Normal range of spinal mobility

An objective clinical study

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Progressive loss of spinal mobility is generally accepted as one of the cardinal features of ankylosing spondylitis. The importance of this sign is emphasized by its inclusion as a clinical criterion for the diagnosis of ankylosing spondylitis at a recent international symposium held in 1966 in New York (Bennett and Wood, 1968). At this conference it was recommended that to be of diagnostic significance spinal mobility should be restricted in three planes (anterior flexion, lateral flexion, and extension). Interpretation of this criterion, however, has proved difficult and unsatisfactory for several reasons:

(1) The widespread current practice of assessing mobility by relatively crude subjective methods has overshadowed more accurate measurement of spinal movement by objective techniques.

(2) Of the available objective methods, few are free from at least one major disadvantage, such as radiation hazard (Wiles, 1935; Tanz, 1953; Jonck and van Niekerk, 1961), special instrumentation (Dunham, 1949; Goff and Rose, 1964; Loebel, 1967), or inconvenience to the patient (Troup, Hood, and Chapman, 1968). Furthermore, these techniques have invariably been limited to spinal measurement in the sagittal plane alone.

(3) The arbitrary grading of mobility as 'normal' or 'abnormal', in the absence of a recognized range of normality, is clearly unacceptable.

(4) No correction has been made previously for the effect of age and sex on these movements—factors which Macrae and Wright (1969) have recently shown to be an important source of diagnostic error.

The principal object of this paper, therefore, is to present for the first time a *range of normal values*

for spinal mobility measured in three planes of movement by means of objective clinical methods. It is envisaged that this will not only enhance the accuracy of diagnosing ankylosing spondylitis but will also help to differentiate this condition from disorders of the lumbar disc—a clinical problem encountered more often than is generally appreciated.

Clinical material

The population studied was obtained by consecutive sampling of clinically and radiologically normal relatives of patients with psoriatic arthritis during a family study of this disease. A total of 237 subjects (119 males and 118 females) comprised the 'normal' group in which all ages between the second and ninth decades were represented.

Methods

The objective clinical methods employed to measure spinal mobility have been developed recently at the Rheumatism Research Unit at Leeds. The method to measure anterior flexion has been reported previously (Macrae and Wright, 1969) and details of the methods to measure lateral flexion and extension will form the substance of separate communications (Moll and Wright, 1971a, b).

Measurements of anterior spinal flexion

This is a modification of a technique originally described by Schober (1937). Three marks were inked on the skin overlying the lumbo-sacral spine with the subject standing erect (Fig. 1). The first mark was placed at the lumbo-sacral junction which is represented by the spinal intersection of a line joining the dimples of Venus. Further marks were inked 5 cm. below and 10 cm. above the lumbo-sacral junction. The subject was then asked to bend forward and touch his toes and the new distance between the upper and lower marks was measured. The distraction between these two marks has

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Accepted for publication March 16, 1971

FIG. 1 Measurement of anterior spinal flexion by a modification of Schober's method (Macrae and Wright, 1969).

been found in a separate study to correlate very closely ($r = 0.97$) with anterior flexion measured radiologically (Macrae and Wright, 1969).

Measurement of lateral spinal flexion

With the subject standing erect, two marks were inked on the skin of the lateral trunk (Fig. 2). The upper mark represents the intersection of a horizontal line through the xiphisternum with the coronal line. The lower mark represents the intersection of a horizontal line through the highest point on the iliac crest with the coronal line. The distance between these two marks was measured in centimetres. The subject was then asked to bend sideways as far as possible by sliding the hand down the homolateral thigh. At the end of this movement the distance between the two marks was again measured. A separate study has revealed that the difference between the first and second measurements correlates reasonably closely ($r = 0.79$; $P < 0.001$) with lateral thoraco-lumbar flexion measured radiologically (Moll and Wright, 1971a).

FIG. 2 Measurement of thoraco-lumbar lateral flexion.

Measurement of spinal extension

The landmarks for this measurement were the same as those used to measure lateral spinal flexion. A simple plumb-line was constructed. This consisted of a pointed weight suspended by thread approximately 20 cm. long. The point of the plumb-line was suspended to coincide with the lower mark and the thread held at the upper mark (Fig. 3). To facilitate the manipulation the subject was asked to stand erect with hands on head. Without support he was instructed to bend over backwards as far as possible without flexing the knees. During this movement the distance traversed by the plumb-line pointer was marked on the skin of the flank and measured in centimetres. This distance has been found to correlate satisfactorily ($r = 0.75$; $P < 0.01$) with thoraco-lumbar extension measured radiologically (Moll and Wright, 1971b).

Results

Distribution of spinal measurements

Histograms constructed to show the distribution of spinal measurements revealed a Gaussian pattern for each plane of movement (Figs 4a, b, c), thus providing firm supporting evidence for the 'normality' of the population surveyed.

FIG. 3 Measurement of thoraco-lumbar extension.

Normal range of spinal measurements

A complete set of normal values for each plane of spinal movement is presented in Table I (overleaf). The mean ± 1 S.D. and range of mobility are shown for each decade, male and female data being tabulated separately. A diagrammatic summary of these observations is shown in Figs 5a, b, and c (overleaf). The vertical lines at each decade represent the normal range of spinal movement (mean ± 2 S.D.). Reference to these diagrams reveals the following important features:

(1) An initial increase in mean mobility from the 15 to 24 decade to the 25 to 34 decade was followed by a progressive decrease with advancing age. This age-dependent pattern was observed in both sexes and in all three planes of measurement. The magnitude of the age effect in decreasing spinal mobility was calculated from the following:

$$\text{Magnitude of age effect (\%)} = \frac{\text{maximal-minimal mean measurement}}{\text{maximal mean measurement}} \times 100$$

Table II (overleaf) shows that age alone may reduce spinal mobility by as much as 23 to 52 per cent. The diagnostic significance of this marked effect will be discussed later.

(2) The scatter (± 2 S.D.) of spinal mobility varied considerably between decades but in each age group this was marked. The wide range of normal mobility was observed in each plane of movement.

(3) Fig. 6 (overleaf) reveals a sex difference at each

FIG. 4a Normal distribution of anterior spinal flexion, by sex.

FIG. 4b Normal distribution of left lateral spinal flexion, by sex.

FIG. 4c Normal distribution of spinal extension, by sex.

Table I Thoraco-lumbar spinal movements, by age and sex

Normal thoraco-lumbar spinal movement	Age (yrs)	15-24		25-34		35-44		45-54		55-64		65-74		75+	
	Sex	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	No. of subjects	21	10	13	16	14	18	19	23	34	30	14	14	5	6
Flexion	Mean (cm.)	7.23	6.66	7.48	6.69	6.88	6.29	7.17	6.02	6.87	6.08	5.67	4.93	5.40	5.10
	S.D.	0.92	1.03	0.82	1.09	0.88	1.04	1.20	1.32	0.89	1.32	1.31	0.90	1.26	1.07
	Range	5.50-9.00	5.20-8.40	6.50-9.00	5.20-8.90	5.70-8.50	3.80-8.30	5.50-10.00	4.00-8.50	4.60-8.10	4.00-10.2	3.20-7.50	3.50-6.50	4.20-7.30	3.40-6.50
Lateral flexion to right	Mean (cm.)	5.43	6.85	5.34	6.32	4.83	5.30	4.71	5.37	5.05	5.10	4.44	5.56	4.50	4.45
	S.D.	1.30	1.46	1.06	1.93	1.34	1.61	1.35	1.54	1.30	1.85	1.03	2.04	1.54	2.07
	Range	3.50-8.50	4.30-8.60	3.20-6.50	2.70-9.30	2.50-7.50	3.10-7.80	2.20-6.90	2.50-7.50	3.30-8.00	1.50-10.1	2.50-6.70	2.50-10.5	3.00-7.00	2.0-8.00
Lateral flexion to left	Mean (cm.)	5.06	7.20	5.93	6.13	4.83	5.48	4.55	5.14	4.94	4.88	4.38	5.55	4.48	4.45
	S.D.	1.40	1.66	1.07	1.42	0.99	1.38	0.94	1.54	1.22	1.61	0.98	2.16	1.49	2.07
	Range	3.10-9.50	5.40-10.0	4.20-8.20	3.00-8.40	2.70-5.90	2.70-8.00	3.00-6.00	2.30-8.30	2.30-7.70	1.50-9.30	2.90-5.90	2.90-10.00	3.00-7.00	2.00-8.00
Extension	Mean (cm.)	4.21	4.34	5.05	4.76	3.73	3.09	3.88	3.12	3.56	3.57	3.41	2.72	2.40	2.63
	S.D.	1.64	1.52	1.41	1.53	1.47	1.31	1.19	1.36	1.28	1.32	1.56	0.95	0.85	0.76
	Range	1.00-7.00	3.00-7.00	3.00-8.00	2.00-7.20	2.10-7.50	0.60-5.20	2.10-6.40	1.40-6.50	1.10-6.30	1.00-6.50	1.50-7.50	1.20-4.20	1.00-3.30	1.60-3.70

FIG. 5a Thoraco-lumbar anterior flexion in normal males and females: mean flexion $\pm$ 2 S.D. plotted against age.
FIG. 5b Thoraco-lumbar lateral flexion to left (—) and right (---) in normal males and females: mean $\pm$ 2 S.D. plotted against age.
FIG. 5c Thoraco-lumbar extension in normal males and females: mean extension $\pm$ 2 S.D. plotted against age.

decade in all three planes of movement. It is interesting to note that in the case of anterior flexion and extension male mobility exceeded female mobility, whereas in lateral flexion the converse obtained. The magnitude of the mobility difference between the sexes has been calculated from the following:

Magnitude of sex effect in anterior flexion and extension (%) = $\frac{\text{overall mean (all decades) male mobility} - \text{overall mean female mobility}}{\text{overall mean male mobility}} \times 100$

Magnitude of sex effect in lateral flexion (%) = $\frac{\text{overall mean (all decades) female mobility} - \text{overall mean male mobility}}{\text{overall mean female mobility}} \times 100$

Table II *Percentage reduction of spinal mobility due to age*

Plane of measurement		Per cent. reduction of spinal mobility	
		M	F
Anterior flexion		27	23
Extension		52	44
Lateral flexion	Left	26	38
	Right	25	35

Table III shows that spinal mobility differed by 7 to 11 per cent. between the sexes.

Table III *Percentage reduction of spinal mobility due to sex difference*

Plane of measurement		Per cent. reduction of spinal mobility
Anterior flexion		10 (F < M)
Extension		7 (F < M)
Lateral flexion	Left	11 (F > M)
	Right	11 (F > M)

Discussion

The present study was prompted by the widespread practice of subjective measurement and arbitrary interpretation of certain international criteria for the clinical diagnosis of ankylosing spondylitis. In an attempt to improve this situation, it was considered important not only to use objective methods to measure spinal mobility in several planes but also to establish a range of normal values for these movements.

A reported feature of considerable importance is the striking decrease in spinal mobility with advancing age. This observation has both diagnostic and prognostic significance. Although the majority of patients with ankylosing spondylitis present before the age of 30 years, a number experience their first symptoms in middle age or even later (Sharp, 1965). It is important, therefore, when considering this disease in the elderly, to allow for the effect of age to avoid false positive diagnosis. Prognostically, if the progressive diminution of mobility with increasing age is not considered, the effect due to this in a spondylitic subject may be ascribed to the progress of the disease rather than to the progress of nature.

Another age-dependent feature of diagnostic significance concerns the delay in peak spinal

FIG. 6 *Mean range of movement, by sex and age group*
(A) Anterior flexion.
(B) Extension.
(C) Right and left lateral flexion.

mobility until the decade following that in which spondylitis most frequently presents, *i.e.* between the age of 15 and 24 years (Mason, 1964). As non-spondylitic back pain and radiological changes mimicking sacro-iliitis (Rogers and Cleaves, 1935) are relatively common at this decade, awareness of this phenomenon is clearly important in order to avoid diagnostic error.

An important practical application of the measurement of back movement in *three* planes (anterior flexion, lateral flexion, and extension) concerns the frequent difficulty in differentiating ankylosing spondylitis from disorders of the lumbar disc. It has been reported that limitation of mobility in spondylitis usually affects all planes of spinal movement in contrast with the pattern of involvement in acute lumbar disc lesions in which lateral flexion is often spared (Bailey, 1960). The common practice of limiting examination of spinal mobility to measurement of anterior flexion in spondylitis surveys may thus lead to the erroneous inclusion of patients with disorders of the lumbar disc (Lawrence, 1970). The clinical paradox in which male mobility exceeded female mobility in the sagittal but not the coronal plane defies simple explanation. An artefactual effect arising from morphological differences, such as a narrower waist and broader pelvis in the female, was considered. More likely, however, is the

possibility that the phenomenon represents a real effect based on female musculo-skeletal peculiarities sufficient to outweigh the usual biological tendency towards male predominance.

Summary

- (1) New *objective clinical methods* have been applied to a study of spinal mobility in a normal population.
- (2) Spinal movement has been measured in *three planes*—anterior flexion, lateral flexion, and extension.
- (3) A *range of normal values* has been reported for each plane of mobility, based on measurements from 237 normal subjects in a family study.
- (4) The *distribution* of measurements in each plane of spinal movement followed a *Gaussian (normal) pattern*.
- (5) The pattern of normal mobility plotted against age revealed an *initial increase* in movement from

the 15 to 24 decade to the 25 to 34 decade followed by a progressive *decrease with advancing age*.

(6) Spinal mobility was found to diminish by as much as 50 per cent. between youth and old age. The diagnostic implications of this age-dependent effect have been discussed.

(7) A considerable scatter of spinal mobility was demonstrated at each decade and the importance of regarding normal mobility in terms of a *wide range* of values was emphasized.

(8) A sex difference was observed in each plane of movement. Male mobility exceeded female mobility in anterior flexion and extension. Female mobility exceeded male mobility in lateral flexion.

We should like to thank Mrs E. W. Davey for technical help and Mrs B. Antcliffe and Mrs B. Gordon for secretarial assistance. We are also indebted to the large number of psoriatic arthritis probands who allowed us to study their relatives. Financial support from the West Riding Medical Trust is gratefully acknowledged.

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