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The Scapula of the First Recognized Neanderthal Skeleton

During a visit to the Rheinisches Landesmuseum in Bonn during 1962 I was extended the privilege of examining the remains of the skeleton, found in the Neander Valley near Düsseldorf in 1856, which provided the name for a previously unrecognized early variety of mankind: the Neanderthals. Aside from a general interest in seeing a famous specimen, I wanted to see in particular the scapula (only the right one was recovered), because I had just finished a review of certain features of Neanderthal scapulae. In preparing the review I had lacked a cast of the Neander specimen and hence had had to rely on Schwalbe's (1914) line drawing thereof[1]. Since the orientation of the specimen in this drawing is not indicated, the drawing affords no way to evaluate the reported unusual dorsal inclination of the glenoid cavity. The main purpose of the present study, therefore, is to remedy this deficiency.

So far as I can determine, Klaatsch was the first to call attention to the unusual backward tilt of the glenoid cavity in the Neander scapula. His figure 8 (p. 152) is here reproduced as my fig. 1 (upper). Referring to this figure, Klaatsch says: 'Projiziert man den lateralen Rand der Scapula und die Cavitas gemeinsam vom Neanderthaler und Recenten, so erkennt man, daß bei der Neanderthal-Scapula die Gelenkfläche dorsal schaut. Diese Abweichung ist bedeutend.' The photographic view of the cast shown in fig. 1 (lower) seems to make the same point as Klaatsch's drawing, although the two outlines bear only a general resemblance.

Krause is said by Vallois (1932 p. 26)[2] to deny that the dorsal deviation of the fossa exists properly speaking; in other words, that 'ce serait une erreur d'optique, due à ce que le bord dorsal de la cavité est émoussé au lieu de former un bourrelet bien marqué.' On the other hand, Schwalbe (1914 p. 572) reaffirmed Klaatsch's observation as follows: 'Klaatsch betont mit Recht, daß die Fossa glenoidalis beim Neanderthaler etwas dorsalwärts schaut, womit ein zweiter Unterschied gegenüber dem Homo sapiens gegeben ist.'

1) Now that there is a large number of skeletons to which the term 'Neanderthal' has been applied, it is no longer easy to clearly designate the Neanderthal skeleton. For example, McCown and Keith (p. 132) say: 'A well-known character of the Neanderthal type of Europe is the absolute and relative massiveness of all their joint cavities and surfaces ... in this respect the Neanderthal glenoid measurements exceed those of the much taller Skhūl man, No. V'. Here it is not at once apparent that use of the term 'Neanderthal' in the general sense is being followed by its use in the specific sense. In the latter case the sense would be clearer, if the term 'Neander' had been used instead of 'Neanderthal'. In other words, the Neander and Skhūl V specimens are being compared as Neanderthals.

2) Vallois does not cite a specific reference at this point, but includes in the bibliography (1946) a reference to W. Krause, as the author of 'Skelett der oberen und unteren Extremitäten' (1901). I have not succeeded in finding anything on this subject in the 1909 edition of this work, the only one consulted.

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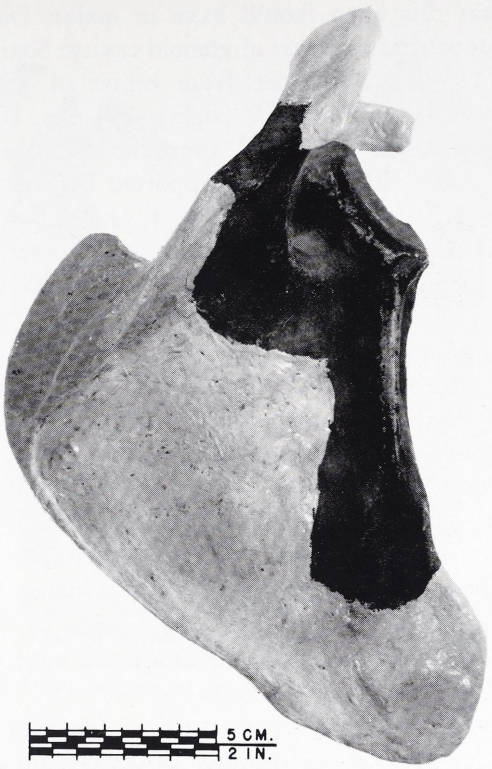
1 *Upper.* Generalized cross-sections through the middle of the right glenoid cavities of Neander (solid line) and recent man (dotted line). *d* = dorsal, *v* = ventral. (Klaatsch, fig. 8, p. 152.).
Lower. Corresponding photograph of the Neander scapula (cast) with transverse axis of the glenoid cavity drawn in.

2 Superimposed cross-sections of the middle part of the left glenoid fossae of an Australian (solid line) and of a Frenchman (dotted line). *v* = ventral limit of the articular surface; *d* and *d'* = its dorsal limit. (Vallois, 1932, fig. 32, p. 27).

Vallois did not rely entirely on Krause's opinion, but examined most of the Neanderthal scapulae available at the beginning of the 1930's and concluded: 'Ce n'est que sur le moulage de l'omoplate de Néanderthal que, en plus de l'emoussement incontestable de bord dorsal, j'ai vu vraiment une légère deviation en arrière de la cavité, mais c'est là, sans nul doute, une particularité individuelle de cet os.' Yet in general, and especially as regards modern man, Vallois tended to agree with Krause that the dorsal inclination of the cavity involves an optical illusion. He illustrated this point in his fig. 32 (p. 27), here reproduced as fig. 2, and stated: 'La déviation n'était qu'une apparence causée par ce fait que le bord dorsal, tout à fait arrondi, se continuait par transition insensible avec la face dorsale du col de l'omoplate: de ce chef, la limite de la surface articulaire se trouvait reportée plus en arrière que d'habitude, et la cavité semblait deviée en bloc de ce côté.'

To my knowledge only McCown and Keith have attempted objectively to quantify the amount of glenoid dorsal inclination. In order to do this, it was necessary for them to relate the transverse axis of the glenoid cavity to some orientation plane. They named the plane which they defined for this purpose the infraspinous plane. As the name implies, only the portion of the bone below the spinous process is used in defining the plane, and specifically the following three points: 1. The most prominent point on the ventral lip of the glenoid cavity, 2. the ventral margin of the inferior angle, and 3. the ventral margin of the vertebral border at the basal end of the spinous process. Exactly how the measuring was done is not explained, beyond the following sentence (footnote on p. 133): 'This and the other scapular angles were projected onto the relevant vertical or horizontal planes[3] and measured with a protractor.' In any case, McCown and Keith state (p. 133): 'In the [Neander] scapula [the angle formed by the intersection of the transverse axis or plane of the glenoid cavity with the infraspinous plane] is 61°, that is, the glenoid cavity has turned dorsally from a position of 90°

[3]) McCown and Keith seem to have visualized the infraspinous plane as being horizontal, and other planes at right angles to the infraspinous plane as being vertical. This is due no doubt to the bone being in the horizontal position during study.



3 Dorsal view of the Neander right scapula as restored by author. The dark portion is a cast of the original.

to the horizontal plane, to an extent of 29°. In Tabūn I, for example, the deflection is about 2–3°; in Skhūl V (with damaged glenoid) the deflection is estimated to have been 16° while in the [modern] specimens it ranged from 8° to 11°. We regard the great deflection of the [Neander] scapula as an extreme variation . . .' To this I can add that the dorsal deflection of the glenoid cavity in the case of Shanidar I is about 4°.

The claim by McCown and Keith that the transverse axis of the glenoid cavity of the Neander right scapula is inclined 29° dorsalwards from a right angle to the infraspinous plane depends on the manner in which the missing parts of the bone have been reconstructed. Since in this specimen only one of the three points defining the infraspinous plane is present, namely, the most prominent point on the ventral lip of the glenoid cavity (fig. 3), practically the whole of the blade, including most of the spinous process must be reconstructed. The record does not show whether McCown and Keith carried out a detailed reconstruction, or whether they simply estimated the position of the plane relative to the preserved part.

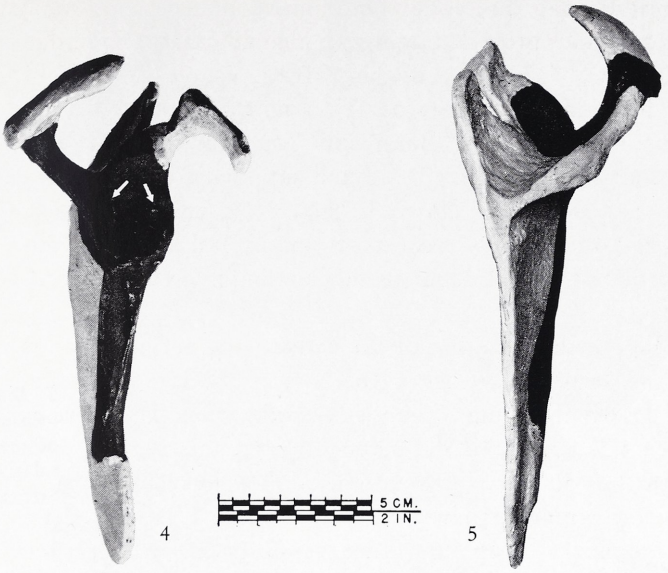
These considerations require, therefore, that the first step in this study be a reasonable reconstruction of the Neander right scapula. Obviously, it is impossible to know this bone's original length and width, much less the form of its vertebral border and of its inferior angle. Fortunately, the findings on the Shanidar Neanderthal scapulae sug-

gest the dimensions that this bone should have in males: Distance from vertebral border at base of spinous process to center of glenoid cavity: Shanidar I (left), 117 mm.; Shanidar IV (right), 115 mm.; distance from center of glenoid cavity to most distal point at inferior angle: Shanidar IV (right), 150 mm. Using a cast generously supplied by the Landesmuseum Bonn and approximating the stated dimensions, I developed the missing parts with plasticine supported by wires glued to the ventral surface. I feel that the result shown in figs. 3, 4, and 5 meets the requirement of reasonableness and that such a reconstruction certainly is much more likely to yield the original position of the infraspinous plane than would be the case were the fragment alone used.

Attention is called to the fact that of the three plane-defining points the true location of the one on the vertebral border at the base of the spinous process has the greatest bearing on the degree of angulation under consideration. The more curvature the blade is given between this point and the plane-defining point on the ventral border of the glenoid fossa, the less dorsally inclined will be the transverse axis of the glenoid cavity relative to the infraspinous plane, and vice versa. I believe that in this respect I have attained about as much curvature as possible without violating the normal relationships of the structures involved (fig. 5). In so doing I have felt that little purpose is served by exaggerating the glenoid inclination in this case. Nevertheless, the possibility remains that more or less inclination could have existed than is present in the reconstruction.

Having achieved a whole scapula by reconstruction, the next step was to devise a simple means of measuring the dorsal inclination of the glenoid cavity. Trial and error quickly led to the device shown in figs. 6, 7, and 8, which is nothing more than a protractor attached to one edge of a piece of board, measuring 8" x 12" x $^3/_4$", so as to be at right angles to the main surface. A board of this size happened to be available when the need arose and was not altered, although its manipulation would be easier, if the size were reduced to 6" x 10". As will be noted, the protractor has been countersunk into the edge of the board so that its base line coincides with the intersection of the two planes represented by the edge and the main surface. If one visualizes this large surface as the infraspinous plane, and the base line of the protractor as the line between the plane-defining points on the glenoid margin and at the base of the spinous process, then, the protractor provides another plane at a right angle against which the inclination of a line, such as the transverse axis of the glenoid cavity, can be measured. Figs. 7 and 8 show a scapula placed in the correct position and held with one hand while the angle is determined by means of a straight-edge held in the other hand. Care must be taken, of course, to see that the straight-edge crosses the midpoint of the base line of the protractor. It is a little easier for a right-handed individual to measure glenoid angulation on right scapulae than on left scapulae, and some ambidexterity is necessary for carrying out the operation on both right and left scapulae. With a little practice, however, comparable results on different bones quickly ensue.

Upon attempting to measure the dorsal inclination of the glenoid cavity in the restored Neander right scapula I noticed at once that the dorsal and ventral margins of the cavity are bevelled, the dorsal more evenly so than the ventral (fig. 4). This means that when a straight-edge is applied in the mid-transverse axis of the cavity, the points of contact are two, as generally is the case, but closer together than usual (actu-

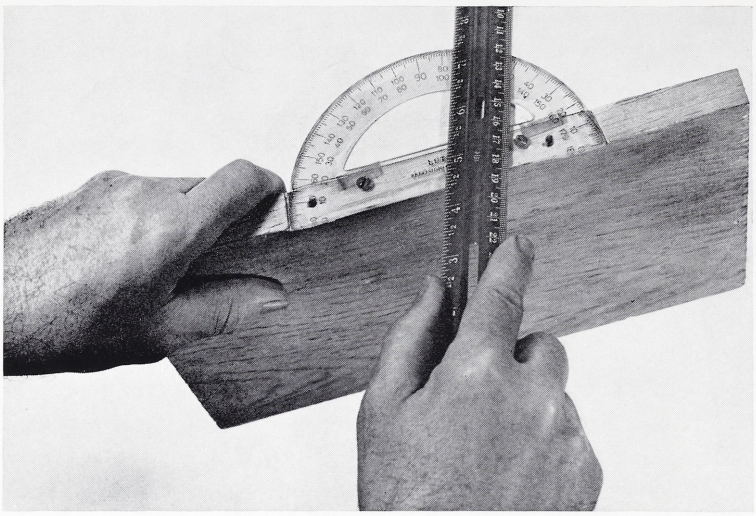


4 Lateral view of the Neander right scapula as restored by author. Arrows point to lines where the pigment has been worn off the inner edges of bevelled areas of the glenoid cavity during measurement.
5 Medial view of same. Many variants of the borders are possible.

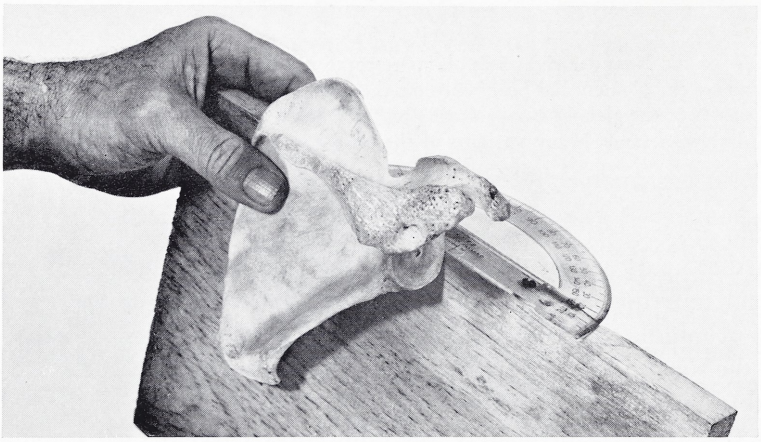
ally, only about 13 mm. apart – cf. with fig. 9). Also, it means very likely that the contact points were farther apart and at different levels at one time. Bevelling of the dorsal margin is seen not infrequently in modern scapulae, particularly on the right side and in individuals of middle to advanced age (fig. 9), seemingly because of excessive use of the arm on the side involved. That the individual whose scapula is the subject of this report used his right arm excessively seems very likely in view of the old injury to his left elbow (fig. 10)[4]. Unfortunately, the failure to recover the left scapula in this case makes it impossible to verify the existence of the expected side differences in the glenoid cavities.

The bevelling of the ventral margin of the cavity is less readily explained. In modern bones this feature is rarely seen, which suggests that its existence in the Neander scapula may be due, at least in part, to postmortem damage. Often, as a counterpart of the dorsal bevelling, one sees in modern man a build-up of bone along the ventral margin. Something of the sort is preserved in the Neander scapula at only one point. Both types of change can be regarded as osteoarthritic. There can be little doubt, therefore, that much of the glenoid joint surface in the Neander scapula is abnormal. For this reason it

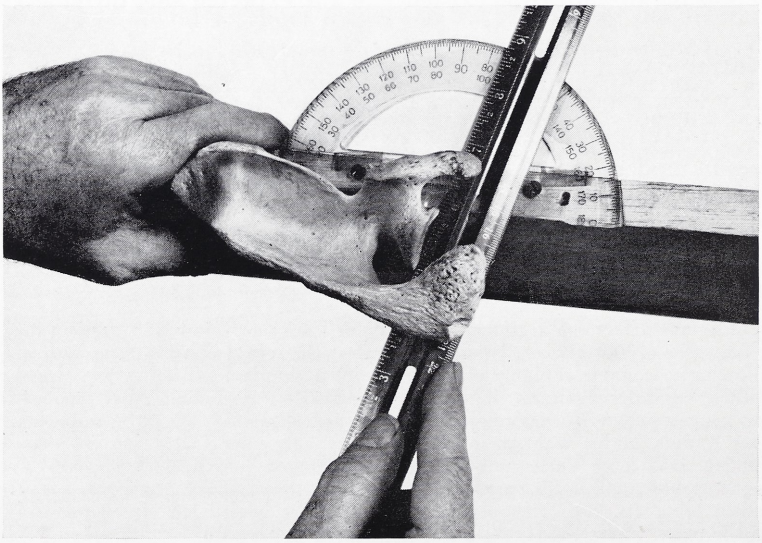
4) The nature of the injury does not affect the argument one way or the other. However, readers may by interested to know that Schwalbe (1900) reviewed this subject after the initial controversies had subsided and developed the following reasonable explanation: 'Mir scheint nach allem gar kein Zweifel mehr möglich, daß die eigentümlichen Veränderungen am linken Ellenbogengelenk als Folgen einer lange vor dem Tode des Individuums eingetretenen Verletzung angesehen werden müssen. Jedenfalls hat eine nicht reponierte Luxation des Radius, höchst wahrscheinlich kombiniert mit einer Infraktion des proximalen Ulna-Endes stattgefunden. Daß diese Verletzung aber schon in jungen Jahren, noch während der Wachstumsperiode, sich ereignet haben muß, dafür spricht die schon von Schaaffhausen erwähnte Verkürzung der linken pathologischen Ulna' (p. 19). It should be added that the healed left elbow probably could not be flexed beyond the point where the forearm was 90° to the upper arm.



6 Simple device used to measure the inclination of the glenoid fossa relative to the ventral infraspinous plane.



7 A right scapula properly placed in the ventral infraspinous plane (the large surface of the board) and ready for measuring the inclination of the glenoid cavity.



8 View of the measuring device in use. The edge of the ruler against the protractor scale indicates that in this case the glenoid cavity is inclined dorsally about 15° (in other words, 15° to the right of the 90° mark).

9 Two pairs of modern scapulae in which the right glenoid cavity of each shows marked bevelling of the dorsal margin (arrows). The ventral and left dorsal margins show either no bevelling or only slight bevelling.

is difficult to say how much the angulation of the transverse axis had changed during the individual's lifetime, although I would judge that it had increased.

Bearing these points in mind, I will now state that measurement of the restored Neander scapula with the device above described yielded an angle of 21°. In other words, the mid-transverse axis of the glenoid cavity is inclined this much dorsalwards relative to a plane at a right angle to the infraspinous plane. This figure is 8° less than that reported for the same specimen by McCown and Keith.

The question now arises as to how a dorsal inclination of 21° compares with the modern range. Although McCown and Keith gave a range of 8–11° for the modern scapulae measured by them, it is evident from their report that they were referring to only 3 such specimens. Table 1 gives figures obtained by means of the device described above on 100 adult males from 5 racial groups: 1. American Whites dying in New York City around the turn of the century (mainly recently arrived European immigrants). – 2. American Negroes of the Washington-Baltimore area dying between 1903 and 1910 and selected because of seeming lack of admixture. – 3. Chinese from around Canton dying in Alaska prior to about 1925. – 4. Alaskan Eskimos from various time periods. – 5. American Indians (probably Arikara) of the Dakota area dying during the interval 1725–1825.

This table indicates that glenoid cavity inclination of the degree present in the Neander scapula was not encountered in the large sample examined, although two specimens

10 The proximal ends of the Neander ulnae (casts) showing that the left bone (to the left in these views) is abnormal. *Upper,* viewed from medial sides; *lower,* viewed from lateral sides.

came within $1^1/_2$–2°. However, since these modern specimens are essentially normal, and none shows arthritic changes of the extent seen in the Neander specimen, it seems probable that the latter is outside the modern range only because of the pathological changes.

Table 1 also indicates that glenoid cavity inclination is more pronounced on the right than on the left side. To give a better idea of the role of sidedness in this respect, tables 2 and 3 are provided. In only 9% of modern scapulae do the cavities of the two sides show equal inclination, whereas 71% show more inclination on the right than on the left. Moreover, in the cases where more inclination occurs on the right than on the left the difference, as expressed in degrees, tends to be far greater than in the cases where the reverse predominance occurs. All of this suggests that the missing left Neander scapula may have had a glenoid cavity with a dorsal inclination well within, but still at the upper end of, the modern range.

Although this study of the Neander scapula has been concerned mainly with the dorsal inclination of the glenoid cavity, the inclination of this cavity relative to the axillary border – the axillo-glenoid angle of Martin (p. 1009 no. 17) – is also worth considering. Here again the accurate determination of the angle requires that the miss-

TABLE 1

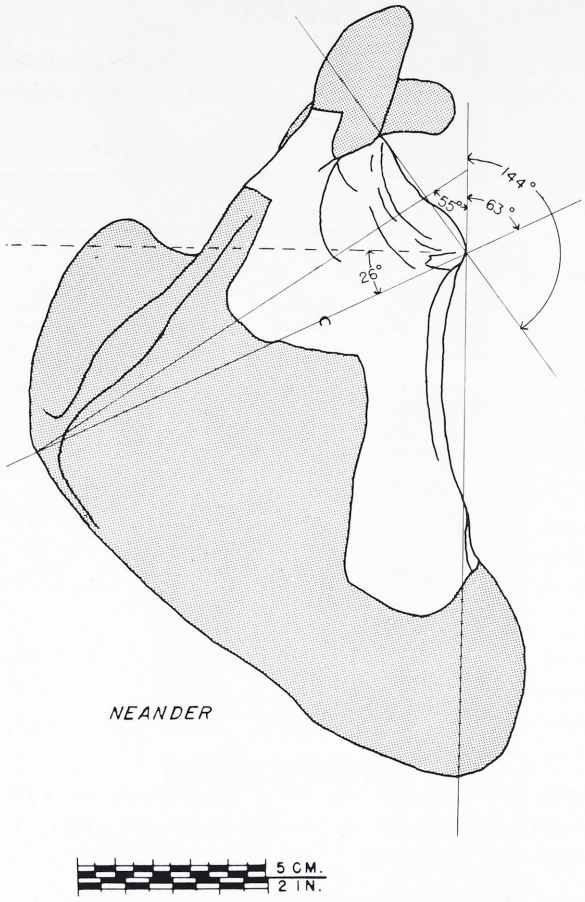
Direction and amount of inclination of the transverse axis of the glenoid cavity in males of five racial groups, by side

Racial group	Direction of inclination	Side: Right No.	Right Mean	Right Range	Left No.	Left Mean	Left Range
Whites	Dorsal	20	9.9°	3.0–19.0°	20	6.6°	2.0–13.0°
	Neutral	–	–	–	–	–	–
	Ventral	–	–	–	–	–	–
Negroes	Dorsal	18	9.6	0.5–18.0°	19	7.9	1.0–19.5
	Neutral	1	–	–	–	–	–
	Ventral	1	0.5	–	1	2.5	–
Chinese	Dorsal	18	8.8	4.0–13.5	17	6.1	2.5–11.5
	Neutral	–	–	–	1	–	–
	Ventral	2	1.0	–	2	2.2	1.5– 3.0
Eskimos	Dorsal	20	9.5	2.5–15.5	19	7.3	3.0–15.5
	Neutral	–	–	–	1	–	–
	Ventral	–	–	–	–	–	–
Indians	Dorsal	20	12.2	4.5–17.5	20	9.7	3.0–16.5
	Neutral	–	–	–	–	–	–
	Ventral	–	–	–	–	–	–

TABLE 2

Numbers of male individuals in five racial groups showing one or other side predominance in amount of glenoid cavity inclination

Racial group	R>L	R=L	L>R
Whites	15	1	4
Negroes	14	1	5
Chinese	13	2	5
Eskimos	14	4	2
Indians	15	1	4
Totals	71	9	20



11 Stereographic drawing of the right Neander scapula as restored by author and as posed in the ventral infraspinous plane. Dotted areas indicate restoration. Added lines and measured angles follow the scheme of McCown and Keith (fig. 88).

ing parts of the bone, and especially the inferior angle, be restored. If the measuring procedure of McCown and Keith is followed, the bone must be oriented in the infraspinous plane as previously explained. Others vary the orientation, using the center of the glenoid cavity rather than its ventral margin (Cf., Martin p. 1009 no. 15). To a limited extent I have followed McCown and Keith in this respect in order to take advantage of their results for comparison.

In my general study of Neanderthal scapulae I was unable to check on the published figures for the axillo-glenoid angle of the Neander scapula, namely, 143° (Vallois 1932 p. 21) and 145° (McCown and Keith p. 144). Fig. 11 indicates that my reconstruction yields an angle of 144°. This is very close agreement. Also, the figure of 144° is close to those reported for Shanidar I (145°, Stewart), La Ferrassie (145°, Vallois 1932 p. 21), and Krapina VII? (145°, Gorjanović-Kramberger, p. 216); whereas it is higher than those reported for Skhūl V (127°, McCown and Keith,

TABLE 3

Distributions of amounts (in degrees) of one or other side predominance of glenoid cavity inclination in males of five racial groups

Racial group	Side predominance	0–1.5°	2.0–3.5°	4.0–5.5°	6.0–7.5°	8°+
Whites	R>L	2	3	4	4	2
	L>R	2	1	1	–	–
Negroes	R>L	6	3	4	1	–
	L>R	1	3	1	–	–
Chinese	R>L	2	4	4	2	1
	L>R	5	–	–	–	–
Eskimos	R>L	1	5	5	2	1
	L>R	–	2	–	–	–
Indians	R>L	4	2	6	3	–
	L>R	2	2	–	–	–
Totals	R>L	15	17	23	12	4
	L>R	10	8	2	–	–

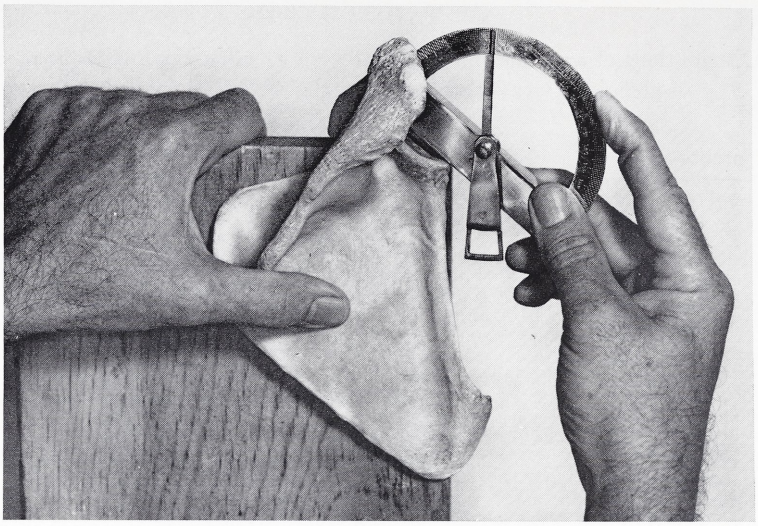
p. 144; 131°, Stewart), Tabūn I (132°, McCown and Keith, p. 144), and Krapina X? (139°, Gorjanović-Kramberger, p. 216).

At the time fig. 11 was made I judged the most distal point on the inferior angle as it appeared when the axillary border was vertical. I am inclined now to think it is better to judge this point as it appears when the axillary and vertebral borders form the two sides of a 'V'. The resulting change in location of the point which determines the distal end of the axillary border axis slightly increases, of course, the axillo-glenoid angle. That a corresponding adjustment has not been made in the drawing (and in the photographic view, fig. 3) is because we are dealing with a hypothetical reconstruction. Readers can experiment with all of the angles in the drawing and add others.

Turning next to modern man, McCown and Keith (p. 144) reported axillo-glenoid angles of 125°, 130°, and 136° for a Bushman, a Sikh, and an Australian, respectively. This raises the question of how representative of modern man these three specimens are. They would seem to range around the general mean, judging from the figures for 113 Finns given by Kajava: mean 129.2°; range 129–155°. Yet Vallois (1932 p. 21) reports somewhat different figures for 120 French: mean 134.9°; range 120–153°.

In order to check this matter further, and yet not spend the time required to orient and draw the individual specimens as usually recommended (see, for example, Vallois 1932 p. 20), I found that I could get seemingly accurate results by using a corner of the device described above in combination with an Ansteckgoniometer as shown in fig. 12. Obviously, this technique differs from the indirect technique usually employed in that it ignores a rigid orientation of the bone, while presenting the two axes in a manner that permits rapid direct measurement of their angular relationship.

Having determined that I could get the same reading of the axillo-glenoid angle of the restored Neander scapula by both the direct and indirect techniques of measurement,



12 Method of measuring the axillo-glenoid angle used in this study. The measuring board rests squarely on a horizontal table top.

I then proceeded to measure the angle directly on the paired scapulae in the 5 modern male series already described. Table 4 shows that the means for these series vary 3–4° at most, with the Eskimos and Indians yielding higher means (133–134°), than the other three groups (131—132°). Also, there is no definite side difference except for a suggestion in table 5 of a tendency for slightly higher angles to occur on the right side. In only one series (Whites) does the upper end of the range for the right side include a figure as high as that for the Neander specimen. This is in contrast to the findings of Kajava and Vallois for Whites cited above in which the ranges extend about 10° higher than the Neander figure. Whether or not this difference is due to the different methods of measurement used, I have not attempted to discover. There can be no doubt, however, that the Neander right scapula, like those of several other Neanderthals, has an axillo-glenoid angle at the upper end of the modern range.

TABLE 4

Means and ranges of the axillo-glenoid angle in males of five racial groups, by side[5]

	Side					
	Right			Left		
Racial group	No.	Mean	Range	No.	Mean	Range
Whites	18	132.8°	123–144°	18	130.7°	124–140°
Negroes	20	131.7	121–141	20	131.9	123–145
Chinese	20	131.8	126–139	17	131.4	122–139
Eskimos	17	134.4	129–141.5	20	134.4	126–143
Indians	17	133.0	124–143.5	17	133.0	125–138

5) The differences in number measured is due to damage to the inferior angle.

TABLE 5

Frequency distribution of the axillo-glenoid angle in males of five racial groups, by side

Racial group		Interval				
		121–125°	126–130°	131–135°	136–140°	141° +
Whites	R	2	5	6	3	2
	L	3	6	6	3	–
Negroes	R	1	5	10	3	1
	L	2	8	5	4	1
Chinese	R	–	8	10	2	–
	L	1	6	8	2	–
Eskimos	R	–	5	6	4	2
	L	–	6	5	7	2
Indians	R	1	1	13	1	1
	L	1	2	9	5	–
Totals	R	4	24	45	13	6
	L	7	28	33	21	3

Conclusions

The inclinations of the glenoid cavity of the Neander right scapula, as regards both the ventral infraspinous plane and the axis of the axillary border, correspond to the upper part of the ranges for these features in modern man. Part of the dorsal inclination of the transverse axis of the cavity can be attributed to secondary arthritic changes reflecting probably the extra 'wear and tear' on this joint resulting from the injury of long standing to the left elbow. Only the very large angle of inclination with the axillary border (axillo-glenoid angle) seems to represent a general tendency among the Neanderthals. Among the primates the accentuation of the tendency for the glenoid cavity to face somewhat dorsally and more laterally than cranially is a peculiarity of man and probably is a response to his unique upright posture. In this respect, paradoxically, the Neander scapula of considerable antiquity would seem to be in advance of the scapulae of many modern men.

Literature cited

Gorjanović-Kramberger — K. Gorjanović-Kramberger, Der diluviale Mensch von Krapina in Kroatien. Ein Beitrag zur Päläoanthropologie (Wiesbaden 1906).

Kajava — Y. Kajava, Über den Schultergürtel der Finnen. Ann. Acad. Scient. fennicae 21, 1942, 1–69.

Klaatsch — H. Klaatsch, Das Gliedmaßenskelett des Neanderthalmenschen. Verh. Anat. Ges. Bonn 15, 1901, 121–154.

Krause	W. Krause, Skelett der oberen und unteren Extremitäten. 3. Sect. in: 'Handbuch der Anatomie des Menschen', by Karl von Bardeleben; I. Skelettlehre (Jena 1909).
Martin	R. Martin, Lehrbuch der Anthropologie 2 (Jena 1928).
McCown and Keith	Th. D. McCown and Sir A. Keith, The Stone Age of Mount Carmel, II. The fossil human remains from the Levalloiso-Mousterian (Oxford 1939).
Schwalbe 1900	G. Schwalbe, Der Neanderthalschädel. Bonner Jahrb. 106, 1900, 1–72.
Schwalbe 1914	G. Schwalbe, Kritische Besprechung von Boules Werk 'L'homme fossile de la Chapelle-aux-Saintes' mit einigen Untersuchungen. Zeitschr. f. Morph. u. Anthr. 16, 1914, 527–610.
Stewart	T. D. Stewart, Neanderthal Scapulae, with special attention to the Shanidar Neanderthals from Iraq. Anthropos 57, 1962, 779–800.
Vallois 1932	H. V. Vallois, L'omoplate humaine. Bull. Soc. d'Anthr. Paris, VIII^{e} sér. 3, 1932, 3–153.
Vallois 1946	dto., IX^{e} sér. 7, 1946, 16–100.