Does Height Influence the Assessment of Spinal and Hip Mobility Measures Used in Ankylosing Spondylitis?

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ABSTRACT. ***Objective.*** It is not known if height contributes to the variability in mobility measures in patients with ankylosing spondylitis (AS) and whether any measures should be reported corrected for height. We examined the contribution of height to the variability of mobility measures in patients with a diverse spectrum of AS disease.

Methods. We assessed the 9 mobility measures comprising the Bath AS and Edmonton AS Metrology Indices (BASMI and EDASMI) in a total of 205 patients. The contribution of height to the variability in mobility scores was analyzed descriptively according to tertiles of height, and also by combined probability scatter plots that combined each individual's height with the corresponding score for either the composite index or each of the 9 spinal mobility measures. Hierarchical (sequential) linear regression was used to assess the contribution of height to the variance in EDASMI and BASMI composite scores and individual measures, adjusted for age, disease duration, and the Bath AS Disease Activity Index.

Results. Descriptive data and correlation analysis revealed significant differences related to height for both the EDASMI and the BASMI, particularly for EDASMI cervical rotation, EDASMI lumbar side flexion, chest expansion, lumbar flexion, and intermalleolar distance. Combined probability scatter plots showed that for a particular height there was a wide distribution of mobility scores and only intermalleolar distance showed some relation to height. Hierarchical regression analysis showed that height contributed significantly, although relatively minimally to the variance of both the EDASMI (3.1%; $p < 0.05$) and the BASMI (3.6%; $p < 0.05$), but only to EDASMI cervical rotation among individual mobility measures (variance of 7.0%; $p < 0.05$).

Conclusion. Body height has minimal effect on the variability of mobility scores in patients with AS. Disease-related factors predominate. (First Release Aug 15 2006; J Rheumatol 2006;33:2035–40)

Key Indexing Terms:
HEIGHT SPINAL MOBILITY HIP MOBILITY ANKYLOSING SPONDYLITIS

Evaluation of spinal mobility is widely accepted as an essential component of the evaluation of patients with ankylosing spondylitis (AS) in both routine clinical practice and clinical trials research. The Assessments in AS (ASAS) Working Group has recommended that spinal mobility constitute one of the outcome domains assessed for both clinical record-keeping and in the assessment of disease controlling antirheumatic therapies[1]. However, although widely practiced it is clear that the approach to both evaluation and recording of mobility measures varies widely, even among those practitioners with an interest in spondyloarthritis, and no clear consensus has emerged on which measures should be adopted or how the measures should be systematically performed. ASAS has specifically recommended the measurement of occiput-to-wall distance, the modified Schober test, and chest expansion as the measures that should be used to assess spinal mobility. However, the reliability of these measures has been modest when assessed using several observers, particularly at different sites, with the major portion of measurement error being due to observer variability[2,3].

Several factors have also been shown to affect spinal mobility independent of disease-related factors. These include age, sex, and time of day when the assessment is performed[4-6]. Some measures, such as chest expansion, have been shown to be more dependent on age and sex than others, e.g., cervical rotation. The effect of height has only rarely been addressed. One study reported a significant correlation with lateral lumbar flexion and the authors implied that this measurement should be reported as a ratio with height as the denominator[7]. The measure of lateral lumbar flexion constitutes one of the 5

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items that compose a validated composite index of spinal and hip mobility, the Bath AS Metrology Index (BASMI)[8], and appears to be particularly responsive to change in patients receiving physiotherapy or treatment with an anti-tumor necrosis factor-α agent. Because of its feasibility and responsiveness it has also been incorporated into an additional composite index of spinal and hip mobility, the Edmonton AS Metrology Index (EDASMI[9]).

It is not known if height might affect the assessment of any additional mobility measures. This might influence comparisons across populations of patients and the responsiveness of mobility measures between clinical trials. We examined the contribution of height to spinal and hip mobility in a large cohort of patients with AS.

MATERIALS AND METHODS

Patients. The patient sample consisted of 205 individuals who were consecutive outpatients followed by rheumatologists in the city of Edmonton at both tertiary (University of Alberta Hospital) and community-based sites. All patients met the modified New York criteria for AS and reflected a broad spectrum of patients with axial and peripheral disease. The study was approved by the ethics committee at the University of Alberta, and all patients provided written informed consent.

All patients have been recruited to a prospective, longitudinal cohort of patients with AS where data is systematically recorded on patient demographics and disease-specific health status [Bath AS Disease Activity Index (BASDAI)][9].

Mobility assessments. The BASMI has been described previously[8]. Briefly, lateral cervical rotation was measured with a goniometer and the patient seated, the mean of right and left results being calculated. For measurement of tragus-to-wall distance the patient stands against the wall and places the head as far back as possible, keeping the chin in. Lateral lumbar flexion is measured by fingertip-to-floor distance. Lumbar flexion is assessed by placing 2 marks 5 cm below and 10 cm above a line joining the dimples of Venus and measuring the distraction between the 2 marks on full forward flexion with knees straight. Intermalleolar distance is measured with the patient supine, the knees straight, and the feet pointing straight up. The distance between the medial malleoli is noted after maximal separation of the legs.

The EDASMI was measured in a standardized fashion by trained clinician nurses using only a measuring tape; it consists of the following:

Cervical rotation: defined as the difference in centimeters between a mark on the suprasternal notch and the right tragus at maximal lateral rotation to the right and left

Lumbar side flexion: distance (cm) between the middle fingertip in neutral position and maximal lateral flexion using a mark drawn on the thigh

Chest expansion: difference (cm) between maximum inhalation and exhalation taken at the xiphisternum rather than the fourth intercostal space

Hip internal rotation spread: maximal intermalleolar distance (cm) while the patient is sitting on the examining couch, knees and hips together and each positioned at 90° of flexion, with a piece of cardboard between the knees.

Video files describing the approach to recording both the EDASMI and BASMI measures are also available at http://www.arthritisdoctors.org/researcher.html. The reproducibility of both composite indices at our center has been shown to be excellent for all mobility measures[9].

Study protocol. All measurements were performed from mid-morning to allow for resolution of morning stiffness. The order of assessment was randomized, and all assessments were performed by a clinician nurse who previously participated in a validation exercise where the reproducibility of mobility measures was shown to be excellent[9].

Statistics. Descriptive statistics (mean, median, standard deviation) and boxplots with median, interquartile ranges, and maximum and minimum values were used to describe the overall distribution of scores according to tertiles of height.

To illustrate an association between mobility and height, combined scatter and cumulative probability plots were created for spinal mobility with height. These plots combine every individual height measurement with the corresponding score for each of the mobility measures. The individual measurement for height of all patients is plotted by its cumulative order (from the lowest value starting at zero to the highest values ending at 100%). The combined procedure yields a scatter plot (observations of 2 variables combined) in which the values of one of the variables (height) is plotted against its cumulative frequency. Correlations on a group level were expressed as Spearman's rho.

Hierarchical (sequential) linear regression was used to assess the contribution of height to the variance in EDASMI and BASMI composite scores and individual measures (dependent variables), adjusted for age, disease duration, and the BASDAI. 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. The independent variables were entered in 2 sets in the following order: (1) age, disease duration, and the BASDAI; and (2) height.

RESULTS

The population demographic data are shown in Table 1. Descriptive data comparing mobility scores in patients at the upper and lower tertiles of height show that among EDASMI measures cervical rotation, lateral lumbar flexion, and chest expansion are significantly affected by height, while internal rotation of the hip is not affected (Table 2). For BASMI measures, lumbar flexion and intermalleolar distance are significantly affected by height (Table 3). Both composite indices of spinal mobility are also significantly affected by height. Correlation analysis showed similarly that the same mobility measures are associated with height (Table 4).

The cumulative probability plots, however, which show data for each individual patient, indicate that the influence of height is relatively minimal, being somewhat evident for inter-

Table 1. Study population demographic data.

Characteristic	Outpatients with AS, n = 205
M:F	158:47
Mean age, yrs (SD)	41.5 (12)
Mean height, cm (SD)	172.1 (9.6)
Mean disease duration, yrs (SD)*	17.1 (12.4)
Peripheral synovitis, %	10.7
Hip disease, %**	18.1
AAU, %	19.5
Psoriasis, %	7.3
IBD, %	8.3
Mean BASDAI (SD)	4.7 (2.4)
Mean BASFI (SD)	3.8 (2.7)
Mean total back pain (SD)	5.2 (2.8)
Mean BASMI (SD)	2.9 (2.5)

* Duration from symptom onset. ** Defined as restricted hip movement as documented by the attending rheumatologist on examination. BASDAI: Bath Ankylosing Spondylitis Disease Activity Index, BASFI: Bath Ankylosing Spondylitis Functional Index, BASMI: Bath Ankylosing Spondylitis Metrology Index, AAU: acute anterior uveitis, IBD: inflammatory bowel disease.

Table 2. Descriptive statistics for spinal and hip mobility measures comprising the EDASMI in a cohort of 205 patients according to upper and lower tertiles of height.

	Cervical Rotation	Lumbar Side Flexion	Chest Expansion	Hip Internal Rotation	EDASMI
Upper tertile of height					
Mean	3.08	13.65	4.80	39.36	6.70
Median	3.00	13.00	4.50	41.00	6.00
SD	1.45	5.85	2.46	11.30	3.59
Minimum	0.20	2.00	0.00	6.00	1.00
Maximum	6.50	27.25	9.50	62.00	16.00
Percentiles					
25.00	2.00	9.75	3.00	33.00	4.00
75.00	4.00	18.00	6.50	47.00	9.00
Lower tertile of height					
Mean	2.27	11.47	3.93	38.71	8.74
Median	2.00	12.00	3.50	40.00	9.00
SD	1.30	6.22	2.29	12.59	3.86
Minimum	0.00	1.25	0.00	0.00	1.00
Maximum	6.50	26.75	9.00	74.00	16.00
Percentiles					
25.00	1.40	5.88	2.40	30.50	6.00
75.00	3.00	16.88	5.50	48.00	12.00
Mean difference* (95% CI)	0.81 (0.34 to 1.28)	2.18 (0.13 to 4.23)	0.87 (0.06 to 1.67)	0.65 (4.71 to -3.41)	-2.04 (-0.77 to -3.30)
P value	< 0.001	0.04	0.03	NS	< 0.001

* Mean difference between upper and lower tertiles of height. NS: nonsignificant.

Table 3. Descriptive statistics for spinal and hip mobility measures comprising the BASMI in a cohort of 205 patients according to upper and lower tertiles of height.

	Tragus-to-Wall	Cervical Rotation	Lumbar Side Flexion	Lumbar Flexion	Intermalleolar Distance	BASMI
Upper tertile of height						
Mean	14.21	60.75	13.24	5.20	106.22	1.97
Median	12.50	67.50	12.50	5.50	109.00	1.50
SD	4.63	20.00	5.28	2.06	20.75	1.98
Minimum	10.00	11.00	2.00	0.90	47.00	0.00
Maximum	31.30	87.50	23.90	9.00	160.00	10.00
Percentiles						
25.00	11.38	50.50	9.75	3.90	94.00	0.75
75.00	15.63	75.00	16.88	6.50	120.00	3.00
Lower tertile of height						
Mean	15.10	54.55	11.56	4.12	96.32	3.25
Median	12.00	59.00	11.38	5.00	98.00	2.00
SD	6.45	19.69	5.97	2.15	23.18	2.68
Minimum	9.00	0.00	1.50	0.00	38.50	0.00
Maximum	37.50	90.00	25.00	7.50	137.00	10.00
Percentiles						
25.00	10.65	44.00	6.24	1.95	82.00	1.00
75.00	18.00	70.00	16.01	6.00	114.25	6.00
Mean difference* (95% CI)	–0.89 (–2.80 to 1.03)	6.19 (–0.64 to 13.03)	1.68 (–0.26 to 3.61)	1.08 (0.36 to 1.80)	9.90 (2.43 to 17.37)	–1.28 (–0.47 to 2.09)
p value	NS	0.08	0.09	< 0.001	0.01	< 0.001

* Mean difference between upper and lower tertiles of height. NS: nonsignificant.

malleolar distance but not at all for lateral flexion of the lumbar spine and either of the composite measures (Figure 1). For a particular height measurement, the scatter plots show a wide distribution of scores for the mobility measures, and there is no tendency for mobility scores to increase as height increases.

Adjusting for age, disease duration, and the BASDAI, height accounted for 3.1% of the variance in the EDASMI ($p < 0.05$) and 3.6% of the variance in the BASMI ($p < 0.05$). For the individual mobility measures, height accounted for 7.0% of the variance in EDASMI cervical rotation ($p < 0.05$). The contribution of height to the variance in the additional mobility measures was not significant.

Table 4. Correlations (Spearman) between mobility scores and height for measures comprising the BASMI and EDASMI.

Mobility Measure	Correlation	p
EDASMI	-0.26	< 0.001
Cervical rotation	0.26	< 0.001
Chest expansion	0.20	0.004
Lateral lumbar flexion	0.17	0.016
Hip internal rotation	0.05	0.439
BASMI	-0.23	0.001
Tragus-to-wall	0.01	0.865
Cervical rotation	0.20	0.005
Lumbar flexion	0.19	0.006
Lateral lumbar flexion	0.15	0.035
Intermalleolar distance	0.20	0.004

DISCUSSION

Our evaluation of a large cohort of AS patients with a diverse spectrum of disease shows that, with the possible exception of intermalleolar distance, height contributes minimally to those mobility measures commonly used in clinical practice and in clinical trials research.

The study was prompted by our clinical observations that tall patients with long necks and lower limbs tended to exhibit greater degrees of spinal mobility, particularly for cervical rotation, lateral lumbar flexion, and intermalleolar distance. However, with the possible exception of intermalleolar distance, this was not evident on formal evaluation. Although multivariate analyses showed that the contribution of height was statistically significant for both the BASMI and the

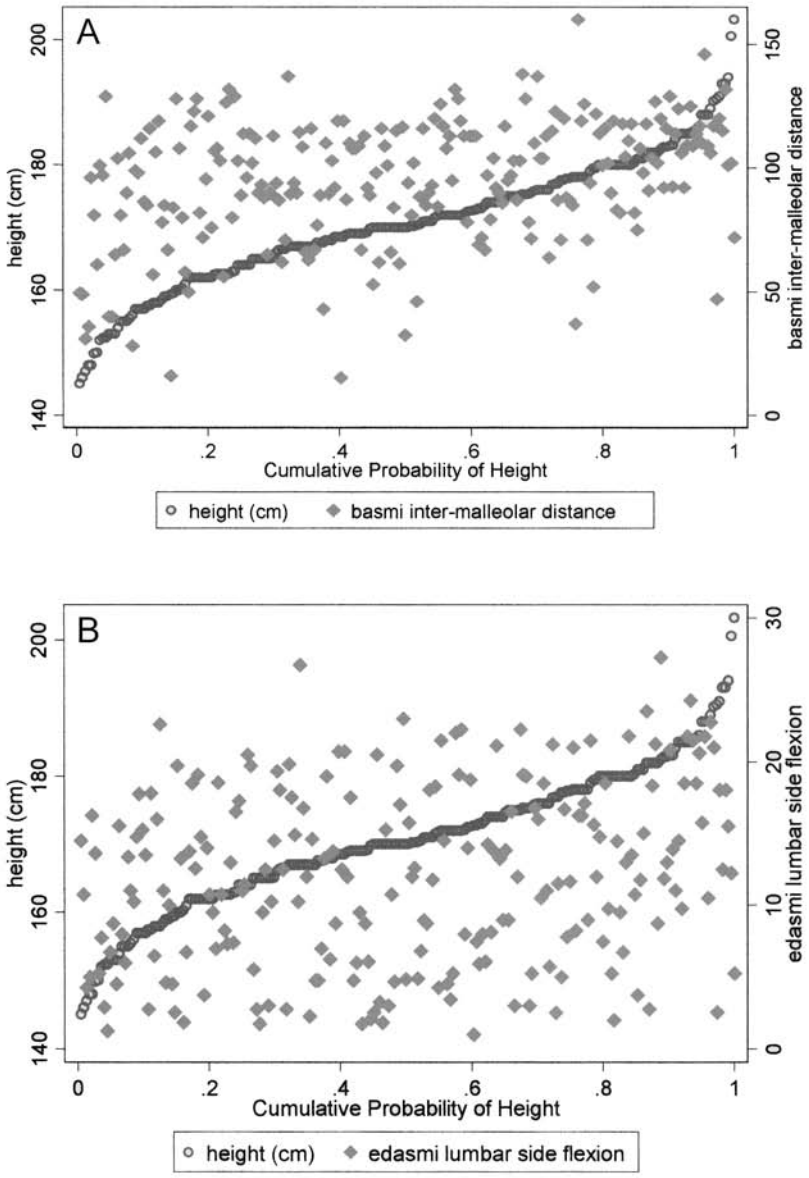

Figure 1. Scatter plots of cumulative height versus mobility measures: (A) intermalleolar distance, (B) lumbar side flexion; opposite page: (C) EDASMI, (D) BASMI.

EDASMI scores, the contribution to the variance in scores was only 3%–4%, indicating that the clinical influence is minimal. Similarly, the contribution of height to the scores for cervical rotation, lumbar side flexion, and intermalleolar distance, while statistically significant, is of minimal clinical significance.

To our knowledge, this study is the first to examine the effect of height on spinal and hip mobility. One study that recruited 200 healthy 19-year-old men reported a higher degree of correlation between body height and lumbar side flexion using the method adopted in the EDASMI ($r = 0.38$)[7]. When the measurement was corrected for height, the ratio was constant. The authors suggested that inability to flex the spine laterally by 10% of height should be interpreted as abnormal. However, others reported either a much lower[11] or no correlation with height[12]. The low correlation noted in our study might reflect the predominant role of disease-related factors in the variance of this measure. Another study evaluated the effect of height on lumbar spinal forward flexion and showed a weak correlation ($r = 0.36$). However, patients were recruited to this study from a chronic low back pain rehabilitation program. The absence of such a correlation in our patients may again reflect the predominant role of disease-related factors.

In summary, height has minimal influence on the variance of spinal mobility in patients with AS, although some effect may be evident for intermalleolar distance. There is therefore no need to adjust spinal measurements for body height.

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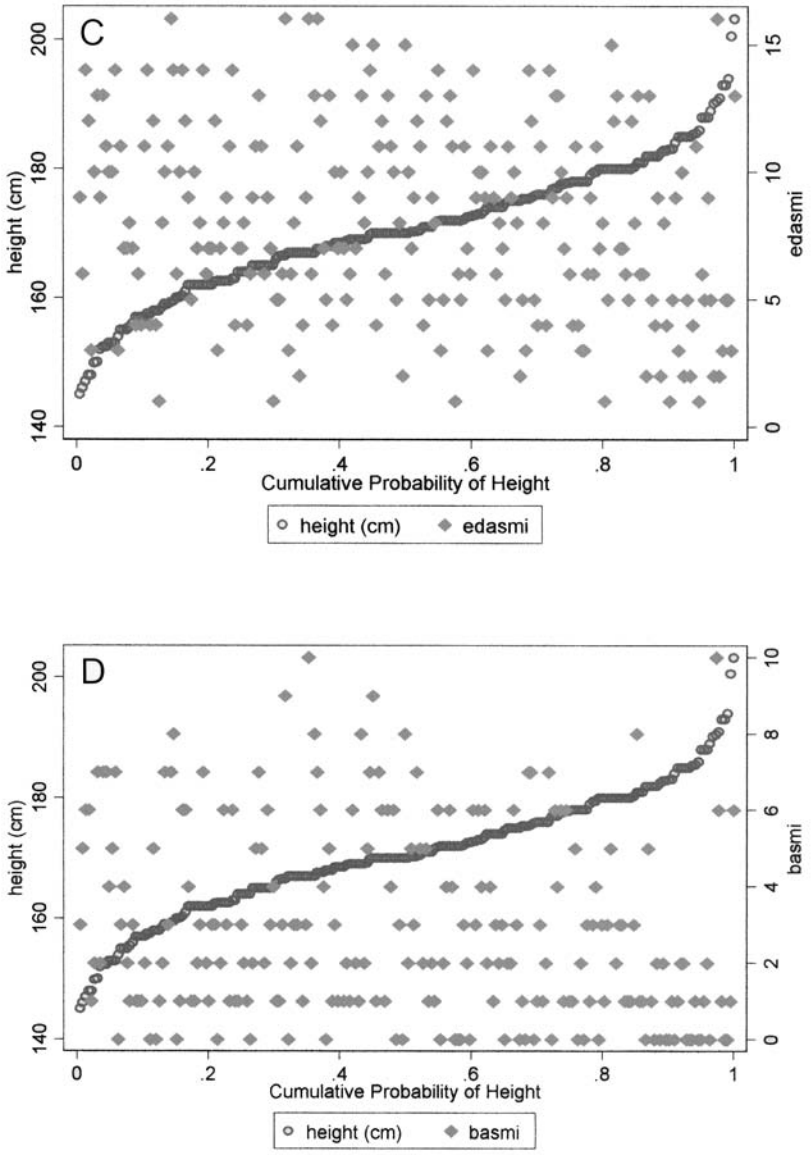

Figure 1 (continued).

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