*Corresponding author. Department of Morphology and Physiology, Faculty of Health Sciences, Semmelweis University, Vas utca 17, Budapest H-1088, Hungary.
E-mail: tamas.valasek@gmail.com

Anatomical changes of the thoracic vertebrae in asymptomatic individuals – A cross-sectional study

T. VALASEK^{1*}, E. VÁGÓ², ZS. DANIELISZ³, M. BABKA³ and É. KOVÁCS¹

¹ Department of Morphology and Physiology, Faculty of Health Sciences, Semmelweis University, Budapest, Hungary

² New Saint John's Central Hospital and Outpatient Clinic of North and Middle Buda, Budapest, Hungary

³ Department of Radiology, St Rókus Hospital, Budapest, Hungary

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ABSTRACT

Purpose: The purpose of the present cross-sectional study is to examine the degree of degenerative patho-anatomical changes in the thoracic vertebrae in asymptomatic adult patients. **Materials and Methods:** A total of 150 adult patients were examined with computed tomography (CT) because of various health conditions (e.g., tumour risk). The images were revised with post-processing procedures to detect bony changes in the thoracic vertebrae. Three types of degenerations (osteophytes, arthrosis, and irregular endplates) were examined and graded using appropriate grading systems. Correlational investigations were carried out in relation to age, BMI, and degenerations. Moreover, to examine the value of the degenerations the frequencies of the grading categories were assessed in each segment. **Results:** The total number of the patients included was 41, who had no trunk symptoms. We found no convincing correlations in terms of age, BMI, and degenerations, however, age and facet joint arthrosis showed a tentative association. The degree of the degenerations was the largest in the Th7-8, Th8-9, Th9-10 segments for osteophytes, in the Th4-5, Th5-6 for arthrosis, and in the Th8-9, Th9-10 for irregular endplates. **Conclusions:** This study found that there are several progressive degenerative changes in the thoracic spine without any clinical symptoms. Accordingly, it can be advised that clinicians should avoid labelling the disorders and planning their treatment based on the results of diagnostic imaging only.

KEYWORDS

asymptomatic thoracic spine, degeneration, computed tomography

INTRODUCTION

The degenerative changes of the musculoskeletal system pose great challenges to both healthcare systems and clinicians (e.g., physiotherapists, orthopaedic doctors). In the future, due to an increasing number of ageing people in Western societies, the expert care of locomotor disorders must be given more attention [1]. Nowadays, there are numerous diagnostic imaging tools which provide clinicians with precise information about the condition of bones, joints, cartilages, and soft tissues. However, the association between the degenerative changes detected with diagnostic imaging and the clinical symptoms is often unclear. Radiological studies showed that the prevalence of progressive degenerative, patho-anatomical changes is high in asymptomatic patients in various regions of the body (e.g., the hip, knee, and shoulder) [2–4]. Accordingly, in many cases diagnostic imaging results have no clinical relevance. Nevertheless, most studies carried out in this topic focus on the spine, since spine disorders have a higher prevalence and add serious burden on the healthcare systems and the socio-economic status of patients [5].

It is well-known that ageing-related degenerative changes affect each region of the vertebral column. Therefore, the examination of degenerative changes of the vertebrae is of utmost importance and seeing the clinical relevance of these degenerative changes is equally important. Numerous cross-sectional and prospective studies have been published about the cervical and lumbar spine [6–8] because clinically these are the regions most commonly responsible for the origin of pain and disability [9]. These radiological studies show that there are a number of cases with severe degenerative findings without any symptoms, as is the case in many regions of the body.

To date, very few studies have looked at the diagnostic imaging results of asymptomatic patients' thoracic spine. The aim of the present study is to investigate the degree of the degenerative changes of the thoracic vertebrae with computed tomography (CT).

MATERIALS AND METHODS

Examination processes

The purpose of the present cross-sectional study was to detect the degenerative patho-anatomical changes in the thoracic vertebrae in asymptomatic adult patients with CT. The patients included in the study arrived for a CT examination because of other health conditions (e.g., tumour risk). All of them were asked to fill out a simple questionnaire form about patient characteristics, spinal symptoms (especially pain), and the regions of their symptoms. The CT examination was carried out in St Rókus Hospital, Budapest, Hungary. The CT tool was a "General Electric Optima 540MS". The images were revised with bone window and other post-processing procedures (e.g., multiple plane reconstruction), with a posterior view, in order to avoid needless radiation exposure. In the present study, three types of bony degenerations were examined: osteophytes, arthrosis of the facet joints, and irregular endplates of vertebrae. The results of the diagnostic images were evaluated by a radiologist with several decades of experience. This study was approved by the Ethics Committee of St Rókus Hospital, Budapest, Hungary.

Subjects

A total of 150 adult patients were examined with CT in 2018. Exclusion criteria were incomplete questionnaire form, detected tumour, low back pain, thoracic pain, and scapular pain originating from the neck. Inclusion criteria were consent to the research, no symptoms in trunk.

Measured variables

Osteophytes. To measure and grade the osteophytes, Nathan's anatomical classification system was used [10], which can be applied in all the regions of the spine and is based on the examination of cadavers. In this grading system the values of 0–4 are used (0 = no osteophytes at all, 1 = only

small isolated hyperostosis points appear, 2 = osteophytes protrude horizontally from the vertebral bodies, 3 = the end of the osteophytes is curved to the intervertebral disc, often contacting the osteophytes from neighbouring vertebrae, 4 = a real bony bridge between two vertebrae) [10].

Arthrosis. To determine the degeneration of the facet joints a 0–3 grading system was used according to Parthia et al. [11]. This grading system is recommended to be used for CT only [12]. In Parthia's grading system the values of 0–3 were used, that is, 0 = no degeneration of the facet joint, 1 = decreased facet joint space (mild), 2 = decreased facet joint space with sclerosis or hypertrophy (moderate), 3 = decreased facet joint space with sclerosis, and osteophytes (severe) [12].

Endplates. The grading system used to classify the degeneration of the endplates was developed for MRI scans. In this system six stages of degeneration are described [13]. However, the CT examination can detect precisely only the more severe states of endplate changes, therefore, in the present study a modified version of the original grading system was used (0 = no detected change, 1 = less than the 25% of the endplate is affected, 2 = up to 50% of the endplate is affected, 3 = up to total destruction of the endplate).

Statistical analysis

Descriptive statistics were used to present the characteristic data of the patients (age, weight, height, and body mass index (BMI)). To determine the association between age and degenerations, as well as between BMI and degenerations, the Spearman correlation coefficient (ρ) was calculated, as this correlation is suitable to calculate both categorical and continuous data. The value of ρ and the value of P -level were stated in every case. To examine the value of the degenerations the frequencies of the grading categories were assessed in each segment. All statistical analyses were carried out using the IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp. Released 2012, Armonk, NY: IBM Corp.) and Microsoft Excel (2018); P values of less than 0.05 were considered significant.

RESULTS

There were several participants who were excluded from the study. The reasons for exclusion were: 13 persons completed the questionnaire form imperfectly, 41 individuals had low back pain, and 49 participants had thoracic and/or scapular pain. Lung cancer was detected in further six cases. Thus, the included patients of this study were 41 persons without any trunk symptoms. The average age was 61.95, the youngest participant was 36 years old and the oldest was 77. The demographic data of the included participants is presented in Table 1.

No correlation was found between the BMI values and the degenerations. Although in three cases the P -level was less than 0.05, the correlation coefficient was not high

Table 1. Study cohort

Male/female; N (%)	15/26 (36.6/63.4)
Age; years, mean (SD)	61.95 (10.1)
Height; m, mean (SD)	1.65 (0.1)
Weight; kg, mean (SD)	77.68 (20.5)
BMI; kg/m ² , mean (SD)	28.3 (6.2)

enough to show relevant correlation ($\rho = -0.35-0.32$, $P = 0.026-0.041$). See in Table 2.

As for age, although the P value showed significance in several segments, especially in arthrosis, the correlation coefficients reached the lower values of the acceptable range only in a few cases ($\rho = 0.39-0.50$, $P = 0.001-0.012$), as presented in Table 3.

The degree of the degenerations was the largest in the Th7-8, Th8-9, Th9-10 segments for osteophytes, in the Th4-5, Th5-6 for arthrosis, and in the Th8-9, Th9-10 for irregular endplates. The frequencies of the grade values of the three degenerations are presented in Table 4. For better perspicuity, the results of frequencies are figured in chart diagrams (Figs. 1–3).

DISCUSSION

The bony degenerations of the thoracic vertebrae are under-published, therefore, there is no widely accepted, valid grading system to examine the degree of the different types of patho-anatomical changes. Accordingly, carrying out the present study required novel methodological solutions. Nevertheless, we aimed for enhancing the quality of the research by using highly precise CT scans, which is the primary tool for examining the bony degenerations of the vertebrae.

There are several classification systems for osteophytes, and most of them focus on the lumbar region [14] or the cervical region [15, 16]. As far as we know, to date there is no validated grading system for the evaluation of osteophytes on thoracic CT scans. Therefore, Nathan's anatomical grading system was used in the present study [10].

The correlation between patients' BMI and the grade scores of the osteophytes was found to be significant in one case only; however, the correlation coefficient was too low to accept it as a real association. The correlations between age and osteophytes were significant in two cases, and, similarly to BMI-osteophyte correlation, the value of the correlation was too low. Based on our results, there were no relevant associations either between BMI and osteophyte grade scores, or age and osteophyte grade scores. However, the low sample size may have caused bias, as based on the current scientific literature, obesity should be one of the main aetiological factors associated with osteophytes [17].

Concerning the extent of the osteophytes, the Th7-8, Th8-9, and Th9-10 segments were the most affected areas, that is to say, the appearance of osteophytes was the largest in the middle-low region of the thoracic spine. These findings are similar to the study results of Klaasen et al. (2011), who found that the Th9-10 was the region most commonly affected by osteophytes [17].

In the present study Parthia's grading system was used to determine the degree of the facet joint arthrosis in the thoracic spine [11]. Originally, it was developed for the lumbar spine, but we decided to use it for two reasons: firstly, because it can be considered reliable ($\text{Kappa} > 0.4$); and secondly, because this grading system is highly recommended to be used in CT scans [12]. Furthermore, this grading system with its four categories is almost the same

Table 2. Correlation between BMI and degenerations ($N = 41$)

		Segments of the thoracic spine										
		1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Osteophyte	ρ	−0.09	−0.16	0.03	0.07	0.04	0.29	0.32	0.16	0.20	−0.02	0.11
	P	0.562	0.328	0.852	0.654	0.978	0.066	0.040	0.318	0.210	0.913	0.505
Arthrosis	ρ	−0.09	−0.02	−0.02	−0.05	−0.35	−0.22	−0.24	−0.16	−0.21	0.10	−0.15
	P	0.560	0.903	0.887	0.732	0.026	0.160	0.137	0.320	0.191	0.536	0.345
Endplate	ρ	0.05	−0.32	−0.09	−0.09	0.02	0.10	0.16	0.10	0.12	−0.13	0.04
	P	0.777	0.041	0.569	0.564	0.876	0.547	0.314	0.515	0.444	0.405	0.790

Table 3. Correlation between age and degenerations ($N = 41$)

		Segments of the thoracic spine										
		1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Osteophyte	ρ	0.24	0.18	0.16	0.22	0.16	0.39	0.30	0.05	0.17	0.39	0.28
	P	0.135	0.269	0.320	0.162	0.321	0.011	0.058	0.769	0.289	0.011	0.072
Arthrosis	ρ	0.21	0.40	0.46	0.29	0.19	0.42	0.50	0.48	0.43	0.40	0.39
	P	0.186	0.009	0.003	0.067	0.214	0.006	0.001	0.002	0.005	0.009	0.012
Endplate	ρ	−0.11	−0.09	0.24	0.39	0.29	0.50	0.20	0.21	0.17	0.17	0.16
	P	0.473	0.586	0.131	0.012	0.065	0.001	0.211	0.187	0.291	0.295	0.325

Table 4. Frequencies of the degenerations (N = 41)

		Segments of the thoracic spine										
Grade		1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Osteophyte	0	24	11	6	6	3	2	1	1	2	9	16
	1	9	19	17	11	9	8	9	8	9	14	6
	2	6	5	11	15	19	19	14	16	15	5	6
	3	0	5	6	6	5	8	10	10	8	9	11
	4	2	1	1	3	5	4	7	6	7	4	2
Arthrosis	0	18	15	11	9	6	12	14	16	17	12	10
	1	15	9	13	11	14	15	15	18	19	18	15
	2	8	15	11	14	18	11	10	7	5	11	14
	3	0	2	6	7	3	3	2	0	0	0	2
Endplate	0	31	30	25	25	22	19	14	5	8	12	15
	1	8	10	14	14	15	13	17	20	17	14	15
	2	2	1	2	2	4	6	7	10	11	10	10
	3	0	0	0	0	0	3	3	6	5	5	1

Fig. 1. Frequencies of osteophytes (N = 41)

Fig. 2. Frequencies of facet joint arthrosis (N = 41)

Fig. 3. Frequencies of endplates (N = 41)

system that was used in the six-year longitudinal study with CT by Jarraya et al. in 2018 [18].

The correlation between patients' BMI and the grade scores of arthrosis was significant in one case only; however, the correlation coefficient was too low to accept it as a real association, similarly to the results of osteophyte correlations. The correlations between patients' age and arthrosis were significant in many segments, and in the Th7-8 segment even the correlation coefficient was at the low edge of the acceptable range (0.5). Although in this segment the value of the coefficient was less than in other segments showing significant results, a real association can be assumed between the age and facet joint arthrosis. Accordingly, with this low sample size we can only hypothesize that there would be a stronger correlation if more participants were involved in the study. Precise data on facet joint degenerations of the thoracic spine have not been published to date, but evidence supports that there is strong correlation between age and joint arthrosis [18]. The extent of the arthrosis was highest in the Th4-5, Th5-6 segments, which is a result found by Jarraya's longitudinal study from 2018 as well [18].

In the present study a modified version of the original MRI grading system was used to determine the degenerations of endplates. Based on our results, the correlations between patients' BMI and the grade scores of endplate degeneration were not significant. There was only one case with an acceptable *P*-level, but the value of the coefficient was too low. The correlations between patients' age and the grade scores of endplate degeneration were significant in two cases, and in the Th6-7 segment the value of the coefficient was at the low edge of the acceptable range (0.5) with strongly significant *P*-level (0.001). Considering our significant results in only two segments with only one acceptable coefficient value, the real association between the age and endplate degeneration is still not established. The endplate degenerations were most articulated in the middle and lower thoracic segments (Th7-11).

In sum, the results of the present study show that patients can have numerous and extensive osteophytes, arthrosis, and endplate changes in the thoracic vertebrae

without any clinical symptoms. Our results confirm the previous evidence which shows similar results in the different parts of the spine and the whole body. Based on our results, there should be two research directions in the future. It would be necessary to validate the grading system, especially for the thoracic spine. Furthermore, it would also be necessary to carry out a study with symptomatic and asymptomatic patients respectively.

Limitations of our study

The study presented has got several limitations. The examining radiologist was alone, so the reliability of the results was not assessed. In order to avoid needless radiation exposure, the images were revised with post-processing procedures and that may have caused further bias. The grading system of the osteophytes was developed using cadavers and has not been validated for CT examination. The grading system for facet joint arthrosis was developed for the lumbar spine, and not for the thoracic region. The grading system of endplates was developed for MRI scans, therefore, the original system was modified and simplified to CT examination. All in all, these limitations may have caused some bias in our research, yet we believe that our methodology is capable of assessing the degree of the three types of degeneration with clinically relevant results.

CONCLUSION

Based on our results, considering the limitations as well, the following statements can be made. This study found that there are several progressive degenerative, patho-anatomical, bony changes in the thoracic spine without any clinical symptoms. The results of the present study fit with the current international literature in this topic. According to these results, it can be advised that clinicians should avoid planning their treatment based on the results of diagnostic imaging only, and they should avoid the labelling of the disorders based on only the value of the degenerations. Such

a labelling may put extra psychological burden on the patients.

Ethical approval: This study was conducted in accordance with the 2008 revision of the 1975 Declaration of Helsinki.

Authors' contribution: TV and EV summarised the scientific background of the study. TV and ÉK carried out the statistical analyses. EV, ZSD, and MB collected the data from CT screens. TV finalised the manuscript.

Conflict of interest/funding: The authors declare no conflict of interest. No financial support was received for this study.

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