Original Article

Radio-morphometric evaluation of clinical and sub-clinical forms of scoliosis in postmenopausal women

Ioannis P. Itounas¹, Dimitris A. Nikolaou²¹Radiology Department, KAT General Hospital, Athens, Greece; ²Private Practice Physiotherapist, Athens, Greece**Abstract****Objectives:** To evaluate the age-dependent changes of the spine in postmenopausal women with adult scoliosis.**Methods:** We screened 180 postmenopausal women who presented within a year for an X-ray evaluation in our Radiology Department. Only postmenopausal women without previous surgery of the spine and with a Cobb's angle of more than 10° were included in the analysis. The acquired X-rays were assessed with the 'SCODIAC' software - evaluating the Cobb's angle, Ferguson's angle, the vertebrae's rotation and the overall torsion of the spinal cord.**Results:** 60/180 women met the inclusion and exclusion criteria and were included in the analysis, in four age-groups (per decade of age) of equal number of subjects (N=15). Their mean age was 70,5 years and mean age of menopause was 50 years. 23% were classified as 'obese', 52% 'overweight' and 25% 'normal'. Mean BMI was 27.45 Kgr/m². 28% were not screened for osteoporosis. 22% of the evaluated subjects had osteoporosis, 38% osteopenia and 12% were normal. The percentage of individuals suffering from degenerative scoliosis, was 27%, 67%, 87% and 73% for each age group respectively. The average of the overall torsion was 23.9°, 19.5°, 23.7° and 32.1°. Percentage of subjects without any participation in 'exercise' was 47%, 40%, 87% and 67% respectively. **Conclusion:** Postmenopausal women presenting primary or secondary osteoporosis alongside high 'BMI' index and/or low levels of physical activity, are prone to cumulative degeneration of the spine resulting in clinical and sub-clinical scoliosis.**Keywords:** Anterior/posterior spine screening, Degeneration of spine, Postmenopausal women, adult scoliosis, 'SCODIAC' software

Introductory - The scoliotic deformity

The international word 'scoliosis' derives from the Greek word 'scolios', which stands for 'distorted'. Scoliosis is defined as the lateral deviation or curvature of the spine at the frontal plane¹. Radio-anatomically the vertebral column (V.C.) is distinguished into the following segments: the cervical, the thoracic and the lumbar spine, the sacral bone and last but not least the coccyx. Each vertebra consists of a vertebral body, a vertebral arch and the associated processes - the articular ones (superior and inferior), transverse and spinous process. The posterior part of each vertebral body, along with the arch, form the vertebral foramen. The summary of the vertebral foramens, form the spinal cavity. The spinal cord is located in the anterior of that particular cavity, surrounded by structures such as the arachnoid mater and the meninges².

Radio-graphical evaluation of scoliosis can be performed via anterior-posterior (AP) x-ray imaging of the spine, while the subject is in erect position, as shown in Figure 1 A. In the

AP x-ray imaging of the V.C., the vertebral bodies as well the inter-vertebral spaces are easily distinguished, being the same width for each individual part of the spinal cord. The vertebrae arch necks look like two oval formations that are projected into the lateral aspects of the spine, as shown in Figure 1 A, B. The spacing of these vertebrae's neck borders (pedicles), corresponds to the transverse diameter of the spinal canal.

Depending on the subject's age, scoliosis can be

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Figure 1. (A) Anterior-Posterior X-ray imaging of the spine. (B) Graphic representation of a vertebrae and its distinctive parts.

distinguished into: childhood or adolescent scoliosis and adult scoliosis. Adult scoliosis can be either the result of the progression of the childhood/adolescent scoliosis, or a '*de novo*' deformity - a vertebral deformity of its own. In some cases, it can be due to a secondary cause of vertebral degeneration³.

With regard to the angle of deformation, also referred to as the 'Cobb's angle', it should be greater than ten (10) degrees when evaluated at the coronary plane, in order to be of diagnostic value. That distinctive finding would also affect the subject, in the respective levels of axial and sagittal plane. Distinguishing '*de novo*' scoliosis from a case of degenerative idiopathic scoliosis, is a rather demanding task^{4,5}. Usually, when it comes to juvenile patients presenting a Cobb's angle greater than forty (40) degrees, a compensatory curve and spine rotation throughout, idiopathic scoliosis is initiated at a young age. Degenerative scoliosis turns to be 'noticeable' around 50 years of age - without excluding a later manifestation and subsequently detection. Usually, in these cases, the Cobb's angle is found to be less than forty (40) degrees. Other clinical findings include the following:

- Partial spinal torsion
- Vertebral stenosis
- Lateral subluxation of the spine
- Imbalance in the level of the sagittal plane⁶

As mentioned above, adult scoliosis might be the result of the progressive development of idiopathic scoliosis in children and adolescents or from degenerative ('*de novo*') scoliosis⁷. The case of idiopathic adult scoliosis, is not stable throughout the individual's life. There are age-related alterations that affect the spinal cord and the associated curvatures as well⁸. Primary degenerative or '*de novo*' scoliosis and secondary degenerative scoliosis,

is met in individuals with no known history of adolescent scoliosis. It usually occurs after the age of 40 years. Spinal deformation, is defined as a three-dimensional deformity, bearing distinctive characteristics given from a plethora of degenerative changes such as arthritis, disc degeneration, compressive fractures and spinal stenosis.

Being driven by the aforementioned publications, we thought of carrying out a project aiming at the evaluation of postmenopausal women suffering from some distinctive case of age-dependent scoliosis. The application "SCODIAC" was used during our study for the performance of radio-morphometric evaluation.

Materials and methods

180 women were initially evaluated in the radiological department of our Hospital in order of appearance. All of them were outpatients and were referred by their attending physicians to perform AP X-ray imaging of the thoracic and lumbar spine. Our inclusion criteria were: a) sex: female, b) postmenopausal status of >2 years, c) Cobb's angle >10 degrees in the AP projection of the thoracic and lumbar spine. We excluded subjects who had undergone any kind of spinal surgery, such as laminectomy, spinal fusion surgery, kyphoplasty etc. All radiographic images of low quality were also excluded from evaluation. We received a detailed personal medical history from each of the 180 women initially evaluated, and all of them signed informed consent in order to participate in the study.

Radio-morphometric evaluation

Prior to the radio-morphometrical procedure, the patient was given two-hundred and fifty (250) ml of water, so the

Figure 2. Cobb's angle measurement .

aqueous levels in the subject's stomach, can be used as a reference for his/her proper positioning⁹. During the radiographic evaluation, any kind of clothing, jewelry or other metal objects that could possibly affect the procedure as well the results, was asked to be removed. The patient was placed in an erect AP position with upper extremities alongside the torso. The lower extremities were placed slightly open (barefoot), with the body weight equally distributed on each foot. The subject's back area was in a resting position, on the image receptor (IR), so a true visualization of the spine's position during walking could be achieved. One important thing for the associated examiner, is to ensure that the patient is aligned centrally to the IR. Last but not least, the rotation of the hip joints as well the shoulder joints, should be the minimum possible (some rotation inherent to scoliosis may be inevitable)¹⁰.

The later step on our study was the evaluation of the Cobb's angle, the Ferguson's angle as well the rotation of the respective spinal segments, via the use of the 'SCODIAC' software. In order to use properly the 'SCODIAC' software, it is of great necessity to have an insight of the anatomy of the vertebrae. That would grant the examiner the opportunity to properly distinguish the associated fundamental bony structures, on the x-ray imaging. This particular evaluation tool, is provided by researchers Pavel Cerny, PhD, Eng., CPO (Czech Republic) and Lukasz Stolinski, PhD, PT (Poland). The title of the software derives from the 'SCOliotic DIAGnostiCs', and is provided free for distribution among students, clinicians and researchers. In order to initiate the whole process, an anterior-posterior x-ray image of the subject's V.C. was required to be loaded, while being off-line.

Radio-morphometric evaluation via the 'SCODIAC' application

An important part of the evaluation procedure, is to place the individual's x-ray film on a PC screen, correctly. That would require the positioning of the x-ray film's left side, to be ipsilateral regarding the examiner's left side of the body. In order to evaluate the Cobb's angle, one must first decide which vertebrae are the end-vertebrae of the curve deformity - the vertebrae whose endplates are most tilted towards each other. After that, lines are drawn along the endplates, and the angle between the two lines (where they intersect) is calculated (Figure 2). The so-called 'measurement error' that is permitted, is approximately three (3) to five (5) degrees in cases of mild scoliosis, and may increase up to ten (10) degrees in severe cases.

To evaluate the Ferguson's angle, we used the spinous processes of the aforementioned vertebrae - the ones we used, for the evaluation of the Cobb's angle (Figure 3). Ferguson's angle presents a slight greater sensitivity when it comes to incorrect selection of the end vertebrae, when it comes to Cobb's angle. It should be addressed that, in cases that the evaluation of Cobb's angle is technically difficult or invalid, the value of the Ferguson's angle should be adjusted by multiplying it by 1,35¹¹. Also, Ferguson's angle provides a more automated evaluation. Regarding the evaluation of the Ferguson angle: The associated measurements start from the lowest lumbar vertebrae, and proceed to the upper thoracic one. In our clinical study, 'a1' refers to the lumbar segment of the spine, and 'a2' to the thoracic.

Additionally, the rotation aspect of each vertebrae was evaluated. In order to achieve that, we marked the two upper and the two lower aspects of the vertebral body (their

Figure 3. Ferguson's angle measurement.

Figure 4. Evaluation of the vertebral rotation via the use of 'SCODIAC' software.

corners in order to be precise), as well the two oval-shaped formations of the neck of the vertebral arch (pedicles), as they can be seen in Figures 4 and 5.

Last but not least, an evaluation of the total torsion of the V.C., was performed by assessing the difference between the thoracic vertebrae presenting the highest degree of rotation, and the lumbar vertebrae of the same status. That particular methodology, is based on the properties of the geometric shape of the vertebrae and their distinguished dimensional

proportions. That means that the relation between the vertebral body width and the height does not change significantly within the entire thoracic and lumbar segments of the spine (Figure 5).

Therefore, the data gathered as part of the individual's personal anamnesis, were archived using the respective tools e.g. Microsoft excel program etc. The clinical record and the measurements of the cases of each category were placed in four tables.

The first table is consisted by the distinctive serial numbers of the subjects, the date of examination, the date of birth, the menopause age, the height, the weight and the body mass index ('B.M.I'). The second table encloses the measurements regarding the Cobb's angle, the Ferguson angle, the vertebral rotation of each individual vertebrae (thoracic and lumbar spine) and the total torsion of the spine. The third table depicts the state of osteoporosis, in respect to the t-score findings, when available and the type of scoliosis. Specially, cases with idiopathic scoliosis were classified by King's classification. Last but not least, the fourth table consists of the associated physical activities, the self-mentioned pain, other diseases, past surgical operations, recent or past fractures, number of births and the associated abuses such as smoking or/and drinking.

Results

Only sixty (60) out of the 180 women initially assessed fulfilled the inclusion and exclusion criteria and were included in the analysis. Their age was 51-91 y and all suffered from mild, moderate or severe case of scoliosis degeneration. All of the subjects included in the analysis were classified into

Figure 5. Vertebral rotation and total spinal torsion measurements via SCODIAC software.

Cases	Cobb's angle	Torsion
Case 02A	24.6 degrees	68.2 degrees
Case 04A	21.9 degrees	69.0 degrees
Case 08A	28.4 degrees	59.9 degrees

Table 1. Cases of the first sub-category are defined by presenting the most excessive scoliosis angle, and torsion of the spine.

four distinctive sub-categories according to their age, in 4 age groups: 51-60 years old (N=15), 61-70 y (N=15), 71-80 y (N=15), >81 y (N=15).

Observations and commentary on the first sub-category

The subjects of the first sub-category, were assessed during a one (1) year and twenty-seven (27) days period of time. Their menopause age ranged from 37-54 y, with an average of 48. In regards to the BMI ranking, 60% were classified as 'overweight' while 33% were classified as 'normal weight'. Cobb A/B angles (Thoracic spine) ranged from 10.1 to 21.8 degrees, and the associated Ferguson a2 angles ranged from 5.2 to 26.1 degrees. On the other hand, on the lumbar segment of the spine, Cobb B/C angles ranged from 10.1 to 36.3 degrees. The Ferguson a1 angles, ranged from 7.1 to 36.4 degrees. The total amount of torsion of the spinal cord, was evaluated to be ranging from 6.4 to 69 degrees of rotation. A significant number of individuals (40%), were not screened for osteoporosis. That was due to lack of knowledge concerning the evaluation procedure, as well as due to their younger age. 73% of the assessed individuals (11

patients), suffered from cases of idiopathic scoliosis. Most of them met symptoms of chronic pain throughout the entire low back area. It is worth mentioning, that 53% of the associated patients, did not participate in any kind of physical activity.

From the first sub-category, three cases (number 2, 4 and 8 as well) (Table 1) are defined by presenting the most excessive scoliosis angle, and torsion of the spine. The aforementioned individuals, belonged to the range of osteopenia, while following hyper-tension treatment. They participated into a moderate physical activity regime, but they were classified as overweight. Last but not least, cases number 2 and 4, underwent a surgical procedure of total hysterectomy.

Observations and commentary on the second sub-category

The subjects of the second sub-category, were assessed during an exact one (1) year period of time. Their menopause age, ranged from 42-55 y, with an average of 49 y. In terms of BMI, 46% were classified as overweight while 27% were classified as 'normal weight' and 27% fell into the obese

	Osteopenia, Osteoporosis	Degenerative Scoliosis
1 st sub-category	47%	27%
2 nd sub-category	60%	67%
3 rd sub-category	67%	87%
4 rd sub-category	67%	73%

Table 2. The progress of the age is followed by an increase in the percentages of 'osteopenia-osteoporosis' and 'degenerative scoliosis' status.

	Obese	Overweight	Healthy
1 st sub-category	7%	60%	33%
2 nd sub-category	27%	46%	27%
3 rd sub-category	47%	40%	13%
4 th sub-category	13%	60%	27%

Table 3. Age-related increase of obesity status.

category. It seems that there was an age-related increase of the obesity in this particular sub-group.

Cobb A/B angles ranged from 11.1 to 53.1 degrees, and the associated Ferguson a2 angles ranged from 6.2 to 57.2 degrees. On the other hand, Cobb B/C angles ranged from 11.6 to 48.3 degrees. The Ferguson a1 angles, ranged from 8.8 to 38.2 degrees. The total amount of torsion of the spinal cord, was evaluated to be ranging from 7.5 to 60.2 degrees.

A rather small percentage of the patients (only 20%), were not screened for osteoporosis. In addition, 60% of the evaluated subjects, seemed to have abnormal levels of bone density. As expected, the ratio of individuals suffering from a case of degenerative scoliosis, was considerable - being 67%. What stands as thought provoking, is that when revisiting the results acquired from the two sub-categories of patients, the following observation can be made: as age progresses, we become witnesses of an increase in the percentages of 'osteopenia-osteoporosis' states and 'degenerative scoliosis' as well (Table 2).

Most of the individuals included in the second category (53%), attended some kind of physical activity. That particular finding comes in contrast, with our observation in the first category - in which the individuals, didn't attend any kind of physical activity.

The increase of the scoliosis angle, was accompanied by an increase in the total spinal torsion.

Observations and commentary on the third sub-category

The subjects of the third sub-category, were assessed during an eleven (11) months and twenty (20) days period

of time. Their menopause age, ranged from 35-55 y, with an average of 51. In terms of BMI, 40% were classified as overweight while 47% were defined as obese, and 13% were classified as 'normal weight'. As raised above, an age-related increase of obesity status is recorded (Table 3).

Cobb A/B angles (Thoracic spine) ranged from 10 to 20.7 degrees, and the associated Ferguson a2 angles ranged from 8.7 to 19.7 degrees. On the other hand, on the lumbar segment of the spine, Cobb B/C angles ranged from 10.2 to 29.7 degrees. The Ferguson a1 angles, ranged from 8.3 to 23.7 degrees. The total amount of torsion of the spinal cord, was evaluated to be ranging from 11.1 to 65.5 degrees of rotation. One observation, coming from the thorough review of the available numbers, is that the total spinal torsion doesn't not increase proportionally to the increase of the scoliosis angle. That leads to the conclusion that a large number of clinical factors contribute to the associated degeneration.

A narrow sample of individuals (26%), were not screened for osteoporosis. About 67% of the assessed individuals, presented a reduction of the bone mineral density. It is worth mentioning, that afore mentioned percentage (of individuals falling into the 'osteopenia-osteoporosis' sub-category) is the highest up to this point, among the sub-categories. Last but not least, the percentage of the degenerative scoliosis cases, is found to be as high as in the second sub-category and accounts for a percentage of 87% - which is the largest percentage thus far (Table 2).

Most individuals comprising the third sub-category (87%), were not participating in any kind of physical activity - that was due to lack of interest, not knowing the benefits of exercising or inability to engage due to illnesses or other disabilities.

Categories	Total torsion	Individuals without sports activity
1 st sub-category	23.9 Degrees	47%
2 nd sub-category	19.5 Degrees	40%
3 rd sub-category	23.7 Degrees	87%
4 th sub-category	32.1 Degrees	67%

Table 4. Average total torsion of subjects presenting degenerative scoliosis and average of the subjects without any participation in sports activity.

	Subcategories	Age range of menopause	Mean values of menopausal age	Mean values of biological age
	1 st	35-54 yrs	48 yrs	56.4 yrs
	2 nd	42-59 yrs	49 yrs	66.0 yrs
	3 rd	35-55 yrs	51 yrs	75.0 yrs
	4 th	46-60 yrs	52 yrs	84.6 yrs
	Average		50 yrs	70.5 yrs

Table 5. Age range and mean values of menopausal and biological age of the subcategories of the sample.

One final, fairly important observation, is that several cases such as e.g. number 2,4,6,9, 13 and 15, demonstrating a high level of total spinal cord torsion, suffered also by degenerative scoliosis as well osteoporosis - meeting more than one pre-disposing factors of secondary osteoporosis such as diabetes, rheumatic disease, inflammatory bowel disease etc.

Observations and commentary on the fourth sub-category

The individuals of the fourth sub-category, were assessed during a one (1) year and seven (7) days period of time. Their menopause age, ranged from that of 46-60 y, with an average being 52 y. In terms of BMI, 60% were classified as overweight while 13% were classified as obese, and 27% were classified as 'normal weight'. Following the trend that was established before, the one of the age-related increase of body weight, the fourth sub-category provides a distinctively larger number of 'overweight' individuals.

Cobb A/B angles (Thoracic spine) ranged from 10.7 to 27.5 degrees, and the associated Ferguson a2 angles ranged from 10.7 to 31.1 degrees. On the other hand, on the lumbar segment of the spine, Cobb B/C angles ranged from 11 to 39.7 degrees. The Ferguson a1 angles, ranged from 10.1 to 44.9 degrees. The total amount of torsion of the spinal cord, was evaluated to be ranging from 12.4 to 72.6 degrees of rotation.

An observation that we can make is that the average of the degrees of the total torsion of the spine of the evaluated patients of the fourth category with degenerative scoliosis

is 10 degrees higher than the subjects of the previous categories, which make us hypothesize that as the age of the patient increases, the level of the degeneration of the spine increases as well. It means that the level of the total torsion of the spine is also affected (Table 4).

A notable number of individuals (26%), were not screened for osteoporosis. About 67% of the assessed individuals, presented bone density levels above normal. The percentage of degenerative scoliosis of the evaluated subjects of the 4th category remains equally high (73%). Also, as expected, in this category a large percentage of the examined individuals (67%) had not any sports activity.

Discussion

Sixty (60) postmenopausal women, with a mean age of menopause being the fifty (50) years of age were evaluated (Table 5).

The age-factor of our sample spanned over an average of forty (40) years. Kicking off the age of fifty-one (51), it spanned till the ninety-one (91) years of age - 91 being the age of the oldest patient included in the study. The average biological age of the sample was 70.5 years (Table 5).

By taking a closer look at the Table 3, one can observe that there is a rather proportional age-related distribution. The single age-group that does not follow the rule is the third one. By excluding the individuals of 71-80 years of age, a proportional distribution of the BMI index can be found. For that reason we reached to the conclusion that the biological age does not influence the BMI index.

The third age-related sub-category (71-80 years old), was described as having the highest attendance at the

B.M.I	Number of women	Percentages
“Obese”	14	23%
“Overweight”	31	52%
“Normal”	15	25%
Total	60	100%

Table 6. Distribution of the percentages of the index “B.M.I.”.

radiology department. During the evaluation of which, we reached to the following commentaries:

The third sub-category of assessed patients presented the highest percentage of obesity (47%), the highest percentage of non-participation in physical exercise (87%), the highest rate of degenerative scoliosis measurements (87%) and at last a high percentage of osteopenia-osteoporosis state (67%). The percentage of osteopenia-osteoporosis was equal to the corresponding percentage of the fourth age-related sub-category.

In this current clinical study, we came across an average B.M.I. score of 26, 27 kg/m² in the first sub-category of subjects. Respectively, the second sub-category showcased an average B.M.I. score of 27, 35 kg/m², the third sub-category ranged at 29, 35 kg/m² and eventually the fourth one ranged at 26, 84 kg/m². The total average of B.M.I. scores ranged at 27, 45 kg/m² (overweight). It is implied that postmenopausal individuals, fall into the range of overweight status.

As aforementioned, in the current clinical study we did not include Cobb angles a/b (thoracic) and b/c (lumbar) found to be <10 degrees. As for the Ferguson angles, a2 (thoracic) and a1 (lumbar), we did not include those evaluated to be <5 degrees.

Cobb a/b angles ranged from 10.1–53.1 degrees and b/c angles ranged from 10.2–48.3 degrees. Ferguson angles ranged a2 from 5.2–57 degrees and a1 from 7.1–44.9 degrees. The total torsion of the spine ranged from 6.4 to 72.6 degrees.

Osteoporosis is a disorder of bone metabolism. When it comes to the structure of the bone tissue, there is a decrease in the quantity of it, which can lead to fracture and degenerative type of deformity of spine¹². The combination of these changes results in the spine losing its ability to maintain a normal shape. So the spine displays a degree of distortion, and as the progression goes, the scoliosis deformity progresses. We made a few more observations, regarding the assessed individuals' bone mineral density (B.M.D.). A percentage of 28% (17 evaluated subjects) did not know further information regarding their bone density, 12% (7 evaluated subjects) presented normal levels of B.M.D and 60% (36 evaluated subjects) were above normal levels. The aforementioned evaluated patients, suffer from primary osteoporosis or other cases of diseases such as

osteoarthritis (O.A.), rheumatic diseases, diabetes mellitus, hypertension, gastrointestinal disorders, neoplasms and mental illnesses. All of these factors, lead to the emergence and subsequent establishment of secondary osteoporosis.

We observed from our associated tables that three subjects of the first sub-category, three subjects of the second sub-category, two subjects of the third sub-category and three subjects of the fourth sub-category, suffered from scoliosis with a Cobb angle more than 20 degrees. All of the above mentioned cases, have an increased B.M.I. (overweight or obese), have a loss of bone density (osteopenic or osteoporotic) and suffer from a disease that could eventually cause secondary osteoporosis.

Our findings support the statement that the unique combination of primary or secondary osteoporosis with an increased B.M.I. index, and low levels of physical activity ('P.A.') are clinical factors that interact with each other and further degenerate the spinal cord - resulting into the manifestation of degenerative ('De Novo') scoliosis. In cases of idiopathic scoliosis, the aforementioned degeneration leads to a further increase of the scoliosis angle. In particular, the identified degeneration, is closely associated to clinical components such as e.g. the age, the physical activity ('P.A.'), the eating habits, the B.M.I. index, the loss of bone mineral density, and the undergoing medication. What granted as extremely demanding, is the determination of the degree of 'contribution' of the above-mentioned clinical factors to the whole degeneration.

Strengths and limitations

The current clinical study, was carried out at 'K.A.T.' hospital, one of the biggest hospitals in Attica with clear orientation in orthopedics and trauma. The recruitment of the sample, comprised a relatively large number of postmenopausal women (180). The available X-rays, as well additional clinical data, were evaluated by two different individuals working independently. That way, a relative accuracy was achieved. Last but not least, the individuals working on the material, were of different scientific expertise. That enhances the importance of the interdisciplinary approach, and 'sets the ground' for further research.

A significant limitation of our study, was the relatively small number of subjects participating. Additionally, it wasn't possible to re-evaluate the aforementioned individuals. That

would assist the assessment of the possible progression of the scoliosis angle.

Conclusion

During our clinical study, we evaluated concurrently, a great number of distinctive clinical factors. We proceeded by studying these factors as independent causes, as well as interacting with each other. In both cases, we concluded that they share a fair amount of responsibility when it comes to the degeneration of the spinal cord, and the increase of the Cobb angle. Our points can be seen as follows:

1. The Cobb angle is partially affected by the evaluated total torsion of the spine. Needless to say, the associated changes are defined as an independent clinical factor.
2. The total torsion of the spine is corresponding to the individual's age.
3. BMI is considered to be an independent factor.
4. A great number of postmenopausal women, fall into the range of "overweight" classification.
5. The osteoporosis, osteopenia and degenerative scoliosis status, are in alignment with the increase of the age.
6. Postmenopausal women aged 71-80 are faced with many clinical factors simultaneously and are the most accessible sub-category in the hospital.
7. Reported degeneration of the spine can be classified as primary ('*De novo*') or secondary. The primary one commences through degenerative alterations that can be located on the intervertebral discs. On the other hand, the secondary one expresses the alteration of the vertebral bodies due to osteoporosis or spondylosis - the secondary type of degeneration, leads to further increase in the scoliotic angle.

In conclusion our study implies that a postmenopausal woman suffers from a sub-clinical form of degenerative scoliosis when clinical factors as low BMD, high BMI, vertebral fracture(s), predisposing comorbidities of secondary osteoporosis, self-reported back pain, drinking and smoking habits, and lack of physical exercise of any kind can be detected. The undergoing of the X-ray imaging will simply, but firmly, confirms and define the state of degeneration. For that purpose, the 'SCODIAC' application could be a great assistance.

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Author contributions

Both I.P.I. and D.A.N. wrote the paper. I.P.I. collected all the data and D.A.N. supervised the data observations and results.

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