



MILAN MED

THE INTERVERTEBRAL ARTICULATION OF THREE FOSSIL INDIVIDUALS FROM DOLNÍ VĚSTONICE

ABSTRACT: *The forms of vertebral articulation of the spines of three fossil individuals from Dolní Věstonice were studied. The shape of the atlantoaxial articulation was found in the archetypal bisphaeroid form appearing only exceptionally in adult humans of the recent population. Articular forms of the other vertebrae were analogical with the recent ones, both as refers to the incidence of the types and their total percentual representation as well as similar position of the spinal segments. The measured size of the angles of the plane of facies terminalis vertebrae and the posterior clivus of processus spinosus have smaller values in most vertebrae of the DV skeletons than in the vertebrae of the recent population.*

KEY WORDS: *Intervertebral articulations — Types of articulations — Dislocations of types — Spine model — Articular archetype — Spinoterminal angle.*

MATERIALS AND METHODS

The form of intervertebral articulation and the shape of the vertebrae were studied in skeletons of three fossil individuals discovered in 1987 at Dolní Věstonice and designated DV XIII, DV XIV and DV XV. The spines found are not complete. Similarly as in the find of the female skeleton DV III found in 1950, the atlas and the axis show only slight damage. Best preserved is the spine of the individual DV XIII buried in lateral position: only the articulation of C_{6/7} and the bodies of Th₂ and Th₃ vertebrae are missing. The individual DV XIV buried in prone position has cranially damaged vertebral bodies C₃-C₇ as well as Th₃-Th₇ and Th₁₁-L₄. However, the condyli are completely preserved. The individual DV XV buried in spinal position is lacking occipital condyli and cervical articulation C_{2/3}-C_{6/7}. Vertebral bodies are missing or very damaged in C₃-C₇ and Th₄-Th₅, as well as in L₁, L₂, L₄ and L₅ vertebrae. The surviving vertebrae do not show any sign of immaturity, lacking also senile or arthrotic alterations.

The aim of the study was to obtain information on the form of intervertebral articulation of fossil man, to

classify its articulation types into the phylogenetic and ontogenetic series and define its difference from the spine of recent man.

This was why the studied spines from Dolní Věstonice were compared with the phylogenetic series of mammalian spines (Med 1983), groups of spines of recent adults (Med 1972, 1973), a collection of skiagrams of recent spines and a series of human foetuses of various ages (Med 1977, 1980, 1982). For the assessment of articulation forms types the relation of the right and left joints in the segment is evaluated as a functional unit. According to the functional shape of the joint the type of intervertebral articulation of all mammals can be classified into three groups, i. e. the dorsocylindrical type with dorsally diverging articular facies, the *articulatio plana* type with articular facies oriented in a common plane and the ventrocylindrical type with ventrally diverging articular facies.

The ventrocylindrical joints are formed in the segments of the kyphotic section of the spine. The dorsocylindrical forms follow the lordotic sections, whereas *articulatio plana* appears at the transition between the lordotic and kyphotic parts of the spine (Med 1982) /Fig. 1/.

Paper presented at the 3rd Anthropological Congress of Aleš Hrdlička, held on September 3–8, 1989 in Humpolec, Czechoslovakia.

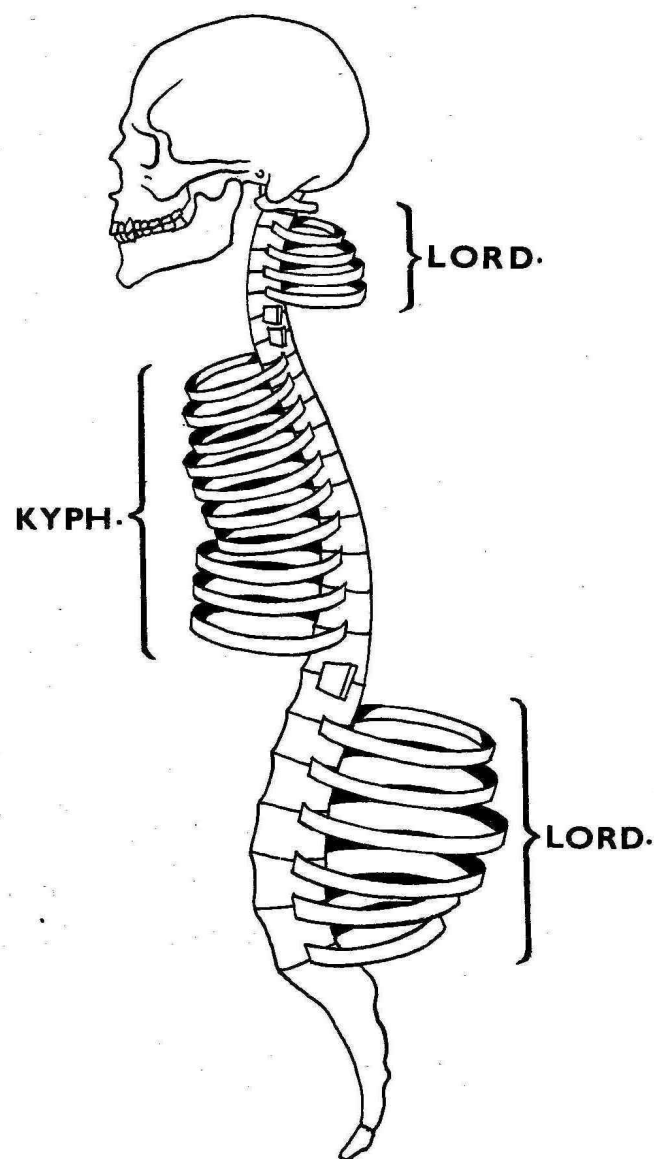


Figure 1. Diagram showing the connection of the segments with dorsally diverging articular facies (represented by a cylindrical band) and the lordotic section of the spine, the connection of the segments with ventrally diverging articular facies and the kyphose section of the spine; in the transitional sections, between the kyphosis and lordosis, a flat plane representing the plane shape of the joint, articular plane, is plotted.

The spinal articulation pattern of the members of various mammalian orders and suborders differs by the very presence and different number of dorsocylindrical segments in the thoracic spine (Med 1983).

RESULTS

The comparison of the spines of Dolní Věstonice individuals with a group of recent spines reveals that – except for one case (*articulatio atlantoaxialis*) – percentually the joint types differ a little (Fig. 2).

Approximately one half of the cases is constituted

by the ventrocyllindroid type, i. e. the type with ventrally divergent cylindrical articular facies common to both the right and the left vertebral joints. In the group of recent spines it appears in 39% (in the following abbreviated as R: 39%). *Articulatio plana*, where the right and left joints are oriented in a common plane, shows a 10% incidence (R: 8.7%). Next follows the dorsocylindrical type with a cylindrical articular facies common to both the right and the left joints, appearing in 22% (R: 12.3%). The bicylindrical type, where the right and left joints have their own cylindrical facies with a separate rotation axis, has a 10% incidence (R: 25%); the hyperboloid type, with a hyperboloid trace of articular facies, occurs in 3% (R: 8%), the asymmetric combined forms, different on the right and left joints of the segment 3% (R: 8%), and finally, the prismatic type, with the facies oriented in craniocaudal direction, occurs in 1.4% (R: 3%).

ARTICULAR ARCHETYPE

The only shape difference in the articular configuration from the recent shapes is the bisphaeroid form of the atlantoaxial articulation, conditioned by the convexly sphaeroid surface of the cranial facies of the axis and the sphaeroid concavity of the caudal facies of the atlas (Fig. 3). The bone surfaces are incongruent forming intraarticular lumen of falciform contour. Such joint configuration is analogical with that in carnivora, primates, yet not in adult humans. The author could find it neither in numerous skeletons nor in series of skiagrams. It was nevertheless found as one of the developmental forms of human prenatal atlantoaxial articulation.

This shape is specific for all three fossile spines studied; conformable is nevertheless also Jelínek's description of the atlas facies of the Dolní Věstonice woman DV III, found in 1950. The author assumes that this joint type can be considered as a fossile archetype.

DISTRIBUTION OF THE TYPES IN SEGMENTS

The defined articulation types, the shape and frequency of which are given above, appear with a rather regular frequency in certain spinal segments. The comparison of the two groups – the recent and the fossile one – confirms the same regularity with dorsocylindrical forms appearing in the lordotic segments and ventrocyllindroid forms in the kyphotic section of the spine.

The frequency of the type incidence in the same segment in the comparative recent group is given in Fig. 4.

The find of frontally oriented articular facies (*articulatio plana*) in the lumbar spine of DV XIII in the Th₁₂/L₁ segment represents a peculiarity in the position of the types on the spine. This individual variety does not occur in modern adult humans: in the prenatal period this position of the articulation facies is nevertheless usual and its persistence until adulthood is explained as a partial developmental halt at the segment level (Med 1982).

SPINOTERMAL ANGLE

The author measured the size of the angle of the plane of *facies terminalis corporis vertebrae* with the

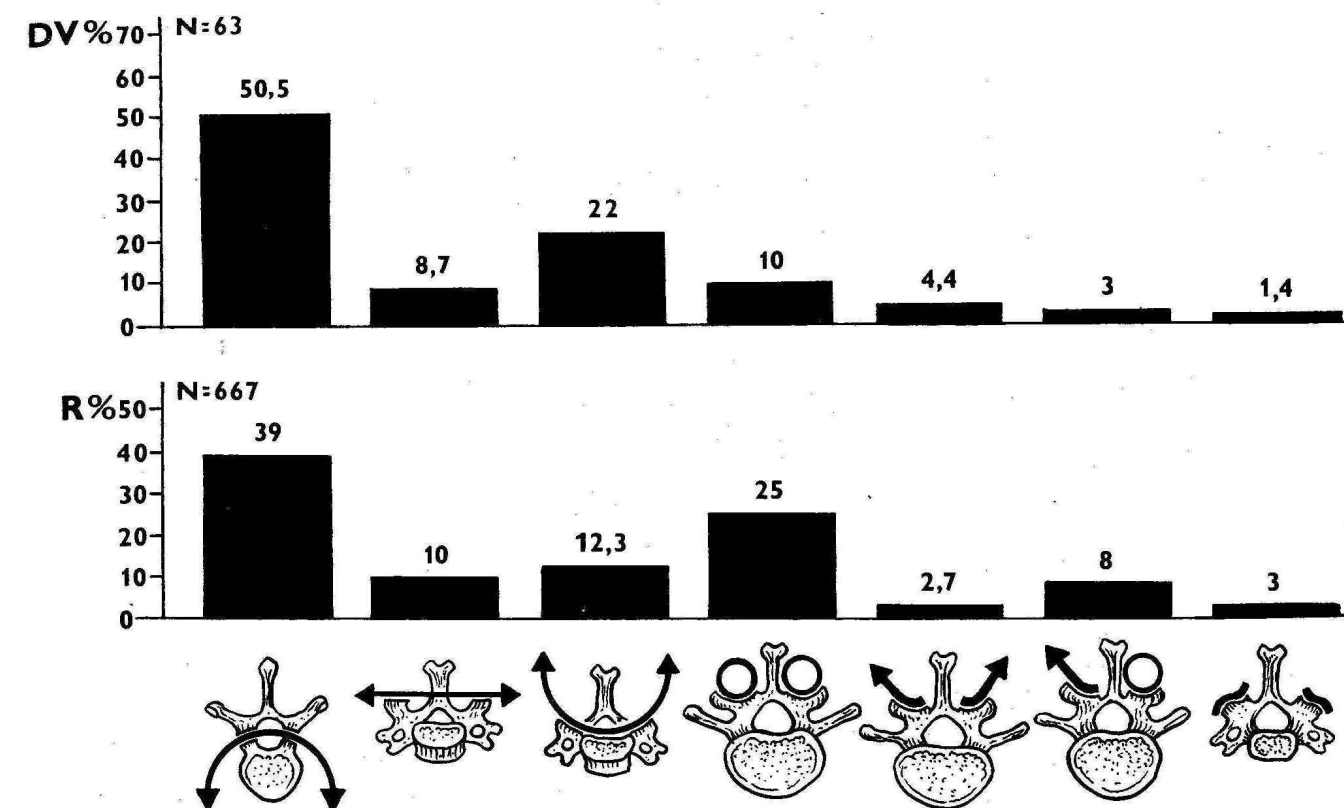


Figure 2. Graphs comparing percentual representations of the individual joint types in three spines from Dolní Věstonice (DV) and in a group of spines of recent population (R). Joint types from left to right: ventrocyllindroid (ventrally monocylindrical), articulatio plana, dorsocylindrical (dorsally monocylindrical), bicylindrical, hyperboloid, asymmetrically combined and prismatic.

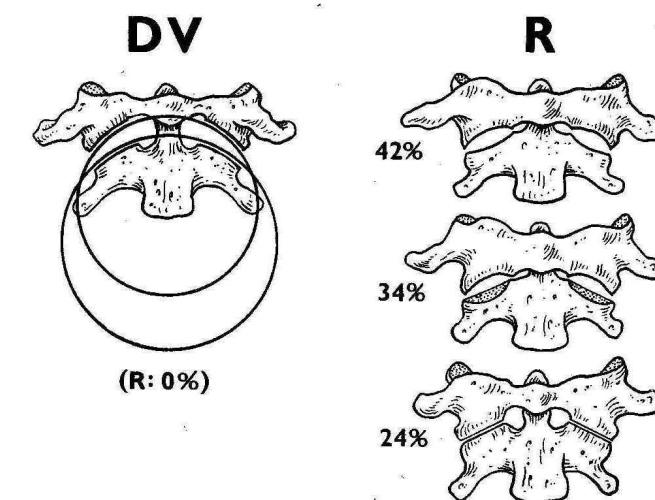


Figure 3. Diagram of the archetypal bisphaeroid form of atlantoaxial articulation (DV) and three types of atlantoaxial articulation occurring in recent population (R).

Figure 4. Table showing in what percentage the designated joint type occurs in the given segment in recent population.

Explanation of abbreviations:

BSP – bisphaeroid, D – dorsocylindrical, V – ventrocyllindroid, P – articulatio plana, B – bicylindrical, H – hyperboloid, AS – asymmetrically combined, PRI – prismatic.

nDV=66
nR=1250

		DV XIII %R	DV XIV %R	DV XV %R
Occ C ₁	condyli	55	55	?
	sphaer.	76	76	?
	silhuet.	57	9	?

	BSP -0-	BSP -0-	BSP -0-
C _{1/2}	D 88	D 88	?
C _{2/3}	D 39	D 39	?
C _{3/4}	D 9	D 9	?
C _{4/5}	V 30	P 4	?
C _{5/6}	?	P 53	?
C _{6/7}	P 31	V 31	D 4

	V 100	V 100	V 100
Th _{1/2}	V 100	V 100	V 100
Th _{2/3}	V 100	V 100	V 100
Th _{3/4}	V 100	V 100	V 100
Th _{4/5}	V 100	V 100	V 100
Th _{5/6}	V 100	V 100	V 100
Th _{6/7}	V 100	V 100	V 100
Th _{7/8}	V 100	V 100	V 100
Th _{8/9}	V 100	V 100	V 100
Th _{9/10}	V 100	V 100	V 100
Th _{10/11}	V 100	V 100	V 100
Th _{11/12}	D 15	D 22	V 100
Th _{12/L₁}	P -0-	B 32	B 21

	H 77	H 77	B 20
L _{1/2}	AS 8	H 55	B 23
L _{2/3}	PRI 8	B 43	B 43
L _{3/4}	D 29	B 29	D 29
L _{4/5}	B 6	B 31	D 31

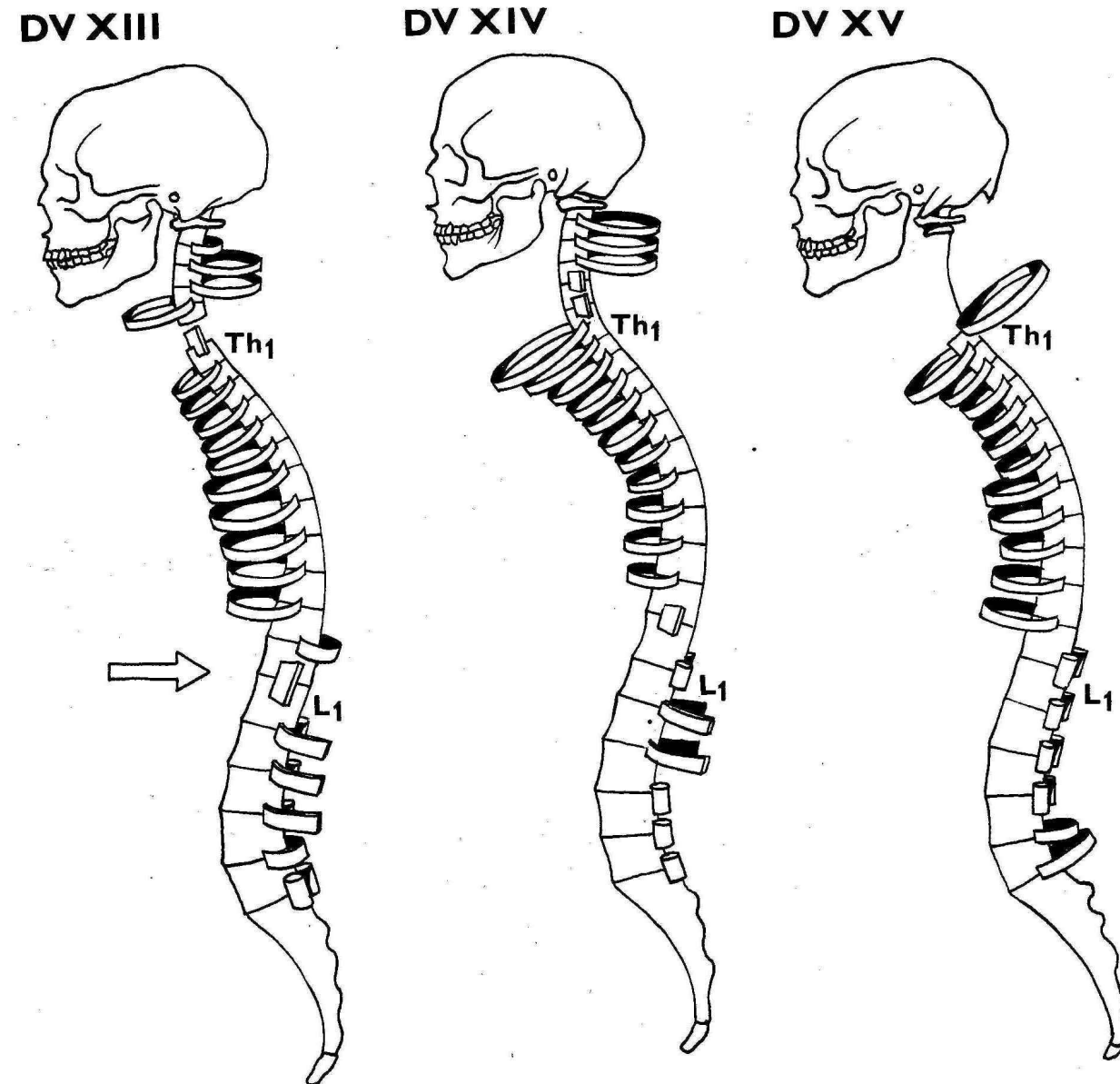


Figure 5. Model representation of articular type distribution in spinal segments of three individuals from Dolní Věstonice. The variously sized articulation cylinders plotted correspond to the measured magnitude of articulation radii. The arrow points to the segment with an unusual frontal position of the articulation facies in the lumbar spine of DV XIII.

dorsal clivus of *processus spinosus* (Fig. 6). In recent spines the spinoterminal angle formed by the vertebrae in the lumbar spine is 160° – 180° . The angle formed by the thoracic vertebrae ranges from 100° – 150° . The range of the angles of the cervical vertebrae is narrower: 125° – 145° . The measured vertebral angle values of DV XIV and DV XV exceed the limits of the variation range of the recent group showing values smaller by 20° – 30° . In DV XIII the values are by 10° – 15° smaller than in the kyphotic part of the thoracic spine and in the caudal part of the lumbar spine. On the contrary, in the caudal part of the thoracic spine they do not exceed the limit of the variation range found in the recent population. The largest angle is found in the vertebrae of the segment with an anomalous position of the articular facies, the Th₁₂ and L₁ vertebrae.

INDIVIDUAL CHARACTERS OF DV XIII SPINE

The atlantooccipital articulation has sphaeroid surface on the right and left joints (in the recent group in 76% – further R: 76%), the condyles are situated outside the *foramen occipitale magnum* (R: 55%). The contours of their *facies articulares* form a united area of curved pyriform outline on the right and left (R: 57%). The facies on the right condyle is located asymmetrically more rostrally as compared with the left one.

The facies of the *processus articulares atlantis* are sphaeroidally concave (R: 56%). The left facies is rostrally prominent into the *arcus anterior atlantis* (Fig. 7).

Articulario atlantoaxialis has the bisphaeroid archetypal shape defined above.

The following caudal parts of the cervical spine correspond to the recent model: the dorsocylindrical

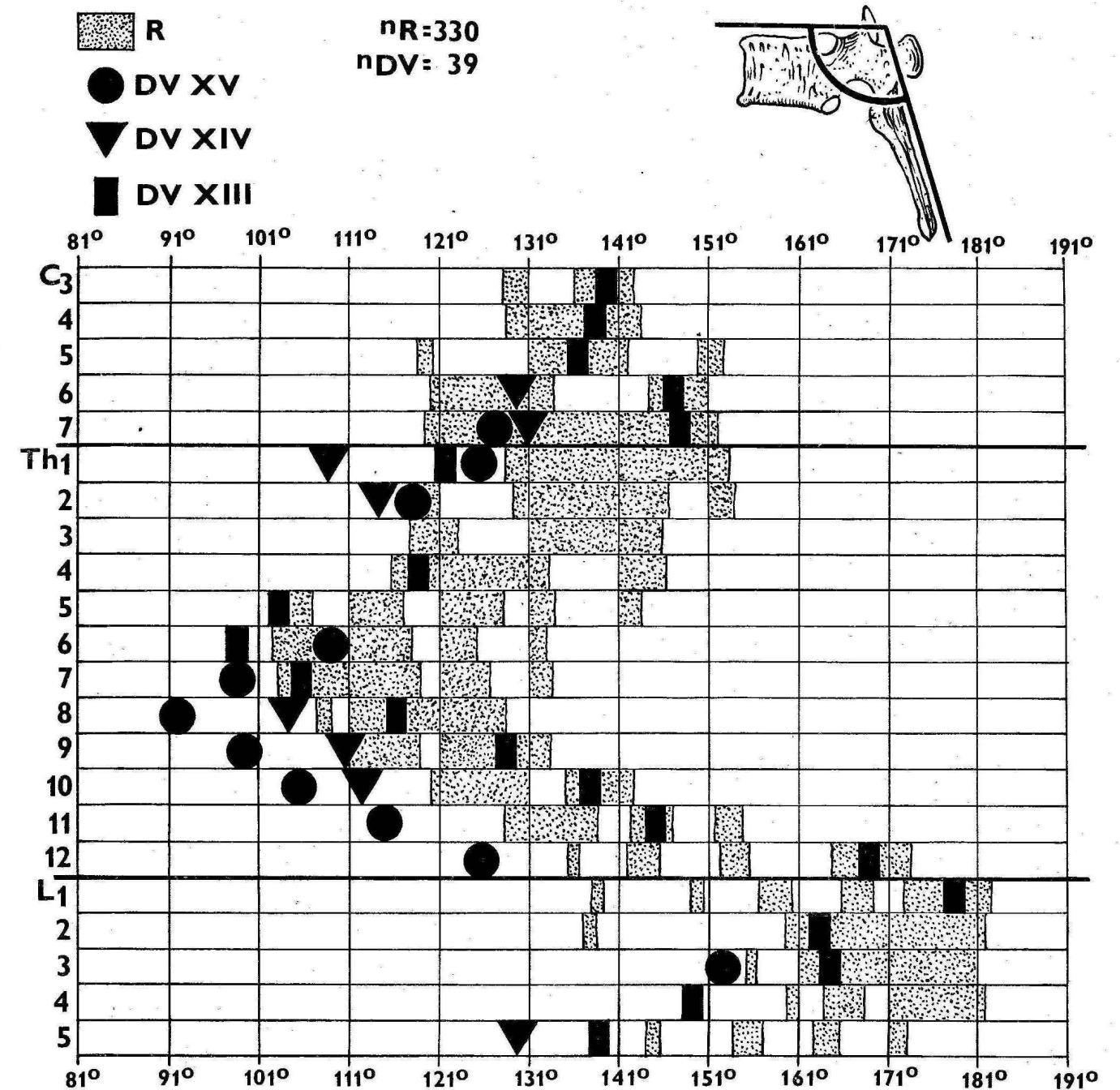


Figure 6. The size of the plane of facies terminalis vertebrae with dorsal clivus of *processus spinosus* is recorded for the group of spines of recent population by the variation range (dotted space) and in the individual maintained vertebrae of three fossil spines designated by a circle (DV XV), a triangle (DV XIV) and a rectangle (DV XIII).

shapes of C_{2/3} (R: 88%), C_{3/4} (R: 39%), C_{4/5} (R: 9%) confirm a lordotic course of the cervical spine. The transition into the kyphotic arcus suggests the ventrocylindrical form of C_{5/6} (R: 30%), the C_{6/7} segment is missing and C₇/Th₁ articulates into *articulatio plana* (R: 31%).

Thoracic vertebrae articulate characteristically in ventrocylindrical forms (R: 100%). However, in Th₁₁/Th₁₂ the dorsocylindrical type (R: 15%) is found. The incidence of *articulatio plana* in the Th₁₂/L₁ segment (R: 0%) is exceptional.

Other vertebrae are already dorsally different: L_{1/2}

hyperboloid (R: 77%), both L_{2/3} and L_{3/4} have asymmetrical configuration (R: 8% both), L_{4/5} has a monocylindrical and L₅/S₁ a bicylindrical form (R: 29% and R: 6% respectively).

The sequence of the joints of the lumbar spine from L_{2/3} to L_{3/4} on the right side forms a rotatable pillar; on the contrary, on the left side of these segments the asymmetrical forms from L_{2/3} to L_{4/5} suggest possible atypical reaction to load.

The spinoterminal angle can be measured in nearly all vertebrae of DV XIII: in the cervical vertebrae high values are measured; on the other hand, beginning with

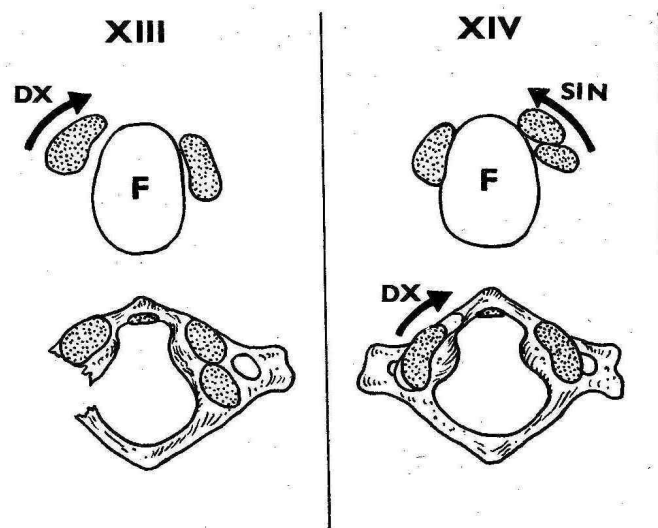


Figure 7. Diagram of the contour of the atlantooccipital joints of three individuals from Dolní Věstonice (F – foramen occipitale magnum).

the last thoracic vertebra the angles are minimal, also below the variation range of the values measured in the recent group. From the 8th thoracic vertebra the angle increases in each vertebra, up to maximal values in vertebrae Th₁₂ and L₁, which form a segment with frontally oriented articular facies. From L₂ low angle values are recorded again.

INDIVIDUAL CHARACTERS OF DV XIV SPINE

The atlantooccipital articulation has a concave surface (R: 76%). The condyles are localized outside the foramen occipitale magnum (R: 55%). The contours of their facies articulares are asymmetrical, the left facies formed by two solitary surfaces rostrally prominent. Facies articulares superiores atlantis are sphaeroidally concave (R: 56%).

The atlantoaxial articulation constitutes again the archetypal form described above. The dorsocylindrical joints of the cranial cervical spine (C_{2/3} R: 88%, C_{3/4} R: 39%, C_{4/5} R: 9%) are evidently more massive on the right side as compared with the left joint.

In clockwise torsion *processus spinosi* are found in C₂, C₃; in anticlockwise torsion they are found in C₄. The third cervical vertebra shows scoliotic torsion of the vertebral body (Fig. 8). The caudal cervical spine passes into kyphosis by plane articulation (C_{5/6} R: 4%, C_{6/7} R: 53%). The thoracic spine articulates by ventrocylindrical forms (C₇/Th₁ – R: 31%, further segments R: 100%). There is a dorsocylindrical form found in Th_{11/12} (R: 22%). In torsion the *processus spinosi* are found in clockwise direction in Th₇ and in anticlockwise direction in Th₈ and Th₉. The lumbar articulations are of the following types:

Th₁₂/L₁ bicylindrical (R: 32%), L_{1/2} hyperboloid (R: 77%), L_{2/3} hyperboloid again (R: 55%), L_{3/4} bicylindrical (R: 43%), L_{4/5} bicylindrical (R: 29%), L₅/S₁ bicylindrical (R: 31%).

The only pathological finding is a cranially oriented outgrowth from the left *processus articularis superior* to the Th₈ vertebra resembling exostosis.

The spinoterminal angle can be determined in the preserved eight vertebrae with intact bodies: in two

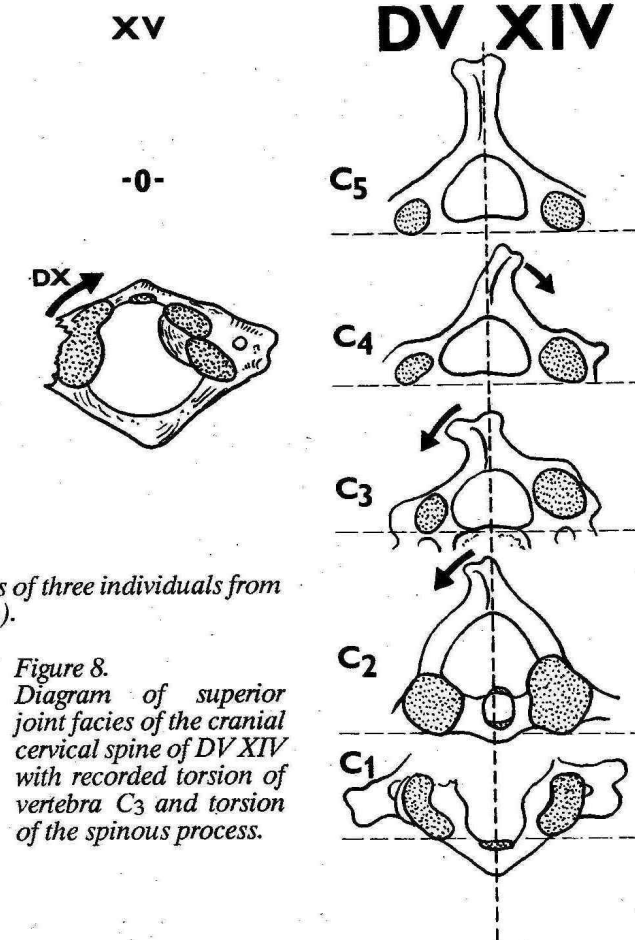


Figure 8. Diagram of superior joint facies of the cranial cervical spine of DV XIV with recorded torsion of vertebra C₃ and torsion of the spinous process.

cervical caudal vertebrae angles within the recent variation range of values are present, in the other thoracic vertebrae and in a lumbar one, values below the limit of the recent variation range are measured.

INDIVIDUAL CHARACTERS OF DV XV SPINE

The occipital condyles are not preserved. The sphaeroid concavities of the superior articular facies of the atlas (R: 56%) pass continually into a compressive concavity on *massae laterales*. A more prominent and larger area has this compression on the left. The right atlas facies is rostrally reaching the *arcus anterior atlantis* in a further compressive impression.

The bisphaeroid form of the atlantoaxial joint corresponds to the above described archetype.

Neither the *processus articulares inferiores atlantis* nor the following vertebrae C₃–C₇ are preserved. Thoracic articulations begin with the dorsocylindrical type in C₇/Th₁ (R: 4%), the following segments articulate in ventrocylindrical form (R: 100%).

Lumbar articulations manifest first the bicylindrical form (in Th₁₂/L₁ – R: 21%, in L_{1/2} – R: 20%, in L_{2/3} – R: 23%, in L_{3/4} – R: 43%), in segment L_{4/5} the monocylindrical type is found (R: 29%), similarly as in L₅/S₁ (R: 31%).

The os sacrum is conspicuously narrow, its width bilaterally ending in the area of *crista sacralis lateralis*: incidence of the narrow Robert's pelvis can be assumed. The longitudinal axis of the sacrum is twisted clockwise, the right facies articularis is by 15 mm shorter than the

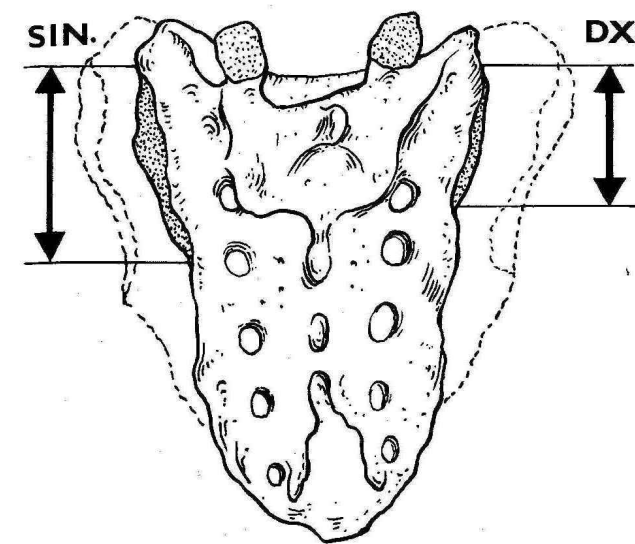


Figure 9. Frontal view of the narrow sacrum of DV XV compared with the silhouette of os sacrum of usual width.

left one. The spinous process is in clockwise torsion (Fig. 9). In all the retained thoracic vertebrae as well as in the single complete lumbar one the spinoterminal angle has extremely small values, far below the limit of the variation range of the values measured in recent population.

REFERENCES

- BOROVANSKÝ L., 1976: *Systematická anatomie člověka*, part I. Praha.
 ČIHÁK R., 1970: Variations of lumbosacral joints and their morphogenesis. *Acta Univ. Carol. Medica* XVI: 145–165.
 ČIHÁK R., 1987: Die Morphologie und Entwicklung der Wirbelbogengelenke. *Die Wirbelsäule in Forschung und Praxis* 87: 13–28.
 ČIHÁK R., 1987: *Anatomie*, part I. Praha.
 GERASIMOVA M. M., 1973: Portret ženštiny iz Dolních Věstonic. In: *Antropologičeskaja rekonstrukcija i problemy paleoetnografii*. Moskva, 5–15.
 JELÍNEK J., 1953: The Fossil Man of Dolní Věstonice III. *Anthropozoikum*, Praha, III: 37–92.

- KLÍMA B., 1950: Burial of the wife of a mammoth hunter at Dolní Věstonice (in Czech). *Archeologické rozhledy*, Praha II: 32–36.
 MED M., 1972: Articulations of the thoracic vertebrae and their variability. *Folia Morph. Praha* XX: 212–215.
 MED M., 1973: Articulations of the cervical vertebrae and their variability. *Folia Morph. Praha* XI: 324–327.
 MED M., 1974: Variability of intervertebral articulations with regard to the movement of the spine. *Rehabilitácia*, Bratislava, VII: 34–41.
 MED M., 1977: Prenatal development of thoracic intervertebral articulation. *Folia Morph. Praha* XXV: 275–277.
 MED M., 1979: Anatomical types of intervertebral articulation (in Czech). *Lékař a tělovýchova*, Praha IV: 60–63.
 MED M., 1980: Prenatal development of intervertebral articulation in man and its associations with ventrodorsal curvature of the spine. *Folia Morph. Praha* XXVIII: 264–267.
 MED M., 1982: Prenatal development of lumbar intervertebral articulation. *Folia Morph. Praha* XXX: 285–290.
 MED M., 1983: Intervertebral articulation in man – a phylogenetic comparison. *Folia Morph. Praha* XXXI: 148–153.
 MED M., 1986: Ontogenetische und vergleichend anatomische Untersuchungen der Wirbelbogengelenke des Menschen. *Verh. Anat. Ges.*, 80: 211–213.
 PUTZ R., 1981: *Funktionelle Anatomie der Wirbelgelenke*. Stuttgart.
 PUTZ R., 1989: Biomechanik der Wirbelsäule. *Krankengymnastik*, München: 41: 20–24.
 SCHUMACHER G. – H., 1985: *Anatomie für Stomatologen*. Bd. 2. Leipzig.
 VLČEK E., 1969: *Neanderthaler der Tschechoslovakei*. Praha.
 VLČEK E., 1970: Relations morphologiques des types humains fossiles de Brno et Crô-Magnon au pleistocène supérieur d'Europe. In: *L'Homme de Crô-Magnon*. Paris, 59–72.

Milan Med
 Věhrdova 6
 118 00 Praha 1
 Czechoslovakia