Clinimetric Evaluation of the Bath Ankylosing Spondylitis Metrology Index in a Controlled Trial of Pamidronate Therapy

EDWIN JAUREGUI, BARBARA CONNER-SPADY, ANTHONY S. RUSSELL, and WALTER P. MAKSYMOWYCH

ABSTRACT. ***Objective.*** The Bath Ankylosing Spondylitis Metrology Index (BASMI) is an index comprising 5 measures of spinal and hip mobility in AS that has been primarily validated in the setting of a physiotherapeutic intervention and has not been validated in relation to functional outcomes. Our aim was to validate the BASMI and its individual components in relation to a validated functional index, the Bath AS Functional Index (BASFI), and to assess its responsiveness in patients with AS receiving 60 or 10 mg pamidronate monthly for 6 months in a double blind, randomized, controlled trial.

Methods. AS patients were assessed with the BASMI and BASFI at baseline and 6 months. Two versions of the BASMI were evaluated: the original scoring was based on a 0–2 score for each measure, while a newer version scores each measure on a 0–10 scale. Paired t tests, effect sizes (ES; mean difference divided by baseline standard deviation), and standardized response means (SRM; mean difference divided by standard deviation of the difference) were used to assess responsiveness. A value > 0.5 was considered to reflect good responsiveness. Responsiveness was also examined by linear regression analysis adjusting for age, sex, disease duration, and baseline Bath AS Disease Activity Index (BASDAI) and BASFI. The contribution of the BASMI to the variance in the BASFI was assessed by hierarchical linear regression analysis, independent variables being entered in the following order: (1) age, sex, disease duration; (2) drug dose group; (3) baseline or change in the BASDAI; and (4) change in the BASMI. Pearson correlation coefficient analysis was also performed to examine the contribution of individual measures of the BASMI. A value > 0.6 was defined as indicative of a good correlation.

Results. Seventy AS patients completed 6 months of therapy [81% male, mean age 40.3 yrs (SD 9.7), disease duration 15 yrs (SD 9.5)]. The responsiveness of the BASMI was poor regardless of which version of the BASMI was used (ES = 0.26, SRM = 0.47 for the 60 mg dose group and using a 0–10 scoring system). Examination of the responsiveness of the individual components of the BASMI revealed significance for lumbar side flexion in the 60 mg dosing group (ES = 0.4, SRM = 0.43; p = 0.01) using the newer version of the BASMI (0–10 scoring) that was of similar responsiveness to the entire BASMI. Linear regression analysis showed no significant effects of age, sex, disease duration, baseline BASFI and BASDAI, or drug dose group on BASMI change scored using a 0–2 grading, but drug dose group had a significant effect on BASMI change scored using a 0–10 grading (p = 0.04). The correlation between changes in the BASMI and the BASFI was low, although significant when either version of the BASMI was examined (0.44 and 0.46 for the 0–2 and 0–10 scoring systems, respectively; p < 0.001). Of the individual components of the BASMI, a significant association was observed between changes in either cervical rotation or lumbar side flexion and changes in the BASFI (0.44 and 0.37, respectively; p < 0.01). After adjusting for age, sex, disease duration, the baseline BASDAI, and drug dose group, the BASMI added significantly to the variance in the BASFI (p < 0.001), but this was no longer significant once change in the BASDAI was added to the regression model.

Conclusion. Responsiveness of the BASMI was poor with either scoring system. Lumbar side flexion was the most responsive of the BASMI components. Changes in the BASMI and its individual components did not correlate well with changes in functional outcomes. (J Rheumatol 2004;31:2422–8)

Key Indexing Terms:
SPINAL MOBILITY RESPONSIVENESS ANKYLOSING SPONDYLITIS PAMIDRONATE

From the Department of Medicine, University of Alberta, Edmonton, Alberta, Canada.

Dr. Maksymowych is a Senior Scholar of the Alberta Heritage Foundation for Medical Research.

E. Jaurequi, MD, Rheumatologist; B. Conner-Spady, PhD, Biostatistician; A.S. Russell, FRCPC, Professor of Medicine; W.P. Maksymowych, FRCPC, Professor of Medicine, Department of Medicine, University of Alberta.

Address reprint requests to Dr. W.P. Maksymowych, 562 Heritage Medical Research Centre, University of Alberta, Edmonton, Alberta T6G 2S2. Email: walter.maksymowych@ualberta.ca

Submitted July 9, 2003; revision accepted June 21, 2004.

Measurement of spinal mobility has been proposed both for clinical record keeping in the routine followup of patients with ankylosing spondylitis (AS) and for the assessment of disease-controlling therapies for AS by the Assessments in AS Working Group (ASAS)[1]. Further, the spinal mobility domain together with acute phase reactants have been proposed as the 2 domains that distinguish the criteria for disease-controlling from symptom-modifying therapies. Yet comparatively few studies have validated the various spinal mobility measures reported in the literature according to the recommendations of the OMERACT filter (truth, feasibility, discrimination)[2], particularly in response to pharmacological interventions. Discrimination between disease states is a function of both reproducibility and responsiveness to change. Although several reports have examined the reliability of measures of spinal mobility, further studies are required to determine which measures are most responsive to change.

The Bath AS Metrology Index (BASMI) is a validated composite index of spinal and hip mobility comprising measures of cervical rotation, tragus-to-wall distance, lumbar spinal forward and side flexion, and hip abduction[3]. Intra- and interobserver reliability was noted to be high (> 0.95) for all the items of this index in both the original report from Bath as well as our own evaluation of this instrument[4]. Responsiveness was initially assessed in inpatients with AS attending a 3-week physiotherapy program[3], and since then it has been employed in 2 controlled trials evaluating infliximab in spondyloarthritis[5,6]. Significant change in the infliximab active treatment group was evident in one trial enrolling 70 patients with AS as early as 2 weeks into the study[5], while in the second infliximab trial, which enrolled 40 patients with a variety of spondyloarthropathies, no significant change was noted in the active treatment group over the course of the 12-week study[6]. The experience with this index in the assessment of pharmacological therapies is, therefore, somewhat limited.

Some of the measures making up the index might be expected to have limited sensitivity to change. These include tragus-to-wall distance, which may strongly reflect irreversible structural damage, and the modified Schober test, which has shown limited sensitivity to change in studies of physiotherapeutic interventions[7]. In addition, intra- and interobserver reproducibility has been modest when the modified Schober test has been examined at different centers, further compromising its sensitivity to change[8]. Responsiveness may be further limited by the use of a graded scoring system for measures making up the BASMI index rather than absolute values. The original version of the BASMI proposed a 0–2 grading system while a subsequent report described a 0–10 grading system[3,9]. Nevertheless, the ASAS has recommended the measurement of occiput-to-wall distance *and* the modified Schober test *and* chest expansion as the specific instruments that should be used to assess spinal mobility[1].

The BASMI was included as one of the secondary outcomes in a recent double blind, randomized, controlled, dose-response evaluation of a bisphosphonate, pamidronate, in patients with AS refractory to nonsteroidal antiinflammatory drugs[10]. In the latter study, patients with AS were randomized to receive either 60 or 10 mg pamidronate by monthly intravenous infusion for 6 months. Primary and secondary outcomes were assessed at baseline, 3 months, and 6 months. At 6 months, the mean Bath AS Disease Activity Index (BASDAI) had decreased significantly by 34.5% in the 60 mg group as compared to 15% in the 10 mg group, although there was no effect of treatment on peripheral pain (item 3 of the BASDAI) and on acute phase reactants. Significantly greater reductions were also noted in the 60 mg group for the Bath AS Functional Index (BASFI) and the BASMI. One objective of this study was, therefore, to assess the responsiveness of the BASMI index. A second objective was to examine the responsiveness of individual measures of the BASMI index to facilitate the development of a more responsive measure of spinal mobility. A third objective was to examine the extent to which change in the BASMI is associated with change in function as measured by a validated instrument, the BASFI. The clinical relevance of a metrology index whose variance has a poor correlation with functional change could be open to question.

MATERIALS AND METHODS

Patients. The patient sample consisted of 70 individuals with AS (81% male) with complete BASMI and BASFI data at baseline and 6 months of pamidronate therapy. This was a randomized, double blinded study in which patients were randomized to receive either 60 mg or 10 mg of pamidronate given intravenously on a monthly basis for 6 months[10]. Thirty-six received 60 mg and 34 received 10 mg pamidronate. The mean age was 40.3 years (SD 9.7) and disease duration was 15 years (SD 9.5).

Outcome assessments. Each of the measures of the BASMI were coded in 2 ways based on the original and a subsequently newer version of the scoring system described by Jenkins, *et al*[3,9]. In the original version of the BASMI[3], each measure was scored on a scale of zero (mild) to 2 (severe), giving a total score from 0 to 10. In the subsequent version of the BASMI[9], each measure was scored on a score of zero (mild) to 10 (severe), giving a total score of 100 from which a mean score of 0–10 was calculated.

Statistics. Descriptive statistics (mean, standard deviation, minimum and maximum, and box plot distribution with 25th and 75th centiles) for each parameter of the BASMI were calculated. The significance of changes from baseline in each measure was assessed by the paired t test. Responsiveness of each measure was determined by calculating both the effect size (ES) and the standardized response mean (SRM). The ES was calculated as the mean difference from baseline to 6 months divided by the standard deviation at baseline[11,12,13]. The SRM was calculated as the mean difference from baseline to 6 months divided by the standard deviation of the difference. T tests for independent means and chi-square analysis were used to test for baseline differences between the 2 drug dose groups. Linear regression analysis was used to test for the effects of baseline variables on change in the BASMI. Age, sex, disease duration, baseline BASFI, baseline BASDAI, and drug dose group were simultaneously entered as independent variables and BASMI change was entered as the dependent variable.

The correlation between changes in the BASFI and changes in either the BASMI or its individual components was calculated using the Pearson correlation coefficient (PCC; 2-tailed test). The contribution of the BASMI

and its individual components to the variance in the BASFI was also assessed by hierarchical (sequential) linear regression analysis, a technique used to order the entry of independent variables based on the purpose and logic of the research[14]. The incremental proportion of variance in the dependent variable (R^2 change) is accounted for by a given independent variable or set of independent variables, beyond what has been accounted for by prior sets. We tested if the BASMI change (0–6 months) would significantly explain the BASFI change (0–6 months) beyond that accounted for by age, sex, disease duration, drug dose group, and both the baseline and the change in the BASDAI. We entered the baseline BASDAI and the change in the BASDAI in 2 separate regression analyses. The order of entry of the independent variables was: (1) age, sex, and disease duration; (2) drug dose group; (3) BASDAI baseline/change; and (4) BASMI change. A p value less than 0.05 was considered statistically significant. P values are presented uncorrected for multiple comparisons.

RESULTS

T tests showed no difference between the drug dose groups for age, disease duration, BASDAI, BASFI, or BASMI. A chi-square analysis showed no significant difference in sex between the 2 drug dose groups. Figure 1 shows the box plot distribution of the 5 components of the BASMI at baseline and 6 months (n = 70). A broad range of scores for lumbar flexion, cervical rotation, and lumbar side flexion is evident at both timepoints. There was relatively little variation in the tragus-to-wall and intermalleolar distance scores. Table 1 shows that relatively few patients had severe scores according to the original version of the BASMI. There was a higher percentage of patients with severe scores in the 10 mg dose group, although differences from the 60 mg dose group were not statistically significant (data not shown). The scores for the 2 versions of the BASMI correlated significantly with each other at baseline (PCC = 0.95, $p < 0.001$) and at 6 months (PCC = 0.96, $p < 0.001$). Change scores were also significantly correlated (PCC = 0.67, $p < 0.001$).

Despite a significant improvement in the BASMI in those patients receiving the 60 mg dose, the responsiveness of the BASMI was poor, regardless of which version of the BASMI was employed (Table 2). Examination of the responsiveness of the individual components of the BASMI revealed significance for lumbar side flexion in the 60 mg dosing group using the newer version of the BASMI (0–10 scoring) that was of similar responsiveness to the entire BASMI (Table 3). The intermalleolar distance also showed limited responsiveness, as defined by the SRM but not the ES. Significant responsiveness was not evident for any individual components of the BASMI when examined using the original version of the BASMI (0–2 scoring). Linear regression analysis showed no significant effects of age, sex, disease duration, baseline BASFI and BASDAI, or drug dose group on BASMI change scored using 0–2 grading, but drug dose group had a significant effect on BASMI change scored using 0–10 grading (p = 0.04).

Correlation between the BASMI and BASFI at baseline was 0.43. A significant correlation was noted between changes in the BASFI and changes in the BASMI using either the 0–2 (PCC = 0.44, $p < 0.001$) or the 0–10 (PCC = 0.46, $p < 0.001$) scoring system. Correlations were similar in each dosing group (data not shown). All of the BASMI components correlated significantly with the BASFI except for tragus-to-wall distance, with correlation coefficients ranging from 0.24 for the tragus-to-wall distance to 0.46 for the intermalleolar distance. Table 4 shows correlations between changes in the BASFI and changes in the individual components of the BASMI based on the newer version of the BASMI (0–10 scoring). A significant association was observed between changes in either cervical rotation or lumbar side flexion and changes in the BASFI, although this was not consistently observed in each dosing group. Changes in these 2 spinal mobility measures were also significantly correlated with each other.

After adjusting for age, sex, disease duration, the baseline BASDAI, and drug dose group, the BASMI added significantly to the regression model (R^2 change = 0.14, $p < 0.001$). The multiple R is the measure of association between the dependent variable and the optimal linear combination of the independent variables, while the R^2 is the proportion of the variance in the dependent variable that is accounted for by the optimally weighted independent variables. After Step 2, the drug dose group added significantly to the model (R^2 change = 0.13, p = 0.002). After Step 4, with all independent variables in the equation, R = 0.56, $p < 0.001$. In the final model, significant predictors of the BASFI change were drug dose group and the BASMI change. These accounted for approximately 25% of the variance in the BASFI change from baseline to 6 months (R^2 = 0.31, adjusted R^2 = 0.25).

When baseline BASDAI was substituted by change in the BASDAI, the BASMI did not add significantly to the regression model (R^2 change = 0.01, p = 0.126). Drug dose group (Step 2) and BASDAI change (Step 3) added significantly to the model (R^2 change = 0.15, $p < 0.001$, and R^2 change = 0.48, $p < 0.001$, respectively). After Step 4, with all independent variables in the equation, R = 0.81, $p < 0.001$. In the final model, the only significant predictor of BASFI change was BASDAI change. This accounted for approximately 62% of the variance in the BASFI change from baseline to 6 months (R^2 = 0.66, adjusted R^2 = 0.62).

DISCUSSION

Our data show that the responsiveness of the BASMI over a period of 6 months in patients receiving monthly intravenous pamidronate is low regardless of the scoring system, and can be largely accounted for by changes in lumbar side flexion. Further, changes in the BASMI accounted for only a small portion of the variance in the BASFI. Of the specific components making up the BASMI, only changes in cervical rotation and lumbar side flexion correlated with changes in the BASFI.

There are several potential reasons for the low responsiveness of the BASMI in this particular trial. Trial related

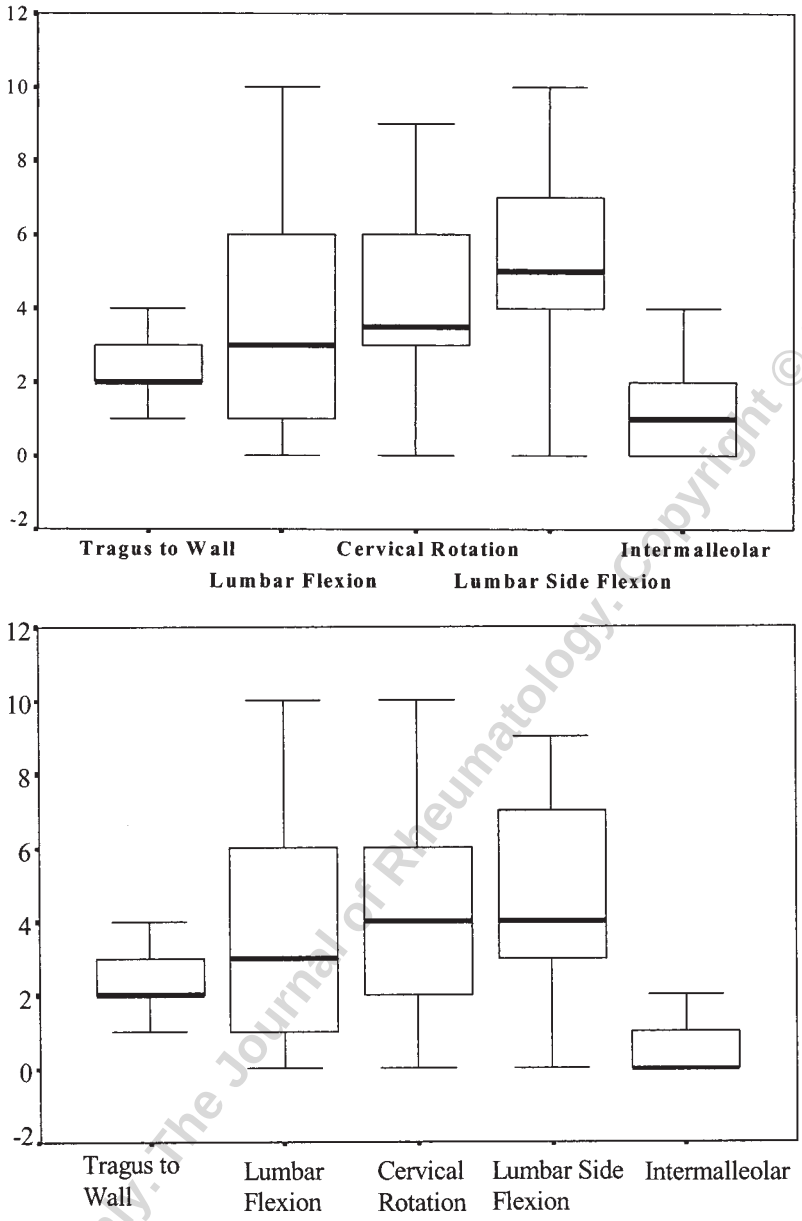

Figure 1. Distribution of the 5 components of the BASMI at baseline and at 6 months (n = 70). A. Distribution of BASMI measures at baseline (0–10 scoring). B. Distribution of BASMI measures at 6 months (0–10 scoring).

Table 1. Frequencies of BASMI item scores (graded 0 to 2) at baseline.

	BASMI SCORE					
	0 (mild)		1 (moderate)		2 (severe)	
	Count	%	Count	%	Count	%
Tragus to wall	47	67.1	22	31.4	1	1.4
Lumbar flexion	42	60.0	20	28.6	8	11.4
Cervical rotation	15	21.4	47	67.1	8	11.4
Lumbar side flexion	35	50.0	24	34.3	11	15.7
Intermalleolar	58	82.9	12	17.1	0	0

Table 2. Effect sizes (ES) and standardized response means (SRM) for original (0–2 scoring) and new (0–10 scoring) versions of the BASMI in AS patients receiving either 60 mg or 10 mg monthly for 6 months.

	Protocol	Minimum Difference	Maximum Difference	Mean Difference	SD Difference	SD Base	ES	SRM
0–10 scoring	60 mg	–1.2	2	0.33	0.72	1.28	0.26	0.47
	10 mg	–1	0.8	0.05	0.51	2.01	0.02	0.09
0–2 scoring	60 mg	–1	3	0.42	1.00	1.68	0.25	0.42
	10 mg	–2	2	0.06	0.81	2.54	0.02	0.07

SD: standard deviation, ES: defined as mean difference divided by baseline standard deviation, SRM: defined as mean difference divided by standard deviation of mean difference.

Table 3A. Responsiveness of the individual components of the BASMI measured by a 0–10 scoring system in AS patients receiving either 60 mg (n = 36) or 10 mg (n = 34) pamidronate monthly for 6 months.

Protocol	BASMI Component	Mean Difference	t Ratio	p Value (2 tailed)	SD Baseline	ES	SRM
60 mg	Tragus to wall	0.00	0.00	1.00	1.19	0.00	0.00
	Lumbar flexion	0.33	1.09	0.28	2.79	0.12	0.18
	Cervical rotation	0.33	1.41	0.17	1.93	0.17	0.23
	Lumbar side flexion	0.72	2.60	0.01	1.80	0.40	0.43
	Intermalleolar	0.28	2.05	0.05	1.35	0.21	0.34
10 mg	Tragus to wall	0.00	0.00	1.00	1.90	0.00	0.00
	Lumbar flexion	0.18	0.70	0.49	3.05	0.06	0.12
	Cervical rotation	–0.32	–1.64	0.11	3.02	–0.11	–0.28
	Lumbar side flexion	0.09	0.50	0.62	2.81	0.03	0.09
	Intermalleolar distance	0.32	3.20	0.00	1.63	0.20	0.54

ES: Effect size, SRM: Standardized response mean, SD: Standard deviation.

Table 3B. Responsiveness of the individual components of the BASMI as measured by a 0–2 scoring system in AS patients receiving either 60 mg (n = 36) or 10 mg (n = 34) pamidronate monthly for 6 months.

Protocol	BASMI Component	Mean Difference	SD	SD Baseline	ES	SRM
60 mg	Tragus to wall	0.03	0.17	0.44	0.06	0.17
	Lumbar flexion	0.08	0.44	0.61	0.14	0.19
	Cervical rotation	0.08	0.44	0.42	0.20	0.19
	Lumbar side flexion	0.17	0.65	0.65	0.26	0.25
	Intermalleolar distance	0.06	0.23	0.32	0.17	0.24
10 mg	Tragus to wall	0.00	0.00	0.56	0.00	0.00
	Lumbar flexion	0.03	0.39	0.79	0.04	0.08
	Cervical rotation	–0.06	0.42	0.69	–0.08	–0.14
	Lumbar side flexion	0.06	0.34	0.83	0.07	0.17
	Intermalleolar distance	0.03	0.17	0.43	0.07	0.17

factors include the long duration of disease with established, and presumably irreversible, structural damage, and the relatively small sample size. The relative efficacy of this treatment approach, particularly in comparison to anti-tumor necrosis factor-directed therapies, also needs to be established. One open-label study of a hospitalized group of AS patients with mean disease duration of 20 years suggested that this approach may be less effective than noted in our study[15]. Although the symptomatic benefit is consistent with the benefits described in patients with malignant metastases to bone, the mechanism remains unexplained[16]. Consequently, the benefits noted in AS may not reflect alleviation of inflammation and effects on spinal mobility may therefore be limited.

Tables 2 and 3 show that both scoring systems for the BASMI show similar responsiveness, but the individual components tend to be more responsive with the 0–10 scoring system, particularly with respect to lumbar side flexion. It is not altogether surprising that the most responsive measures of spinal mobility contributed most to the variance in the BASFI. However, the overall contribution of changes in the BASMI to the variance in the BASFI was small, high-

Table 4. Pearson correlations between changes in the BASFI and changes in the individual components of the BASMI (0–10 scoring) in AS patients treated with either 60 mg or 10 mg of pamidronate monthly for 6 months.

Protocol	BASMI Component	BASFI Δ	TTW Δ	LF Δ	CR Δ	LSF Δ
60 mg (n = 36)	TTW Δ	0.19				
	LF Δ	0.08	0.21			
	CR Δ	0.57**	0.31	0.04		
	LSF Δ	0.24	0.20	0.04	0.38*	
	IMD Δ	0.28	–0.12	0.22	–0.21	–0.03
10 mg (n = 34)	TTW Δ	0.25				
	LF Δ	0.00	0.06			
	CR Δ	0.09	0.08	–0.13		
	LSF Δ	0.49**	0.00	0.03	0.36*	1.00
	IMD Δ	0.19	0.15	–0.07	0.34*	0.25

** Correlation is significant at the 0.01 level (2 tailed). * Correlation is significant at the 0.05 level (2 tailed). TTW: tragus to wall, LF: modified Schober's, CR: cervical rotation, LSF: lumbar side flexion, IMD: intermalleolar distance.

lighting the importance of additional variables influencing the BASFI, such as active inflammation and psychosocial factors. The BASMI was designed to provide a feasible, readily reproducible, and standardized approach to spinal and hip mobility assessment. Its sensitivity to change was addressed following a 3-week intensive course of inpatient physiotherapy[3]. However, a previous study of intensive inpatient physiotherapy over 3 weeks showed that chest expansion, fingertip to floor distance, lumbar flexion, and cervical rotation were most responsive to change[17], while a second study that also examined mobility measures following physiotherapy also concurred with these findings, adding lateral lumbar spinal flexion, hip internal rotation, and thoracolumbar rotation to the measures most responsive to treatment[7]. Lumbar flexion and occiput–wall distance were not considered responsive in this latter study. According to these 2 studies, the BASMI does not include 2 measurements, fingertip to floor distance and chest expansion, that are most responsive to change. On the other hand, studies have shown that the intra- and interobserver reproducibility of chest expansion and fingertip to floor distance measurements are poor[18-20]. The poor reliability of chest expansion likely reflects both a lack of standardization, measurements being taken variably at either the fourth intercostal space or at the xiphisternum, and the difficulties in measuring chest expansion in women. These latter single-center studies showed that the most reliable measures of spinal mobility are cervical rotation, cervical lateral flexion, tragus-to-wall distance, lateral flexion, and modified Schober test. A multicenter study showed that while the reliability of chest expansion and occiput-to-wall distance was high, the reliability of the modified Schober test was inadequate[8]. Additional studies have also demonstrated the responsiveness of cervical spinal mobility assessment in patients undergoing physiotherapy intervention[21,22].

Several studies have examined the responsiveness of various spinal mobility measures following pharmacological interventions. In one study, responsiveness was most evident with fingertip to floor distance in AS patients with 16 years' disease duration receiving ACTH for 2 months[23]. Most other studies have evaluated salazopyrin and generally shown no treatment-group differences with placebo for measures such as the modified Schober test and chest expansion[24-28]. The mean disease duration of patients enrolled in these trials was over 10 years. One study examined salazopyrin after 26 weeks of therapy in AS patients with 4 years' mean disease duration and noted significant improvement in chest expansion[29]. Four placebo controlled trials have now reported the effects of anti-tumor necrosis factor-directed therapies in spondyloarthritis. One 12-week study of infliximab in AS reported significant change in the BASMI as early as 2 weeks after the start of therapy[6], lateral flexion being the most responsive measure, while a second trial that enrolled patients with different subtypes of spondyloarthritis did not observe significant improvement in the BASMI after 12 weeks[5]. In the first placebo controlled trial of etanercept in AS, which recruited 40 patients, a significant improvement in chest expansion, but not the modified Schober test or the occiput-to-wall distance, was evident at 4 months[30]. In a second controlled trial of etanercept in AS that recruited 277 patients, significant improvement was noted in chest expansion, modified Schober test, and occiput-to-wall distance at 24 weeks, but this study did not evaluate the responsiveness of the BASMI[31].

Our work, and that of others, suggests that the BASMI may not be the most responsive spinal mobility index for relatively short term trials. Responsiveness could be improved by using the newer version of the BASMI that incorporates a 0–10 rather than a 0–2 scoring system. Lumbar side flexion is the most responsive component of the BASMI and reflects functional change better than the other components of the BASMI. Two of the 3 mobility measures recommended by the ASAS Working Group, occiput-to-wall distance and the modified Schober test, lack responsiveness.

REFERENCES

1. Van der Heijde D, Calin A, Dougados M, Khan MA, van der Linden S, Bellamy N. Selection of instruments in the core set for DC-ART, SMARD, physical therapy, and clinical record keeping in ankylosing spondylitis. Progress report of the ASAS Working Group. J Rheumatol 1999;26:951-4.
2. Bellamy N. Clinimetric concepts in outcome assessment: The OMERACT filter. J Rheumatol 1999;26:948-50.
3. Jenkinson TR, Mallorie PA, Whitelock HC, Kennedy LG, Garrett SL, Calin A. Defining spinal mobility in ankylosing spondylitis (AS). The Bath AS Metrology Index. J Rheumatol 1994;21:1694-8.
4. Chung C, Jauregui E, Spady B, Mallon C, Russell AS, Maksymowych WP. The Edmonton Ankylosing Spondylitis Metrology Index (EDASMI): Validation of a new composite index of spinal and hip mobility [abstract]. Arthritis Rheum 2003;48 Suppl:S176.
5. Van den Bosch F, Kruithof E, Baeten D, et al. Randomised double-blind comparison of chimeric monoclonal antibody to tumor necrosis factor a (infliximab) versus placebo in active spondyloarthropathy. Arthritis Rheum 2002;46:755-65.
6. Braun J, Brandt J, Listing J, et al. Treatment of active ankylosing spondylitis with infliximab: a randomized controlled multicentre trial. Lancet 2002;359:1187-93.
7. Heikkila S, Viitanen JV, Kautiainen H, Kauppi M. Sensitivity to change of mobility tests; effect of short term intensive physiotherapy and exercise on spinal, hip, and shoulder measurements in spondyloarthropathy. J Rheumatol 2000;27:1251-6.
8. Auleley GR, Benbouazza K, Spoorenberg A, et al. Evaluation of the smallest detectable difference in outcome or process variables in ankylosing spondylitis. Arthritis Rheum 2002;47:582-7.
9. Jones SD, Porter J, Garrett SL, Kennedy LG, Whitelock H, Calin A. A new scoring system for the Bath Ankylosing Spondylitis Metrology Index (BASMI) [letter]. J Rheumatol 1995;22:1609.
10. Maksymowych WP, Jhangri GS, Fitzgerald A, et al. A six-month randomized, controlled, double-blinded, dose response comparison of intravenous pamidronate (60 mg versus 10 mg) in the treatment of NSAID-refractory ankylosing spondylitis. Arthritis Rheum 2002;46:766-82.
11. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.
12. Husted JA, Cook RJ, Farewell VT, Gladman DD. Methods for assessing responsiveness: a critical review and recommendations. J Clin Epidemiol 2000;53:459-68.
13. Anderson JJ, Chernoff MC. Sensitivity to change of rheumatoid arthritis clinical trial outcome measures. J Rheumatol 1993;20:535-7.
14. Cohen J, Cohen P. Applied multiple regression/correlation analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1983.
15. Haibel H, Brandt J, Rudwaleit M, Sorensen H, Sieper J, Braun J. Treatment of active ankylosing spondylitis with pamidronate. Rheumatology Oxford 2003;42:1018-20.
16. Terpos E, Palermos J, Tsionos K, et al. Effect of pamidronate administration on markers of bone turnover and disease activity in multiple myeloma. Eur J Haematol 2003;71:471-2.
17. Roberts WN, Larson MG, Liang MH, Harrison RA, Barefoot J, Clarke AK. Sensitivity of anthropometric techniques for clinical trials in ankylosing spondylitis. Br J Rheumatol 1989;28:40-5.
18. Pile KD, Laurent MR, Salmond CE, Best MJ, Pyle EA, Moloney RO. Clinical assessment of ankylosing spondylitis: a study of observer variation in spinal measurements. Br J Rheumatol 1991;30:29-34.
19. Viitanen JV, Kokko M-L, Lehtinen K, Suni J, Kautiainen H. Correlation between mobility restrictions and radiological changes in ankylosing spondylitis. Spine 1995;20:492-6.
20. Gauvin M, Riddle D, Rothstein J. Reliability of clinical measurements of forward bending using the modified finger-to-floor method. Phys Ther 1990;70:443-7.
21. O'Driscoll SL, Jayson MIV, Baddeley H. Neck movements in ankylosing spondylitis and their responses to physiotherapy. Ann Rheum Dis 1978;37:64-6.
22. Tomlinson MJ, Barefoot J, Dixon ASTJ. Intensive in-patient physiotherapy courses improve movement and posture in ankylosing spondylitis. Physiotherapy 1986;5:238-40.
23. Wordsworth BP, Pearcy MJ, Mowat AG. In-patient regime for the treatment of ankylosing spondylitis: an appraisal of improvement in spinal mobility and the effect of corticotrophin. Br J Rheumatol 1984;23:39-43.
24. Corkill MM, Jobanputra P, Gibson T, MacFarlane DG. A controlled trial of sulphasalazine treatment of chronic ankylosing spondylitis: Failure to demonstrate a clinical effect. Br J Rheumatol 1990;29:41-5.
25. Dougados M, van der Linden S, Leirisalo-Repo M, et al. Sulphasalazine in the treatment of spondyloarthropathy. Arthritis Rheum 1995;38:618-27.
26. Clegg DO, Reda DJ, Weisman MH, et al. Comparison of sulphasalazine and placebo in the treatment of ankylosing spondylitis. Arthritis Rheum 1996;39:2004-12.
27. Kirwan J, Edwards A, Huitfeldt B, Thompson P, Currey H. The course of established ankylosing spondylitis and the effects of sulphasalazine over 3 years. Br J Rheumatol 1993;32:729-33.
28. Taylor HG, Beswick EJ, Dawes PT. Sulphasalazine in ankylosing spondylitis. A radiological, clinical and laboratory assessment. Clin Rheumatol 1991;10:43-8.
29. Nissila M, Lehtinen K, Leirisalo-Repo M, Luukkainen R, Mutru O, Yli-Kerttula U. Sulfasalazine in the treatment of ankylosing spondylitis: A twenty-six-week, placebo-controlled clinical trial. Arthritis Rheum 1988;31:1111-6.
30. Gorman JD, Sack KE, Davis JC Jr. Treatment of ankylosing spondylitis by inhibition of tumor necrosis factor a. N Engl J Med 2002;346:1349-56.
31. Davis JC Jr, van der Heijde D, Braun J, et al. Recombinant human tumor necrosis factor receptor (etanercept) for treating ankylosing spondylitis. Arthritis Rheum 2003;48:3230-6.