'self-care'. Change in SODA score is related to changes in general pain assessed with the IRGL pain scale. The relationship with changes in general pain assessed with the VAS is not significant. A decrease in SODA score is related to an increase in pain during the SODA test. Finally, changes in SODA are related to changes in self-reported psychological functioning. A decrease in SODA is correlated with a decrease in 'cheerful mood' and an increase in 'depressive mood'.

DISCUSSION

The findings in this study show that even within a sample of patients with moderate to long disease duration, there is a slow but marked decrease in dexterity. The observed loss of dexterity is not only statistically significant, but also clinically relevant, amounting to one-third of the standard deviation at baseline.

Duration of disease is only weakly related to dexterity at baseline and unrelated to change in dexterity. Loss of dexterity may thus be apparent in any stage of the disease. It seems, therefore, that even after a prolonged duration of the disease, there may be considerable loss of dexterity.

Impairment of the hands at baseline is related to subsequent loss of dexterity. High Larsen scores and a high number of deformities, as well as impairment of range of motion of thumb and index finger, are related to loss of dexterity. These variables are indicative for damage to the joints due to cumulative disease activity [22]. These findings seem to indicate that patients with an aggressive and destructive disease which has resulted in abnormalities in the hands are more likely to experience further loss of dexterity than patients with less damage to the joints in the hands.

Disease activity does not predict subsequent changes in SODA, but an increase in disease activity does. The average score on ESR, number of swollen joints and number of painful joints in this sample does not change between the two assessments. However, disease activity does vary over time within each patient [23]. Those patients who experience an increase in disease activity are more likely to lose some of their dexterity than patients whose disease activity has decreased or remained equal. Disease activity seems both to determine change in grip strength and change in SODA. The fluctuation of disease activity over time is one of the reasons why not all patients experience loss of dexterity over a period of 1 yr. A minority of patients, 25%, had equal or improved score on the SODA at second assessment compared to the first assessment.

Pain is strongly associated with SODA score at baseline. Both general pain and pain during SODA were related to SODA score. Pain during SODA was more strongly related to SODA after controlling for impairment of the hands than both general pain measures. This might be expected because the SODA score is based on observation of the therapist, and the patient's evaluation of the difficulty of each task. Consequently, the relationship between change in

SODA and change in pain during SODA might also have been expected.

The relationship between SODA change and the changes in self-reported physical and psychological functioning further validate the sensitivity of the SODA. A decrease in SODA score is related to a decrease in 'self-care'. The observed change in dexterity is thus reflected in the self-reported dexterity. The change in SODA score is also related to changes in psychological functioning. A decrease in SODA score is related to a decrease in 'cheerful mood', while 'depressive mood' is increased. These last findings underline the importance of dexterity in ADL activities for the patient's psychological functioning.

The relationship between SODA and impairment of the hands at baseline strongly resembles the relationships reported in other studies using different instruments. The set of variables used to assess the impairment of the hands explained 48% of the variation on SODA. Similar relationships between impairment and dexterity have been reported using different instruments to measure dexterity [8]. Measurements of impairment of both hands explain only ~50% of the variation in dexterity. This means that patients with similar impairment of the hand may vary considerably in their dexterity.

The conclusion of this study is that it is important to measure dexterity in ADL activities. Conventional measures relevant to the separate hand, like range of motion, grip strength and Larsen score, explain only part of the limitations in ADL activities. To the patient, this ADL function of the hands is more important than conventional measures of the hand. In clinical practice, improving the patient's functioning is the most important aim of treatment. Therefore, the SODA may be of assistance in clinical practice to measure the patient's dexterity and evaluate treatment.

Recently, two studies have reported results using measurements of observed hand function in ADL [8, 24]. The observed hand function test [8] and the grip ability test [24] are both short instruments which are easy to use in clinical practice. However, their sensitivity to changes in dexterity in patients is unclear. SODA is relatively easy to administer and is sensitive to change. Therefore, SODA seems to be a good instrument to measure changes in dexterity in evaluation studies. The SODA is currently being used in a study to measure the effect of hand surgery on dexterity. Furthermore, the patients described in this article will be followed longitudinally to investigate the deterioration of dexterity over a number of years.

References

1. van Lankveld W, Näring G, van der Staak C, van 't Pad Bosch P, van de Putte L. Stress caused by rheumatoid arthritis: Relation among subjective stressors of the disease, disease status and well-being. J Behav Med 1993;16:309–21.
2. Cornelissen PGJ, Rasker JJ, Valkenburg HA. The arthritis sufferer and the community: A comparison of arthritis sufferers in rural and urban areas. Ann Rheum Dis 1988;47:150–6.
3. Taal E, Rasker JJ, Seydel ER, Wiegman O. Health status, adherence with health recommendations, self-efficacy and social support in patients with rheumatoid arthritis. Patient Educ Counsel 1993;20:63–76.
4. Souter WA. Planning treatment of the rheumatoid hand. Hand 1979;11:3–16.
5. Badley EM, Wagstaff S, Wood PHN. Measures of functional ability (disability) in arthritis in relation to impairment of range of joint movement. Ann Rheum Dis 1984;43:564–9.
6. van Lankveld W, van 't Pad Bosch P, Bakker J, Terwindt S, Franssen M, van Riel P. Sequential Occupational Dexterity Assessment (SODA): A new test to measure hand disability. J Hand Ther 1996;9:27–32.
7. World Health Organization (WHO). International classification of impairments, disabilities and handicaps. Geneva: WHO, 1980.
8. Vliet Vlieland TPM, van der Wijk TP, Jolie IMM, Zwinderman AH, Hazes JMW. Determinants of hand function in patients with rheumatoid arthritis. J Rheumatol 1996;23:835–40.
9. Gschwend N. Assessment of the functional gain of various operations in the complex hand. Rheumatology 1987;11:80–90.
10. Ewing Fess E. The need for reliability and validity in hand assessment instruments. J Hand Surg 1986;11: 621–3.
11. McPhee SD. Functional hand evaluation: a review. Am J Occup Ther 1987;41:158–63.
12. Jebsen RH, Taylor N, Trieschmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. Arch Phys Med Rehabil 1969;50:311–9.
13. Bass BM, Stucki RE. A note on a modified Purdue pegboard. J Appl Psychol 1951;35:312–3.
14. Meenan RF. The AIMS approach to health status measurement: conceptual background and measurement properties. J Rheumatol 1982;9:785–8.
15. Fries JF, Spitz PW, Kraines RG, Holman HM. Measurement of patient outcome in arthritis. Arthritis Rheum 1980;23:137–45.
16. Bakker J, van Lankveld W, van 't Pad Bosch P. SODA: een instrument voor het meten van de handvaardigheid van RA patiënten (SODA: an instrument to measure dexterity in RA). Ned Tijdschr Ergother 1995;23:39–49.
17. Arnett FC, Edworthy SM, Bloch DA, McShane DJ, Fries JF, Cooper NS *et al.* The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 1988;31:315–24.
18. Prevoo MLL, van 't Hof MA, Kuper HH, van Leeuwen MA, van de Putte LBA, van Riel PLCM. Modified disease activity scores that include twenty-eight-joint-counts: development and validation in a prospective longitudinal study of patients with rheumatoid arthritis. Arthritis Rheum 1995;38:44–8.
19. Gerhardt JJ, Rippstein J. Measuring and recording of joint motion: instrumentation and techniques. Toronto: Hogrefe and Huber, 1990.
20. Larsen A, Dale K, Eek M. Radiographic evaluation of rheumatoid arthritis and related conditions by standard reference films. Acta Radiol Diagn (Stockh) 1977;18: 481–91.
21. Huiskes CJAE, Kraaimaat FW, Bijlsma JWJ. Development of a self-report questionnaire to assess the impact of rheumatic diseases on health and lifestyle. J Rehabil Sci 1990;3:65–70.

22. van Riel P, van Lankveld W. Quality of life in rheumatoid arthritis: A review. Pharm World Sci 1993;15:93–7.
23. Geenen R, Jacobs JWG, Godaert G, Kraaimaat FW, Brons MR, van der Heide A *et al*. Stability of health status measurement in rheumatoid arthritis. Br J Rheumatol 1995;34:1162–6.
24. Dellhag B, Bjelle A. A grip ability test for use in rheumatology practice. J Rheumatol 1995;22:1559–65.