The prevalence and radiological findings in 1347 elderly patients with scoliosis


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In order to determine the epidemiology of adult scoliosis in the elderly and to analyse the radiological parameters and symptoms related to adult scoliosis, we carried out a prospective cross-sectional radiological study on 1347 adult volunteers. There were 615 men and 732 women with a mean age of 73.3 years (60 to 94), and a mean Cobb angle of 7.55° (SD 5.95).

In our study, 478 subjects met the definition of scoliosis (Cobb angle ≥ 10°) showing a prevalence of 35.5%. There was a significant difference in the epidemiological distribution and prevalence between the age and gender groups. The older adults showed a larger prevalence and more severe scoliosis, more prominent in women (p = 0.004). Women were more affected by adult scoliosis and showed more linear correlation with age (p < 0.001). Symptoms were more severe in those with scoliosis than in the normal group, but were similar between the mild, moderate and severe scoliosis groups (p = 0.224) and between men and women (p = 0.231).

Adult scoliosis showed a significant relationship with lateral listhesis, vertebral rotation, lumbar hypolordosis, sagittal imbalance and a high level of the L4-5 disc (p < 0.0001, p < 0.0001, p = 0.002, p < 0.0001 respectively). Lateral listhesis, lumbar hypolordosis and sagittal imbalance were related to symptoms (p < 0.0001, p = 0.001, p < 0.0001 respectively).

Perceptions concerning scoliosis in adults have been changing. Adult scoliosis is becoming of greater significance with the ageing of the general population worldwide, the increased attention to quality of life and the increase in degenerative pathological conditions in the elderly.1-4 There have been several studies of the prevalence and radiological changes in adult scoliosis. The prevalence in the general population has been reported to range from 1.4% to 32%.5-8 Recently, Schwab et al2 recorded an incidence of 68% of adult scoliosis in 75 elderly volunteers. They showed that although many patients had pain and dysfunction, there appeared to be a large group with no marked physical or social impairment. There have been various reports on the related radiological factors.1-3,9-14 Glassman et al14 presented the parameters associated with the patient-based outcome measures in 298 adults with scoliosis. They examined the type of curve, its location, its magnitude, the coronal balance, the sagittal balance, apical rotation and rotatory subluxation, and found that sagittal balance was the most reliable predictor of symptoms. However, little is known about the prevalence of adult scoliosis and its epidemiology compared with idiopathic scoliosis, and no relationship has been established between the radiological parameters and adult scoliosis. The questions which arise are whether focal radiological parameters that can be identified in adult scoliosis play an important role in its management and the epidemiology of adult scoliosis in a large population. Our aim was to determine the prevalence of adult scoliosis and to identify the radiological parameters and symptoms related to it in a large, elderly population of volunteers.

Subjects and Methods
The subjects were recruited from a health promotion programme in a number of centres for the elderly between 2006 and 2009. The programmes included social (sport, recreation, cooking, etc) and medical (hygiene care, physiotherapy, rehabilitation, etc) activities for the elderly. The subjects were recruited randomly, regardless of their level of activity or mobility. The ethics committee of our institutional review board approved the study. The radiological evaluation was performed in
14 meeting centres and 1522 adult volunteers were enrolled. The exclusion criteria were < 60 years, previous surgical procedures on the spine and a previous diagnosis of adult or adolescent idiopathic scoliosis. Overall, 1347 volunteers met the appropriate criteria and their radiological parameters were evaluated. A self-reported visual analogue scale (VAS) was used to assess pain. Each volunteer completed a questionnaire regarding general details, symptoms (VAS 0 to 10) and other previously diagnosed disease which could affect the quality of bone such as osteoporosis, chronic renal disease, metabolic bone disease, etc.

All the subjects had whole spine posteroanterior and lateral radiographs taken standing by a single technician at a standard distance of 180 cm using a standard technique and the same x-ray machine. The volunteers were divided into three age groups: 60 to 69, 70 to 79 and ≥ 80 years. They were also divided into those who had both thoracolumbar/lumbar or thoracic scoliosis according to their Cobb angle as follows: < 10°, 10° to 19°, 20° to 29° and ≥ 30°. Those with a Cobb angle ≥ 10° in the coronal plane were defined as having adult scoliosis. The radiological measures of deformity were recorded digitally using the picture archiving computer-analysis system (PACS; Infinitt 2004, Seoul, South Korea). Parameters measured in the coronal plane included the location of the curve, its magnitude, the number of vertebrae in each curve, the direction of the curve, lateral listhesis, vertebral rotation and the level of the L4-5 disc space. Measurements in the sagittal plane included thoracic kyphosis, lumbar lordosis, spondylolisthesis, the sagittal balance and the presence of a compression fracture. All the measurements were performed independently by two spinal fellows (JYH, HNM) in order to decrease the intra-observer (interclass correlation (> 0.91, 95% confidence interval (CI) 0.88 to 0.94) and inter-observer error (intraclass correlation coefficient > 0.88, 95% CI 0.82 to 0.90).

Lateral listhesis was defined as a slip ≥ 5 mm between two adjacent vertebrae using the centroid method and spondylolisthesis as a slip of similar amount on the lateral radiograph. Thoracic kyphosis was measured between the T2 and T12 vertebrae and hyper-kyphosis was defined as a kyphosis ≥ 40°. Lumbar lordosis was measured between the L1-5 vertebrae using the Cobb method, and hypolordosis was defined as lordosis ≤ 20°. Sagittal balance was determined by comparing the vertical line from C7 to the posterosuperior border of the sacrum, and sagittal imbalance was defined as deviation from this line ≥ 20 mm. The level of the L4-5 disc space was measured to compare the intercrest line. A high L4-5 disc was defined as at a level through or above the intercrest line. Vertebral rotation was defined as more than grade II (Nash-Moe). A compression fracture was defined as collapse of > 10% compared with the mean height of the adjacent two vertebrae.

Statistical analysis. The data were analysed to determine the relationship between the radiological parameters, the severity of pain and adult scoliosis using SPSS version 13.0 (SPSS Inc., Chicago, Illinois). Data were analysed using the chi-squared, Fisher’s exact, analysis of variance (ANOVA) and t-tests. A p-value 0.05 was considered to be significant.

Results

Epidemiological distribution. There were 1347 volunteers (615 men, 732 women) with a mean age of 73.3 years (60.0 to 94.0) with 374, 739 and 234 in the 60 to 69, 70 to 79 and ≥ 80 age groups, respectively. The mean Cobb angle was 7.55° (SD 5.95) and the mean number of affected vertebrae was 5.62 (2 to 10). Of the 1347 subjects, 420, 47 and 11 had a Cobb angle of 10° to 19°, 20° to 29° and ≥ 30°, respectively. Thus, in the study group, 478 subjects (171 men, 307 women) met the definition of adult scoliosis with a Cobb angle ≥ 10°. The prevalence was 35.5%. The mean age and Cobb angle of the scoliosis group was 73.9 years (60.0 to 90.0) and 14.00° (SD 4.78), respectively. The distribution of the curve patterns of the scoliosis group was thoracic in nine (1.9%), thoracolumbar in 167 (34.9%), lumbar in 234 (49%) with 68 (14.2%) of patients having a thoracic and thoracolumbar/lumbar double curve. The direction of the main curve was to the right in 254 (53.13%) and to the left in 223 (46.65%). In all the groups, epidemiological distributions of the male, female and combined group divided by age and Cobb angle were significantly different (chi-squared test and Fisher’s exact test, p = 0.01, p = 0.001, p < 0.0001 respectively), and most did not have a notable curve. Mild scoliosis was found in all age groups with women aged ≥ 80 years having a higher percentage of those with mild scoliosis. In the male group a severe degree of scoliosis was not found in any group but in those aged ≥ 80 there was a higher percentage of moderate scoliosis than in the younger groups, and the group aged 60 to 69 years had a higher percentage of mild scoliosis than did the other groups. In the female and the combined groups, the percentage of moderate and severe scoliosis was higher in the older age group. The ≥ 80 year group had the highest and the 60- to 69-year group had the lowest percentage of moderate and severe scoliosis.

Prevalence and symptoms. There was a significant difference in the prevalence, the mean Cobb angle and the mean Cobb angle of those with scoliosis according to age and gender. The mean Cobb angle increased with age in the female and combined groups (ANOVA, p < 0.0001). The prevalence of scoliosis increased significantly in proportion to age in the female and combined groups (chi-squared, p < 0.0001, p = 0.004), and was prominent in the female group. However, there was no significant difference in the prevalence and mean Cobb angle between the different ages in men (ANOVA, p = 0.214), but the mean Cobb angle in those aged ≥ 80 years with scoliosis was significantly higher than in the other age groups in men (ANOVA, p = 0.041). The mean Cobb angle of those with scoliosis was significantly different between age groups in both the female and combined groups (ANOVA, p = 0.005, p = 0.001). The mean Cobb angle was higher in women than in men (8.51° vs 6.40°, t-test, p < 0.0001), and the mean Cobb
angle of those with scoliosis was significantly different between women and men (14.52° vs 13.06°, t-test, p = 0.001). The prevalence was also higher in women than in men (41.9% vs 27.8%, chi-squared test, p < 0.0001). Symptoms were more severe in those with scoliosis than in those without (chi-squared, p < 0.0001). The symptoms in the normal group were significantly different from other groups in both men and women (t-test, p < 0.0001). However, the severity of pain did not differ between the mild, moderate and severe scoliosis groups (ANOVA, p = 0.244), or between age groups in those with scoliosis (ANOVA, p = 0.098). The symptoms did not differ between women and men with scoliosis.

Radiological parameters. There was a significant difference in the incidence of the five measured parameters in the four groups of severity, and between those with scoliosis and those without (lateral listhesis, vertebral rotation, L4-5, hypolordosis and sagittal imbalance; p < 0.0001, p < 0.0001, p < 0.0001, p = 0.002, p = 0.002, chi-squared test). The moderate and severe scoliosis groups had a higher incidence of lateral listhesis and vertebral rotation, which was higher in the combined than in the normal group. The severe scoliosis group had a higher incidence of a high L4-5 disc, which was also greater in the combined than in the normal groups. In analysis of the radiographs in the sagittal plane, the moderate and severe scoliosis groups had a higher incidence of hypolordosis and sagittal imbalance, which was higher in the combined group than in the normal group. However, there was no significant difference in the incidence of spondylolisthesis, compression fracture and thoracic kyphosis between the severity groups and between the normal and combined groups (chi-squared test, p = 0.348, p = 0.348, p = 0.321). In the analysis of the radiological parameters in those with symptoms, the levels of lateral listhesis, hypolordosis and sagittal imbalance were related to the severity of the pain (t-test, p < 0.0001, p = 0.0001, p < 0.0001).

Discussion

More patients are being diagnosed with adult scoliosis. Although the clinical course is benign in the early stage, degenerative scoliosis can develop into a debilitating condition. It may be thought of as the asymmetrical collapse of a disc along with associated incompetence and hypertrophy of the facet joints, leading to a lateral and rotational deformity. The deformity progresses with varying degrees of central and lateral recess and foraminal stenosis.\(^1\)\(^\text{3-4,18}\) If not treated appropriately, patients with degenerative scoliosis may present with severe, unrelenting pain in the back and leg, claudication and a considerable deterioration in their quality of life. Treatment ranges from observation to extensive combined anterior and posterior reconstruction.\(^3\)\(^\text{18}\) The early detection and treatment of adult scoliosis are important in the elderly and surgeons should be aware of the epidemiology, prevalence and related radiological changes. However, there have been few studies in a large elderly volunteer population.\(^2\)\(^\text{5-8}\) Robin et al\(^19\) recorded a higher rate of scoliosis in patients aged between 65 and 84 years and noted that 394 of 554 patients with osteoporosis had some degree of scoliosis. Recently, Schwab et al\(^2\) observed that 68% of 75 asymptomatic patients older than 60 years had scoliosis. They noted that these elderly people described themselves as normal and proceeded with their lives regardless of back pain.

In our study, the subjects were elderly volunteers. The female and elderly dominance of this group may have contributed to the higher prevalence but the demographic shift and increase in degenerative disease reflect the worldwide trend of adult scoliosis.

Degenerative disc disease, facet arthritis and lateral listhesis have been implicated as factors in the development of degenerative scoliosis.\(^1\)\(^\text{2,10,11,14}\) These conditions commonly progress with ageing, and account for the high prevalence and severity of adult scoliosis. Women are generally more affected and show a more linear correlation with age, although Robin et al\(^19\) found no relation of adult scoliosis to gender and Schwab et al\(^2\) observed that the proportion of men to women was not statistically significant in their study.

Our study evaluated radiological factors which had a proven association with adult scoliosis in the literature.\(^1\)\(^,3,7,12,14,18,20-23\) Degenerative scoliosis may be thought of as an asymmetrical collapse of the disc and incompetence of the facet joints, leading to lateral listhesis. Korovessis et al\(^7\) showed that lateral listhesis of the apical vertebra was related to the progression of scoliosis. They observed in a study of 91 patients that this was not a late phenomenon, but an initial characteristic of adult scoliosis. Our study also showed a high incidence of lateral listhesis which was seen in almost half of the moderate and severe groups. Lateral listhesis is more common in those with severe and moderate degrees of scoliosis, which may be related to the development of the deformity, but the patients in our study showed some degree of lateral listhesis even when the grade of scoliosis was mild (18.3%). It has been suggested that this is a late complication of adult scoliosis,\(^7,18\) but it appears that it is both a late phenomenon and an initial characteristic of degenerative scoliosis. Its presence corresponded to our finding that severe pain can occur in the early stages of scoliosis. Vertebral rotation and the level of the L4-5 disc are independent factors in adult scoliosis. Previous studies have observed that when the intercrest line passes through the disc space of L4-5 or below, it produces an unstable lower lumbar balance resulting in the progression of all curves.\(^1\)\(^,3,12,22,23\) Prominence of the L5 vertebrae was considered in these studies to be an important predictive factor in the progression of the curve as was the degree of vertebral rotation. In our study, the incidence of this rotation and elevation of the L4-5 disc were higher in the scoliosis group, with the highest incidence in those with severe scoliosis. A high L4-5 disc causes extra instability resulting in severe scoliosis and apical vertebral rotation is closely related to the progression of advanced scoliosis, but these factors were not associated with the severity of symptoms.
In the 200 adult patients with scoliosis examined by Pritchett and Bortel,\textsuperscript{1} degenerative spondylolisthesis coexisted in 111. Adult patients with a degenerative spondylolisthesis, can show a different pelvic orientation as well as sagittal alignment.\textsuperscript{24} However, in our study, the incidence of spondylolisthesis was not significantly higher.

Herkowitz and Kurz\textsuperscript{21} observed that compression fractures were associated with adult scoliosis. They suggested that adult scoliosis developed from the symmetrical degeneration of discs, osteoporosis and fractures of the vertebral body, which could also cause thoracic kyphosis or lumbar hypolordosis. We observed that some patients with advanced scoliosos had compression fractures with concomitant thoracic kyphosis or lumbar lordosis, but the incidence was not significantly higher than those with scoliosis.

The incidence of lumbar hypolordosis and sagittal imbalance was significantly higher in the scoliosis group, and those features appeared to represent a critical change in adult scoliosis.\textsuperscript{1,12-14,20} The condition is a complex three-dimensional change with axial rotation and coronal and sagittal tilting of the vertebra. During the progression of the scoliosis the three-dimensional spinal alignments can collapse. Lumbar hypolordosis and sagittal imbalance occur gradually with the progression of adult scoliosis, and are related to symptoms.

There were some limitations in our study. Although we randomly analysed the elderly volunteers who participated in the health promotion programme regardless of their mobility, most came to the elderly meeting centres independently and were much more mobile than a patient with degenerative scoliosis and back pain who attends a clinic seeking treatment. However, in terms of the types of curve, lumbar and thoracolumbar were the most common, and these findings correspond to those in the literature.\textsuperscript{3,18,20}

Generally, degenerative spinal disease occurs in the lumbar area and this is the site most commonly affected in adult scoliosis. However, in our study, 14.3% of subjects had a double curvature. Although the single-thoracic or double-curvature type of scoliosis can originate from the degenerative process, it can be assumed that some part of adult scoliosis may originate from adolescent idiopathic scoliosis which commonly shows these types of curvature.

We evaluated osteoporosis retrospectively and it was present in many of our subjects. It can be a possible factor in development of scoliosis but we could not confirm a relationship.

There was a prevalence of adult scoliosis in 478 (35.5%) of the 1347 elderly volunteers. This incidence was higher than that observed in previous studies, and higher in women. There was a significant difference in the epidemiological distribution and prevalence between the age and gender groups. The older group showed a higher prevalence and more severe scoliosis in women. Those with scoliosis suffered from more severe pain than the normal population, but the symptoms were not in proportion to the Cobb angle.

Supplementary material

Five tables showing i) epidemiological distribution of the subjects by age, ii) prevalence and Cobb angle of the subjects, iii) visual analogue scale (VAS) of the subjects iv) details of the incidence of the radiological parameters and v) correlation between the VAS and the radiological parameters are available with the online version of this article on our website at www.jbjs.org.uk

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References

15. Cobb JR. Outline for the study of scoliosis. AADS Instructional course Lectures, 1948:5,261-75.