

# Dynamics of morphotopometric characteristics and X-ray density of T<sub>VI</sub> vertebra in men from the first period of mature age to old age

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## Abstract

**Aim** – to evaluate the dynamics of anteroposterior dimensions and X-ray density of the T<sub>VI</sub> vertebra in men from the first period of adulthood to old age according to computed tomography (CT) of the chest.

**Material and methods.** The work is based on the results of CT scans of patients undergoing chest examinations. The height, width, anteroposterior dimension, and X-ray density of the T<sub>VI</sub> vertebra body were measured. The study sample consisted of individuals with normal body weight, mesomorphic body type, without history of injuries and skeletal abnormalities. 60 patients were randomly selected from 78 subjects, so that each group had the same number of patients: 20 people. The first group consisted of men of the first period of adulthood (22-35 years of age), the second group included men of the second period of adulthood (36-60 years of age), the third group consisted of elderly men (61-75 years of age).

**Results.** The study revealed a tendency for the T<sub>VI</sub> vertebral body height parameters to decrease by 7.8% in old age ( $t=2.01$ ;  $p>0.05$ ). A tendency for the

T<sub>VI</sub> vertebral body width parameters to increase by 2.18% in old age ( $t=0.54$ ;  $p>0.05$ ) was revealed. At the same time, a tendency for the anteroposterior size parameters of the T<sub>VI</sub> vertebral body to increase by 2.25% was determined ( $t=0.60$ ;  $p>0.05$ ). The X-ray density indices of the T<sub>VI</sub> vertebral body are characterized by a significant decrease in parameters with increasing age ( $p<0.001$ ).

**Conclusion.** As a result of the conducted intravital study, new data on the age-related anatomy of the T<sub>VI</sub> vertebra in men were obtained. Since the anatomical parameters of the vertebra are not static values and change with age, this information will be useful in clinical practice of such specialists as gerontologists, traumatologists, vertebrologists, radiation diagnosticians, in sports medicine and in the work of exercise therapy doctors.

**Keywords:** vertebra T<sub>VI</sub>, age-related changes, morphometry, CT, X-ray density.

**Conflict of interest:** nothing to disclose.

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# Динамика морфотопометрических характеристик и рентгеновской плотности T<sub>VI</sub> позвонка у мужчин от первого периода зрелого до пожилого возраста

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## Аннотация

**Цель** – оценить динамику высоты, ширины, передне-заднего размера и рентгеновской плотности тела T<sub>VI</sub> позвонка у мужчин от первого периода зрелого до пожилого возраста по данным компьютерной томографии (КТ) грудной клетки.

**Материал и методы.** В основу работы положены результаты КТ пациентов, проходивших обследование органов грудной клетки. Определяли высоту, ширину, передне-задний размер и рентгеновскую плотность тела T<sub>VI</sub> позвонка. Выборку исследования составили лица с нормальной массой тела, мезоморфным типом телосложения, без травм и аномалий развития скелета в анамнезе. Из 78 обследуемых

случайным образом были отобраны 60 пациентов так, чтобы в каждой группе было их одинаковое количество – 20 человек. Первая группа состояла из мужчин первого периода зрелого возраста (22–35 лет), вторая группа включала мужчин второго периода зрелого возраста (36–60 лет), третью группу составили мужчины пожилого возраста (61–75 лет).

**Результаты.** В ходе исследования установлена тенденция к снижению параметров высоты тела T<sub>VI</sub> позвонка к пожилому возрасту на 7,8% ( $t=2,01$ ;  $p>0,05$ ). Выявлена тенденция к увеличению параметров ширины тела T<sub>VI</sub> позвонка к пожилому возрасту на 2,18% ( $t=0,54$ ;  $p>0,05$ ). Наряду

с этим определена тенденция к увеличению параметров передне-заднего размера тела  $T_{VI}$  позвонка на 2,25% ( $t=0,60$ ;  $p>0,05$ ). Показатели рентгеновской плотности тела  $T_{VI}$  позвонка характеризуются достоверным снижением параметров к пожилому возрасту ( $p<0,001$ ).

**Заключение.** В результате проведенного прижизненного исследования получены новые данные о возрастной анатомии  $T_{VI}$  позвонка у мужчин. Поскольку анатомические параметры позвонка не являются статичными

величинами и изменяются с возрастом, полученные сведения будут востребованы в клинической практике у таких специалистов, как геронтологи, травматологи, вертебрологи, лучевые диагносты, врачи спортивной медицины и лечебной физкультуры.

**Ключевые слова:** позвонок  $T_{VI}$ , возрастные изменения, морфометрия, КТ, рентгеновская плотность.

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## INTRODUCTION

The thoracic section of the spine is a peculiar, interesting region of the body for researchers of various disciplines. It is the bases of the rib cage and the most rigid part of the spine; at the same time, it retains some degree of mobility required for normal vital activities. Usually, biomechanical stability and mobility are opposite characteristics: as stability increases, the mobility decreases. However, the thoracic section of the spine is unique in combining the two properties [1].

The object of our study is the sixth thoracic vertebra (TVI). It is the 'center' of the thoracic section of the spine and plays a number of clinically important roles. It borders on the main primary bronchus forming the thoracic kyphosis and undertaking a complex load: the posterior of the base of this spinous process is usually exposed to tensile forces, and the anterior side, conversely, to forces of compression [2–4].

We studied the changes of the TVI vertebra in the aspect of age in men. Such data is practically absent in the scientific literature despite its importance for a number of reasons. Firstly, according to the medical statistics, men of advanced and old age are a category of population fairly vulnerable to trauma. Several factors are at work: coordination disorders due to age-associated changes in the cerebral structures, vestibular sickness, sedentary lifestyle, and excess body mass [5–7]. According to the findings of a study of Irish researchers in 2022, duration of hospital stay of patients aged over 65 with spinal traumas was 1.5 times longer than that of younger patients (21 vs. 14 days), and the mortality in the older group was more than 4 times higher (4.6% vs. 0.97% in the younger group) [8]. Secondly, men, even in the advanced age, are an important element in the economy of developing countries. Quite a significant number of them are actively working and are in demand in the labor market. The above factors pose global tasks for the development of personalized medicine [9].

## AIM

To evaluate the dynamics of anteroposterior dimensions and X-ray density of the TVI vertebra in men from the first period of adulthood to old age according to computed tomography (CT) of the chest.

## MATERIAL AND METHODS

The work is based on the results of CT scans of patients undergoing chest examinations in the admissions department of Perm Region City Clinical Hospital No. 3 in 2023–2024. All patients provided a consent for the study that was performed to exclude possible pulmonary pathologies according to indications.

The height, width, anteroposterior dimension, and X-ray density of the TVI vertebra body were measured on the Optima 660 computed tomography scanner (Fig. 1–3).

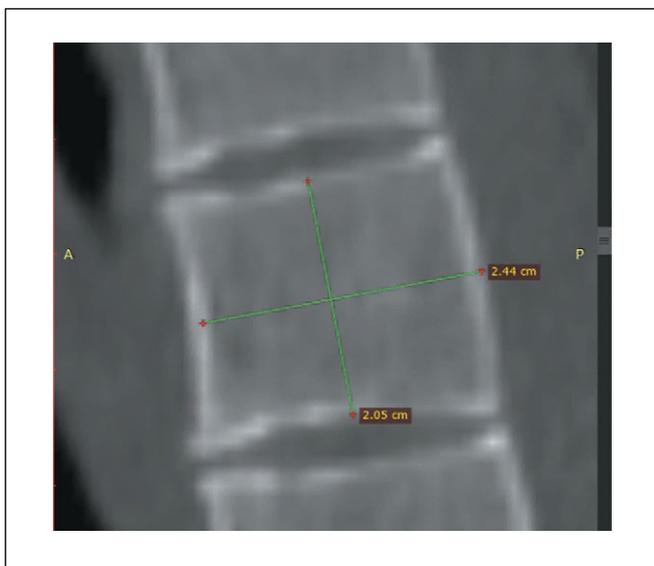
The analysis of CT scans was performed with the RadiAnt specialized software suite. The subjects of the study were individuals with normal body weight, mesomorphic build, no history of skeletal trauma or development abnormalities.

Of the 78 examined subjects, 60 patients were randomly selected in such a way that each group had an equal number of patients (20). The first group consisted of males of the first adult period (22–35 years of age), the second, men of



**Figure 1.** Example of width measurement of the vertebral body in a 23-year-old man.

**Рисунок 1.** Пример измерения ширины тела позвонка у мужчины 23 лет.



**Figure 2.** Example of height and anteroposterior size measuring of the vertebral body in a 23-year-old man.

**Рисунок 2.** Пример измерения высоты и передне-заднего размера тела позвонка у мужчины 23 лет.



**Figure 3.** Example of X-ray density measurement of the vertebral body in a 23-year-old man.

**Рисунок 3.** Пример измерения рентгеновской плотности тела позвонка у мужчины 23 лет.

the second adult period (36–60 years), third group, elderly men (61–75 years).

The statistical analysis was performed in Microsoft Excel 2019. The results were presented as the arithmetic mean (M) and standard error (m), median and variation coefficient. To check the normality of distribution of variation rows, the Kolmogorov-Smirnov test was used. Student’s parametric t-test was used to test the equality of average values in the two samples. Differences were considered statistically significant at  $p < 0.05$ .

Age period	M±m	Max	Min	$\sigma$	Cv	Me
First adult period (n=20)	19,09±0,27	20	17,5	0,76	0,04	19,3
Second adult period (n=20)	18,78±0,59	21,4	16	1,88	0,10	18
Elderly age (n=20)	17,60±0,69	20,4	14,9	1,83	0,10	17,3

**Table 1.** Body height indicators  $T_{VI}$  spine in men in the studied age periods according to CT-scans, mm (n=60)

**Таблица 1.** Показатели высоты тела  $T_{VI}$  позвонка у мужчин в исследуемых возрастных периодах по данным КТ, мм (n=60)

Age period	M±m	Max	Min	$\sigma$	Cv	Me
First adult period (n=20)	27,92±0,94	32,7	25,3	2,65	0,09	28,1
Second adult period (n=20)	27,55±0,65	31,4	25,3	2,05	0,07	27,6
Elderly age (n=20)	27,31±0,64	29,9	25,2	1,68	0,06	27,2

**Table 2.** Indicators of the body width of the  $T_{VI}$  vertebra in men in the studied age periods according to CT- scans, mm (n=60)

**Таблица 2.** Показатели ширины тела  $T_{VI}$  позвонка у мужчин в исследуемых возрастных периодах по данным КТ, мм (n=60)

Age period	M±m	Max	Min	$\sigma$	Cv	Me
First adult period (n=20)	26,27±0,64	28,3	23,6	1,80	0,07	27,3
Second adult period (n=20)	26,41±0,65	29,3	23,5	2,04	0,08	26,3
Elderly age (n=20)	26,86±0,75	29,6	23,5	1,99	0,07	26,4

**Table 3.** Indicators of anterior-posterior body size of the  $T_{VI}$  vertebra in men in the studied age periods according to CT- scans, mm (n=60)

**Таблица 3.** Показатели передне-заднего размера тела  $T_{VI}$  позвонка у мужчин в исследуемых возрастных периодах по данным КТ, мм (n=60)

Age period	M±m	Max	Min	$\sigma$	Cv	Me
First adult period (n=20)	217,27±2,00	373	165	63,31	0,29	215
Second adult period (n=20)	206,00±1,07	296	143	30,48	0,15	205
Elderly age (n=20)	194,13±2,48	253	104	65,77	0,34	186

**Table 4.** Indicators of X-ray body density of the  $T_{VI}$  vertebra in men in the studied age periods according to CT- scans, HU (n=60)

**Таблица 4.** Показатели рентгеновской плотности тела  $T_{VI}$  позвонка у мужчин в исследуемых возрастных периодах по данным КТ, HU (n=60)

## RESULTS

The data on the dimensions and X-ray density of the TVI vertebral body in the tested age groups follow in **Tables 1–4**.

In the course of the study, a tendency was identified for the parameter of height of the TVI vertebra body to decrease over elderly age by 7.8% ( $t=2.01$ ;  $p>0.05$ ). There was a tendency for the width of the TVI vertebra body to increase over the elderly age by 2.18% ( $t=0.54$ ;  $p>0.05$ ). At the same time, a tendency was identified for the antero-posterior dimension of the TVI TVI vertebra body to increase by 2.25% ( $t=0.60$ ;  $p>0.05$ ). The value of the X-ray density of the TVI TVI vertebra body demonstrates a reliable decrease over the elderly age ( $p<0.001$ ).

In other words, when discussing age-related dynamics, it can be stated that the vertebral body flattens with age, meaning its height decreases, while its width and anteroposterior

dimension, conversely, increase. Radiographic density decreases by advanced age.

## DISCUSSION

Aging is a systemic process with its proper laws and changes taking place on the molecular and cellular level. The aging of an organism can be defined as the state of progressive functional deterioration of its tissues. Accumulated cellular damage by mitochondrial oxidation, disorders in the DNA molecular structure by 'incorrect' proteins affects the operation of their organelles. The changes that follow lead to accumulation of dysfunctional cells in the tissues, which complicates maintenance of homeostatic mechanisms thereby limiting the regenerative potential [10–12].

There are several interesting publications in the literature that focus on biomechanical features of the aging spine. In their paper, M. Papadakis et al. (2011) presented a brief review of pathophysiological processes taking place in the aging spine and described the outcomes of these changes for the spine biomechanics. According to this review, the body of the vertebra is subjected to a greater part of the load that the spine is exposed to. The vertebra body consists of a spongy bone that becomes more dense and strong at the periphery forming the external layer; however, the main factor that defines the mechanical strength of the vertebra body is not that external layer but the microarchitecture. The osseous trabeculae adjoining the end plate and located in the posterior area of the body are much larger and their network denser. Conversely, the central and the anterior parts of the vertebra body have lower regional density, thinner and less ordered trabeculae. At the same time, the mechanical properties of the vertebra body are directly related to its mineral density. The correlation between the bone density and strength under

compression is exponential; therefore, a minor decrease in the former parameter leads to a major decrease in the latter [13].

The review of S.J. Ferguson and T. Steffen was published much earlier (2003). According to this study, starting from the fourth decade of life men can easily lose up to 30%, and women up to 50% of bone mass. The researchers also noted heterogeneity in the microstructure of the vertebra bodies. They explain these differences in the mechanical properties with adaptation to environment; in the specific case of the spine this is explained by higher axial loads transferred by the central area adjacent to the nucleus pulposus, unlike the peripheral area adjacent to the annulus fibrosus [14].

One should also mention the study of Swiss scientists published in 2018. D. Ignasiak et al. studied the effect of age-related changes of the spine on its kinematic features in the course of daily activities with respect to segmental loads. The researchers found that the maximum compression loads predicted in elderly people were lower than those in young people at the following levels: L2/L3 and L3/L4 of the lumbar spine during flexure; upper thoracic levels during transition from standing to sitting position (T1/T2–T8/T9), and from the sitting to the standing position (T3/T4–T6/T7) [15].

## CONCLUSION

As a result of the conducted intravital study, new data on the age-related anatomy of the TVI vertebra in men were obtained. Since the anatomical parameters of the vertebra are not static values and change over age, this information will be useful in clinical practice of such specialists as gerontologists, traumatologists, vertebrologists, radiation diagnosticians, in sports medicine and in the work of exercise therapy doctors. ■

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
<b>Ethics approval:</b> Approval of the LEC is obtained (No. 9 dated 23.10.2024).	<b>Этическая экспертиза.</b> Получено положительное решение ЛЭК (№ 9 от 23.10.2024 г.).
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<b>Conflict of interest.</b> The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	<b>Конфликт интересов.</b> Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
<b>Contribution of individual authors.</b> Balandin A.A., Chudinov O.A.: collection of material, data analysis, writing of the text of the article. Balandina I.A., Balandin A.A.: study design, interpretation of results, editing of the article. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	<b>Участие авторов.</b> Баландин А.А., Чудинов О.А. – сбор материала, анализ данных, написание текста статьи. Баландина И.А., Баландин А.А. – дизайн исследования, интерпретация результатов, редактирование статьи. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.
<b>Statement of originality.</b> No previously published material (text, images, or data) was used in this work.	<b>Оригинальность.</b> При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, иллюстрации, данные).
<b>Data availability statement.</b> The editorial policy regarding data sharing does not apply to this work.	<b>Доступ к данным.</b> Редакционная политика в отношении совместного использования данных к настоящей работе не применима.
<b>Generative AI.</b> No generative artificial intelligence technologies were used to prepare this article.	<b>Генеративный искусственный интеллект.</b> При создании настоящей статьи технологии генеративного искусственного интеллекта не использовали.
<b>Provenance and peer review.</b> This paper was submitted unsolicited and reviewed following the standard procedure. The peer review process involved 2 external reviewers.	<b>Рассмотрение и рецензирование.</b> Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали 2 внешних рецензента.

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