Effects of age, gender and speed on three dimensional lumbar spine kinematics

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This article reports an investigation into the influences of gender, speed of motion and chronological age on the active movements of the lumbar spine. Data were collected from 100 able-bodied volunteers using an automated motion analysis system. Subjects performed movements at two self-selected speeds. Consistent patterns of motion coupling during the actions were detected and no significant gender-specific differences were observed. With advancing age, significant reductions in the ranges of forward and side flexion, but not axial rotation, were found. Age-related differences in the patterns of coupling between movements were also determined. The results of this study will provide therapists with data upon which to base judgments regarding movement restriction, particularly in older clients.

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Clinical assessment of lumbar spinal mobility has utilised a variety of mono-planar measurement systems, generally employing devices mounted over the spinous processes. Although these devices produce an index of motion, there is often very little correlation between the measurement and true spinal motion (Stokes et al 1987). There is also little evidence to show that such measurements provide the clinician with more information than subjective observation with regard to restriction of movement (Pearcy and Hindle 1989).

Alternative methods such as two-dimensional radiographic measurement can be used clinically, but these measurements will become inaccurate if out of plane movements occur (Benson et al 1976, Stokes et al 1987), and are liable to large errors unless invasive techniques are used to locate body landmarks (Benson et al 1976). In any case, these techniques are expensive, potentially hazardous and not readily accessible. Another system for measuring and documenting lumbar motion is a computer-based motion analysis system. Such systems analyse the motion of the spine using retro-reflective markers placed on specific surface landmarks. The video image is recorded on videotape and digitised by the computer. Although kinematic data related to the lumbar spine have been obtained by a variety of methods, the data are generally reported in terms of maximum displacement, without describing the patterns employed.

Since the spine is a complex structure exhibiting multi-axial motion, it should not be assumed that motion will be confined to a single plane (Hindle et al 1990). The primary movement about one axis is likely to be accompanied by movements about the other two axes. These movements may change in response to speed of motion, gender, advancing age or as a result of disorders of the spine.

The effect of advancing age has been implicated in reducing the range of lumbar spine motion, particularly in the sagittal and frontal planes (Fitzgerald et al 1983, Hindle et al 1990, Twomey and Taylor 1984). The age of onset of these changes has not been identified. In particular, the differences between healthy young adults and those in the middle and older age groups are unclear.

The main purpose of this study was to investigate the effects of advancing age and varying speed of movement on lumbar spine kinematics in healthy male and female subjects. It was also

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designed to describe the typical kinematic characteristics of the lumbar spine, including range of motion, angular velocity and patterns of primary and coupled movement.

Methods

Subjects

Forty-six male and fifty-four female volunteers aged over 20 years were recruited. Subjects were divided into three age groups: Group A (age range 20-35), Group B (age range 36-59) and Group C (60 years and over). Each group contained between 15 and 20 subjects. Details of the age, weight and height of subject groups are presented in Table 1. Subjects were free of back or lower limb pain for at least the six months prior to testing and had no history of serious spinal or hip joint trauma, including surgery. Subjects with pain or stiffness of the shoulder joints were excluded from this study, as were those regularly taking medication likely to affect muscle function or control of balance.

Subjects were informed of the nature of the test and were at liberty to withdraw at any time. An informed consent form was signed by each subject and the study was approved by The University of Sydney Human Ethics Committee.

The subjects were interviewed to categorise their activity levels and general health. A questionnaire modified from that used by the National Heart Foundation of Australia (1986) was used to assess activity in subjects aged more than 60 years. On the basis of the criteria in this questionnaire, all subjects in this study were physically active and functionally independent.

Procedure

Subjects were filmed using a four camera automated video system (ExpertVision, Motion Analysis Corporation™, Santa Rosa, California) while seated on a backless stool. The system involves a computer based video-processor which calibrates a volume in three-dimensional space and subsequently identifies and locates, using direct linear transformation (Abdel-Aziz and Karara 1971), the centroid of retroreflective marker spheres in space. From these coordinates the trajectories of the markers and the orientations of body segments defined by such markers can be computed.

Table 1.
Study group profile - mean (SD) values.

Gender	Group	*n*	Age (years)	Weight (kg)	Height (cm)
Male	A	15	27.1 (4.3)	75.9 (12.5)	177.0 (8.6)
	B	15	44.3 (6.6)	72.9 (10.5)	171.4 (9.9)
	C	16	70.0 (7.1)	73.1 (8.7)	169.6 (5.0)
Female	A	20	27.1 (5.1)	58.7 (11.3)	163.6 (6.5)
	B	18	43.1 (7.8)	60.3 (10.7)	161.4 (7.8)
	C	16	68.3 (5.7)	61.1 (9.3)	158.6 (7.0)

Calibration was conducted using a rigid cubic frame of side length one metre, to which were attached 18 spherical markers of known location. The accuracy and reproducibility of the system for angular measurement has been reported as better than 0.4 degrees (Linden et al 1992), and the manufacturer reports precision of the system with respect to marker identification to one part in 2000 of the field of view. Our estimates of marker location error, using both the norm of residuals of the camera views and tracking of markers of a known configuration through space were less than 0.1 per cent.

Eight spherical reflective body markers were applied over selected anatomical landmarks:

- spinous processes of the 6th and 12th thoracic (T6, T12) and 5th lumbar (L5) vertebrae;
- left and right lateral border of erector spinae muscles at the T12 level;
- left and right posterior superior iliac spine; and
- sacrum over S2/3.

All markers were located by the same investigator following a predetermined standard protocol for identification of anatomical landmarks.

In order to minimise error from skin or soft tissue movements, the markers were placed over the spinous process of the thoracic vertebrae, where there is little overlying tissue (Atha 1984). The pelvic markers were similarly attached over subcutaneous bony landmarks. Gracovetsky et al (1990 p.33) have suggested that the measurement error associated with skin motion during full range forward or lateral flexion is about 2 degrees. A pilot study in which skin motion errors were measured in 10 subjects confirmed these error values. There are errors and drawbacks in any measurement system. We consider that the lack of encumbrance of the subject by the lightweight markers in the present system minimises movement distortion and outweighs any disadvantages arising from the small error terms.

Subjects were secured to the stool by two broad nylon straps over the thighs and around the pelvis. The starting and finishing position for each activity was upright sitting. For the forward flexion test, the subjects' arms were elevated above the head; for lateral flexion they sat upright with both arms hanging relaxed by their sides; and for axial rotation they crossed their arms over their chest.

The tests were conducted with the subjects in a seated position. This enabled us to compare our results with previously published studies in which the subjects were tested in standing (eg Hindle et al 1990) with an unconstrained pelvis. Additionally, because therapists may choose to assess active motion in such a posture, it was considered that information about likely ranges and patterns of spinal movement in sitting would be of value.

Three movements (forward flexion, continuous lateral flexion to the right and left sides, continuous axial rotation to the left and right sides) were performed four times each at both the subject's preferred speed and at a self-selected faster speed. The order of testing was randomised. The subjects were instructed to move as far as possible through range in each case and to complete two cycles in each test.

The Expertvision System operates using an NTSC video configuration with an internal clock and data were sampled at a frequency of 60Hz over the duration of the relevant movement. Automated digitisation and realisation of three dimensional coordinates of the markers was performed by the system. The x,y,z position coordinates were filtered using a zero-lag fourth order Butterworth filter at a frequency of 5Hz.

To compute angular displacement during the activities, a paired local coordinate system embedded in the pelvis and lower thorax was used. The relative orientation of the three orthogonal local axes were computed using a procedure similar to that described by Pearcy et al (1987). In this case a model which treated the defined segments as rigid links was used. We believe this is a reasonable assumption for the pelvis, but the additional assumption that the lower thoracic spine exhibits little intrinsic motion during movement is a limitation of this study. The relative motion of the two rigid bodies was used to describe patterns of motion in the lumbar spine. Using this approach the order of rotation did not affect the results. However, it is important to note that this approach best describes relative motion rather than determining absolute values within conventional anatomical references.

By the convention of this study, the embedded axes in the pelvis provided a reference for the movements. The Z axis (caudo-cephalic) was defined by the position vector S2/3 - L5 and was positive upwards; the Y axis (transverse) was provisionally defined by the posterior iliac markers and the X axis (anteroposterior) was the cross-product of the two defined axes and was positive in the anterior direction. The corrected Y axis was then computed from the X and Z axes and was positive towards the subject's left side.

In the upper segment, it was apparent that the two lateral markers would be subject to distortion due to muscle activity. Therefore, a provisional direction vector from these two markers was defined and subsequently corrected to be mutually perpendicular to the other two axes.

The normal right hand conventions to define positive and negative rotations about the axes was used. Forward flexion was thus defined as positive rotation about the Y axis. Lateral flexion occurred about the X axis and was positive when the subject moved towards their right side. Axial rotation occurred about the Z axis and was positive when the subject turned towards their left side.

It was anticipated that the primary motion would be accompanied by rotations about the other axes (Pearcy and Hindle 1989). These secondary rotations are described as coupled movements throughout this report.

Statistical analysis

The hypotheses investigated in the study, namely that there are no gender-, age- or speed-related changes in the patterns or ranges of lumbar spine motion during the performance of simple planar movements were tested. For the purposes of this study data from only the first complete cycle of each movement was used.

Preliminary descriptive analysis of the data indicated normal distribution within sub-groups for all values and similarity in variance between groups. Therefore Multivariate Analysis of Variance (MANOVA) using SPSS^x (SPSS Inc., Chicago) was used to test for significant differences in the mean values of range of motion and of angular velocity with respect to the age effects, gender effects and speed effects. Schéffé multiple comparison of pairs was used as a post-hoc procedure to test for the differences between age groups in the case of significant age effects as shown by MANOVA. Pearson product moment correlation coefficients were constructed to analyse the relationships between the primary and coupled movements.

Average angular velocity values were derived from the raw data from each subject. Subsequently, all data sets were time normalised to 100 per cent of the movement cycle and the mean of the four repetitions was calculated for each subject and the group mean and standard deviation values across the normalised total movement time were computed using an ensemble averaging routine.

Results

Age and gender effects on range of motion

The mean values and standard deviations of range of forward flexion, lateral flexion and rotation in all groups are summarised in Tables 2(a) and (b). MANOVA revealed significant differences between the groups for the ranges of forward flexion ($F_{(2,94)} = 12.30, p < 0.001$) and lateral flexion ($F_{(2,94)} = 13.00, p < 0.001$). There were significant differences between male Groups A and B compared with both male and female Group C for range of forward flexion. No significant differences between the three female groups were detected.

For lateral flexion, significant differences were seen between males and females in Group A and Group C females at both speeds. MANOVA also

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Table 2a.
Mean values of maximum range of motion (SD) for primary and coupled movements at the preferred and fast speeds of motion in male subjects.

Movements		**Preferred**			**Fast**	
Primary	Group A	Group B	Group C	Group A	Group B	Group C
Coupled	(*n*=15)	(*n*=15)	(*n*=16)	(*n*=15)	(*n*=15)	(*n*=16)
Flexion	48 (11)	46 (11)	33 (9)	49 (10)	47 (11)	33 (10)
Lateral flexion	0 (3)	0 (4)	-2 (2)	0 (3)	0 (4)	-2 (2)
Rotation	0 (2)	1 (4)	0 (2)	0 (2)	0 (4)	0 (2)
Left Lateral flexion	-35 (8)	-32 (8)	-29 (6)	-32 (8)	-30 (8)	-29 (6)
Flexion	8 (8)	9 (6)	6 (5)	8 (7)	7 (5)	5 (4)
Rotation	-5 (3)	-3 (4)	-4 (4)	-4 (4)	-2 (4)	-4 (4)
Right Lateral flexion	32 (8)	30 (9)	24 (8)	31 (9)	29 (8)	23 (6)
Flexion	9 (8)	12 (6)	9 (6)	8 (6)	11 (7)	9 (6)
Rotation	6 (4)	7 (5)	5 (4)	5 (4)	6 (5)	6 (5)
Left Axial Rotation	23 (4)	23 (6)	22 (4)	25 (6)	25 (6)	23 (4)
Flexion	7 (3)	8 (5)	6 (3)	11 (4)	11 (4)	7 (4)
Lateral flexion	2 (6)	5 (6)	2 (5)	4 (5)	4 (6)	4 (5)
Right Axial Rotation	-21 (5)	-23 (6)	-20 (4)	-25 (6)	-25 (7)	-21 (4)
Flexion	7 (5)	8 (5)	8 (4)	11 (5)	10 (4)	9 (4)
Lateral flexion	-3 (6)	-2 (8)	-1 (6)	-4 (5)	-3 (7)	-1 (5)

Note: Sign conventions for primary and coupled movements follow definitions of positive and negative rotations given within the text.

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indicated significant gender effects in forward flexion ($F_{(1,94)} = 12.40$, $p = 0.001$) and axial rotation ($F_{(1,94)} = 9.34, p = 0.003$). Females in Groups A and B demonstrated a reduced range of forward flexion and axial rotation compared with males in these age groups. After correcting for the offset of the initial starting position, it was found that the actual range of forward flexion through which male and female subjects moved was not significantly different for each speed condition. No significant differences in gender-age combination effects were found for any movement.

Age and gender effects on angular velocity

Angular velocity characteristics were significantly lower for both genders in Group C, ($F_{(2,94)} > 6.5, p < 0.005$). The older subjects averaged around 70 per cent of the velocity of the youger subjects in all cases. In each movement, at the preferred and fast speeds of motion, the male groups showed significantly higher values of angular velocity than the female group of the same age ($F_{(1,94)} > 4.90, p < 0.05$). In most cases this increase was of the order of 15 per cent. There were no clear gender-age combination effects in any movement for either velocity value. No differences were detected in the decreasing trend of angular velocity between male and female subjects across age groups.

Patterns of movement

The general patterns of the coupled movements were consistent across all age groups and for both genders. Figures 1(a) and (b) demonstrate the patterns of motion of lateral flexion and rotation in male group A at the preferred speed of motion.

Lateral flexion was accompanied by both forward flexion and contralateral axial rotation. Primary axial rotation was generally accompanied by contralateral side flexion in the male groups and in female Groups A and B. No particular association of lateral flexion with primary rotation was

Table 2b.
Mean values of maximum range of motion (SD) for primary and coupled movements at the preferred and fast speeds of motion in female subjects.

Movements	**Preferred**			**Fast**		
Primary	Group A	Group B	Group C	Group A	Group B	Group C
Coupled	(n=20)	(n=18)	(n=16)	(n=20)	(n=18)	(n=16)
Flexion	39 (9)	37 (11)	32 (7)	39 (9)	37 (11)	31 (6)
Lateral flexion	1 (2)	0 (2)	0 (4)	1 (3)	0 (3)	0 (3)
Rotation	0 (2)	0 (2)	0 (2)	0 (2)	0 (2)	0 (2)
Left Lateral flexion	-33 (4)	-31 (5)	-25 (6)	-30 (4)	-29 (5)	-24 (5)
Flexion	12 (7)	9 (7)	6 (6)	10 (5)	8 (7)	6 (5)
Rotation	-5 (4)	-3 (5)	-3 (4)	-5 (4)	-2 (4)	-3 (3)
Right Lateral flexion	33 (7)	31 (6)	24 (7)	29 (6)	29 (5)	22 (6)
Flexion	11 (7)	10 (7)	10 (5)	10 (6)	10 (6)	9 (5)
Rotation	5 (4)	4 (4)	5 (4)	5 (4)	5 (3)	5 (3)
Left Axial Rotation	19 (4)	20 (7)	19 (6)	21 (5)	21 (8)	19 (6)
Flexion	7 (5)	6 (4)	3 (4)	8 (4)	7 (5)	5 (4)
Lateral flexion	5 (6)	4 (4)	-1 (9)	5 (4)	4 (5)	-1 (8)
Right Axial Rotation	-19 (5)	-20 (7)	-17 (5)	-21 (6)	-22 (7)	-18 (6)
Flexion	7 (4)	5 (3)	5 (5)	8 (5)	7 (4)	6 (5)
Lateral flexion	-3 (4)	-5 (5)	2 (6)	-4 (5)	-5 (5)	1 (7)

Note: Sign conventions for primary and coupled movements follow definitions of positive and negative rotations given within the text.

found in female Group C at either speed (eg positive axial rotation was accompanied by positive lateral flexion in eight subjects and by negative lateral flexion in eight subjects at both speeds) [Table 2b].

Both lateral flexion and axial rotation were closely correlated to secondary forward flexion in all groups ($R^2 > 71.4\%$, $p < 0.01$). With the exception of Group C females, lateral flexion and axial rotation were strongly correlated with one another whatever the order of primary and coupled movement ($R^2 > 77\%$, $p < 0.01$). Neither axial rotation nor lateral flexion was coupled with forward flexion in any of the groups [Tables 2a and 2b].

Speed effects on lumbar kinematics

When the subjects changed the speed of their motion from preferred to faster, no significant effects in range or overall pattern of the coupled movements were observed. However, significant differences in the ranges of primary lateral flexion ($F_{(1,94)} = 55.32$, $p < 0.001$) and axial rotation ($F_{(1,94)} = 67.39$, $p < 0.001$) were detected. The range of lateral flexion decreased while axial rotation increased in Groups A and B ($p < 0.05$) for both genders with increased speed.

Discussion

Limitations of study

Although the resolution and reliability of the system used is more than adequate for the purpose of this study, the method used to define spinal segments is prone to some error. In particular, the assumption of a rigid lower thoracic segment is questionable. The technique uses a primary local axis with its origin at T12, defined by markers placed over T6 and T12. Substantial intrinsic motion within the lower thoracic segment will tend to exaggerate the apparent motion of the lumbar region. We acknowledge this

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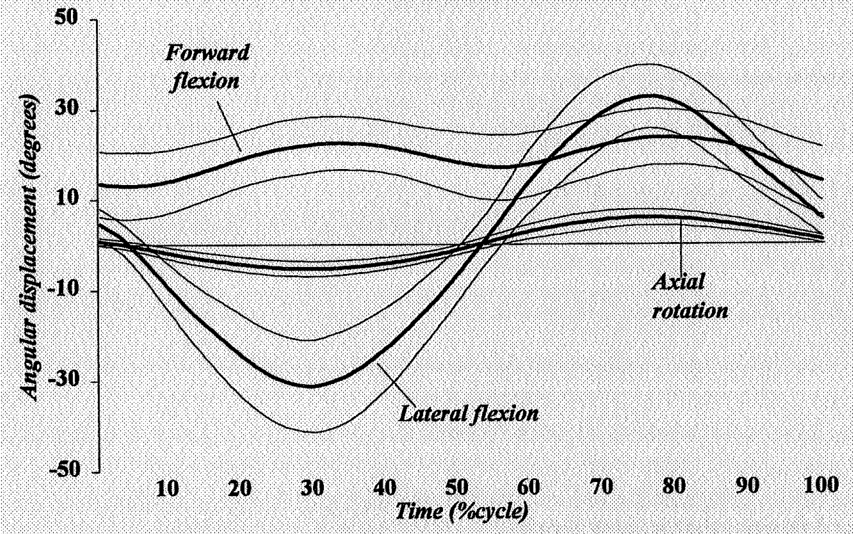
limitation, but believe that it is relatively consistent across the population studied. Therefore, conclusions regarding age, speed and gender effects remain valid. Vachalathiti (1994) found that the lower thoracic segment and the lumbar segment moved in the same direction during "anatomical" movements in subjects of all ages and at the two speeds reported in this paper. Thus there is no reason to believe that one group displayed segmental movement patterns different from those of other groups.

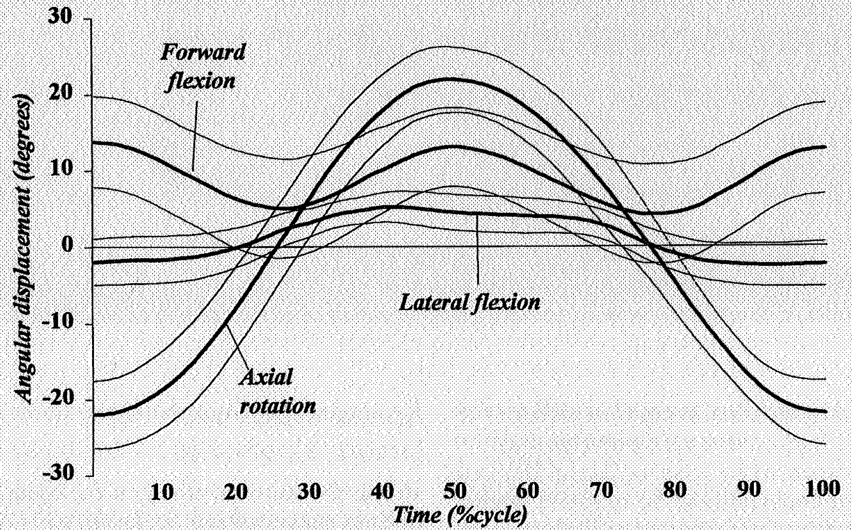
Patterns of movement

The lumbar spine exhibits consistent patterns of motion coupling during quasi-planar movements. Changing the speed of activity has no apparent effect on the overall patterns of these motions, thus movement coupling may be an essential component of normal spinal motion. The patterns between primary and coupled movements are attributable to the geometry of the individual vertebrae, the connecting ligaments and intervertebral disc, the orientation of the articular facet joints, the interplay between spinal movement and muscle activity and the local spinal posture (White and Panjabi 1990 p.108).

This study has shown a closely coupled pattern of forward flexion occurring with lateral flexion and axial rotation. This supports the observations of Panjabi et al (1989). However, this finding contrasts with the findings of Pearcy et al (1987), where lateral flexion was generally accompanied by extension. Hindle et al (1990) reported no significant coupled forward flexion or extension with axial rotation. One possible reason for the difference may be that the subject's posture in standing was less constrained and some degree of initial lumbar flexion might have been present. Panjabi et al (1989) have shown that subjection of the lumbar spine to axial torque in flexion introduces an extension coupling. It was noted that the patterns of lateral flexion coupled with primary axial rotation and vice versa in our study did not differ substantially from previously reported data in which the subjects were standing (Hindle et al 1990, Pearcy et al 1987). The pattern of "uncoupled" primary forward flexion in the present study is consistent with the results of previous studies and demonstrates a logical symmetry.



(a) primary lateral flexion with coupled forward flexion and axial rotation.



(b) primary axial rotation with coupled forward flexion and lateral flexion. Dark line represents mean value, fine line represents ±1 standard deviation.

Figure 1.
Patterns of primary and coupled movement in the lumbar spine at preferred speed in Group A males ($n = 15$).

Gender effects on range of motion

Many authors have reported gender differences with respect to range of lumbar mobility, with greater values for men than for women, particularly in the sagittal plane. Burton and Tillotson (1988) reported that males have higher values for flexion, whilst females show higher values for extension. Wolf et al (1979) and Hindle et al (1990) reported that women tended to show greater range of motion for trunk rotation and lateral flexion while forward flexion was greater in men.

All previous studies have measured the maximum angular displacement of forward flexion, that is, how far the subject could move in the sagittal plane. The effect of the initial posture on the range of forward flexion has been largely ignored. In terms of maximum range of forward flexion, this study found that male subjects have a greater range than female subjects in the same age group. However, when a correction was made for the subject's starting posture, the amplitudes of the movement were not significantly different between males and females. The "maximum range" of forward flexion is therefore misleading and is influenced by the curvature of the spine at the outset of the movement.

Fernand and Fox (1985) measured lordotic angle on radiographs of 973 adults and reported that female subjects demonstrated a greater lumbar lordosis than male, a difference which was independent of age.Therefore the female subjects in our study may have had a more accentuated initial lumbar lordosis than male subjects in the same age group.

Age effects on range of motion

There is a general acceptance of the theory that mobility of the spine decreases with advancing age. This finding has been particularly reported for the sagittal and coronal planes (Einkauf et al 1987, Fitzgerald et al 1983, Moll et al 1972). It is not clear whether the reduction in range is an independent variable, reflecting spontaneous changes in the mechanical properties of the tissues, or related to lifestyle changes occurring as a result of functional inactivity (White and Panjabi 1990 p.349). There is little information concerning motion in the horizontal plane, largely because of methodological problems. Most of the studies into spinal mobility have confined measurements to movements in the sagittal and coronal planes. It has previously proved difficult to measure lumbar rotation in the living, either directly or radiographically, with any degree of accuracy (Einkauf et al 1987, Taylor and Twomey 1980).

The maintenance of range of axial rotation in the lumbar spine across the age range tested is interesting and somewhat unexpected. Although the findings of our study confirm those of Hindle et al (1990), they are somewhat at variance with those of Taylor and Twomey (1980). This may be attributable to variations in the populations studied. For the present study, active, independent older subjects were deliberately recruited. Thus the maintenance of their range may be due to their preservation of a relatively active lifestyle. More research into spinal range of motion in subjects with active and inactive life style is needed to determine the effects of level of physical activity on spinal mobility.

The decrease in range of forward flexion without decrease in axial rotation may be explained, at least in part, by the functions of, and the age-related changes in, the apophyseal joints of the lumbar spine. The lumbar apophyseal joints not only restrict axial rotation but also prevent excessive forward flexion. The anteromedial third of the facet joint, which is orientated in the coronal plane, limits the forward translational component of forward flexion. The posterior two-thirds, lying in the sagittal plane, restricts axial rotation (Twomey and Taylor 1984). Sclerotic changes and thickening of the articular cartilage occur particularly in the coronal component of the superior articular process more than in the sagittal component. This sclerosis may lead to a limitation in range of forward flexion.

The decrease in range of forward flexion could also be associated with progressive postural change. Our research confirmed the general observation that older subjects develop a more kyphotic posture, thereby reducing their range of forward flexion, although they are still able to reach forward. This group of subjects may not be concerned by their decreased range of forward flexion during daily activities, because the movement of forward flexion can be compensated for by many combinations of movement of the hip and knee joints.

This study showed that lateral flexion demonstrated the greatest decrease in range of motion with increasing age. One possible explanation for this is that lateral flexion is not regularly performed in daily activities and this may lead to adaptive shortening of muscles and soft tissues in the direction of side bending.

Hindle et al (1990) have suggested that, overall, the coupled movements of the lumbar spine tend to be affected in the same manner as the primary movements, being reduced with age. However, the ranges of the coupled movements were not reported. Our results do not support these conclusions. We have found no clear age-related changes in the ranges of the coupled movements of the lumbar spine.

Within each movement speed tested, our study showed linearly declining relationships between angular velocity and age for both genders. The only exception to this was preferred speed axial rotation, which retained its velocity across the age range. This suggests that, with advancing age, the reduction in speed of motion is inevitable and unrelated to subject's functional activity level.

Speed effects on range of motion

The study compared the movement ranges between the preferred and fast speeds to clarify whether the range of

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motion demonstrated was independent of the speed at which it was performed. During forward flexion, it was observed that the subject's range was limited by compression of the abdominal soft tissues. Therefore, the fact that no speed effects on range of forward flexion were detected was not surprising.

A general trend for increasing range of axial rotation with the fast speed was found in all groups. A simple explanation for this would be the effect of the body's inertia. When the trunk rotates with a high angular velocity it possesses greater angular momentum, increasing the range of movement. It was observed that, when the subjects were asked to rotate at a faster speed, they tended to overshoot on returning to the midline neutral position.

By the same principles, a similar change in lateral flexion might have been expected at the faster speed. However, as the subjects moved their trunk away from the stable midline position and displaced their weight vector towards the perimeter of their base of support, they may have felt less stable. In order to minimise this instability, they limited the range of motion and did not reach the end of range. Thus a general trend towards a decreasing range of lateral flexion with increasing speed was noted.

Clinical implications

Spinal range of motion has long been considered an acceptable means of evaluating impairment. Distinguishing between age-related and pathological limitations to spinal mobility in the clinic is difficult because the values of spinal mobility may vary widely within the same group (Fitzgerald et al 1983, Moll et al 1972, Taylor and Twomey 1980). Because ageing is associated with a general decrease in spinal mobility, the physiotherapist must be able to distinguish between age-related decreases and pathological limitations (Wolf et al 1979). When measuring spinal motion in the clinic, the physiotherapist should be aware of normal values for each motion based on the client's age and gender.

Examining range alone will not provide enough information to determine the nature of a spinal disorder. Marras and Wongsam (1986) have suggested that the changes in trunk velocity associated with back pain or back injury are substantial and may be subjected to less variability compared to changes in range of motion. Therefore, the angular velocity of the spinal motion should be considered in the assessment of the spine. However, there are practical and methodological difficulties associated with this measurement.

During clinical assessment of clients with back pain, the complexity of the patterns of movement may confuse the physical finding. For example, if pain is reported during lateral flexion or axial rotation, the pain might arise from either the primary movement or its coupled movements. Although ranges of the coupled movements are small compared with the primary movement, their patterns are very consistent. In such cases, the physiotherapist needs to be concerned with which movement or what direction causes the pain. This study found no substantial coupled lateral flexion or axial rotation with forward flexion, so it might be expected that pain on that movement would be a function of the primary rather than any coupled motion. However, no data were available for movement coupling in subjects with back pain. It is important that investigation of coupled movements is repeated using symptomatic subjects.

In common with other studies, this study demonstrated a significant decrease in lumbar range of motion with increasing age. Forward flexion and lateral flexion show the greatest decreases. Range of motion declined most markedly between the young, middle-aged and older subjects in both genders. No significant differences were found between Groups A and B in any of the movements in either gender. We are not convinced that these findings indicate a need for specific range of motion exercises in otherwise active elderly people and suggest that the preservation of function in older people indicates that such decreases in range and velocity are benign characteristics of ageing. Further research into the kinematics of specific spinal disorders and the benefits of maintenance programs are needed.

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