THE OCCIPITAL BONE AND THE BONES OF THE SUPERIOR EXTREMITY IN RELATION TO "RIGHT" OR "LEFT" HANDEDNESS.

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In an article published in the British Medical Journal of 7th November 1925, Professor Elliot Smith made the statement that a fossilised skull found in London was that of a left-handed person. To a number of people the statement seemed somewhat imaginative, and considerable disagreement was expressed.

In a later address to the Westminster and Holborn Division of the British Medical Association, Professor Elliot Smith recapitulated the evidence upon which the assertion was based; at the same time he referred to some previous communications of his own, and also to the works of some other authorities.

A consideration of those previous statements of his own to which Professor Elliot Smith referred leads one, justifiably I think, to ascribe to him the following postulate:—

That if, in any given skeleton, the impression made by the right cerebral hemisphere on the occipital bone is larger and more definite than that made by the left hemisphere, then the skeleton is that of a left-handed man or woman, and, in addition, it will be found that the left humerus is longer and stronger than the right, the left clavicle shorter and stronger than the right, and the left radius longer than the right.

He does not assert that there are no exceptions to this rule, but indicates that it holds good for the vast majority of the skeletons.

Since 1845, when Arnold drew attention to bodily asymmetry and the relative proportions of the bones of opposite sides, a considerable amount of evidence has been produced tending to the conclusion that the bones of the right superior extremity are generally stronger than those of the left, in right-handed people; but there is much less evidence with regard to the impressions made upon the occipital bone by the occipital lobes of the brain.

The question at issue at present, however, is neither whether or not the right humerus and radius are longer than the left,
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and the right clavicle shorter and stronger than the left in right-handed people, nor whether or not a marked left occipital lobe impression is more commonly found in conjunction with right-handedness, but rather, whether or not it is justifiable to assert that a skeleton possessing a longer and stronger right humerus was necessarily right-handed, or that a skull with a more strongly marked right occipital lobe impression belonged to a left-handed man or woman.

The evidence so far available is not entirely conclusive. It suggests that the right humeri of right-handed people are generally longer than the left humeri, but it by no means justifies a categorical statement in any one particular instance; and the evidence with regard to the clavicles and occipital bone is still less conclusive.

The anatomical interest of the subject is obvious, and, if it were possible to establish Professor Elliot Smith's contention beyond all question, the medico-legal aspect might become important; therefore it seemed worth while to seek for some further data.

There were two sources available; firstly, 214 skeletons belonging to the Anatomy Department of the University of Edinburgh, and, secondly, the section of the Nubian Survey Report dealing with the human remains to which reference was made by Professor Elliot Smith.

Both humeri of all the 214 skeletons of the Edinburgh collection were available. One hundred and thirty-nine were Europeans, and in all but 17 of the Europeans both clavicles were present also. The sex of 78 skeletons was known, and in 32 cases it was possible to obtain endocranial casts of the occipital portion of the cranium.

The total lengths and weights of the clavicles were taken. The trochlear and capitular lengths of the humeri were measured, and the weights also were ascertained. An attempt was made to determine the volumes of the bones by displacement, but was abandoned owing to the difficulty of finding any adequate method of preventing the entry of fluid into the dried bones. The estimation of general strength and development by inspection was not wholly satisfactory either: not only was there a large number of skeletons in which there was no detectable difference between the humeri; in actual fact these numbered 52.6 per cent. of the European skeletons in the Edinburgh series, but even in the remainder, the difference, if
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present at all, was so slight as to render its estimation a matter of some difficulty. And, further, the opinions of different observers were not always in agreement about any one pair of humeri. Exactly the same difficulties occurred with regard to the clavicles.

The results of the examination of the skeletons in the Anatomy Department at Edinburgh can best and most easily be appreciated as set forth in tabulated form as follows:

(1) Taking the series as a whole, and regarding only the trochlear measurements—

In 72.77 per cent. the right humeri were longer than the left.
,, 17.38 per cent. the left humeri were longer than the right.
,, 9.85 per cent. the humeri were of equal length.

(2) In those cases in which the sex was known—

Males . . In 66.66 per cent. the right humeri were longer than the left.
,, 18.18 per cent. the left humeri were longer than the right.
,, 15.15 per cent. the humeri were of equal length.

Females . In 85.71 per cent. the right humeri were longer than the left.
,, 9.52 per cent. the left humeri were longer than the right.
,, 4.76 per cent. the humeri were equal.

(3) Of European skeletons only—

In 71.53 per cent. the right humeri were the longer.
,, 19.00 per cent. the left were the longer.
,, 9.42 per cent. they were equal.

(4) Considering these by sexes—

Males . . In 65.45 per cent. the right humeri were longer.
,, 20.00 per cent. the left were longer.
,, 14.34 per cent. the humeri were equal.

Females . In 85.71 per cent. right humeri longer.
,, 9.52 per cent. left humeri longer.
,, 4.76 per cent. humeri equal.

(5) The whole series may be reconstructed with capitular measurements instead—

In 68.69 per cent. right humeri longer.
,, 22.9 per cent. left humeri longer.
,, 8.41 per cent. equal.
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(6) Where the sex was known—

**Males**
- In 65.65 per cent. right humeri longer.
- 26.26 per cent. left humeri longer.
- 8.09 per cent. equal.

**Females**
- In 80.00 per cent. right longer.
- 12.50 per cent. left longer.
- 7.50 per cent. equal.

(7) Of the European skeletons—

- In 68.35 per cent. right humeri longer.
- 25.89 per cent. left longer.
- 5.76 per cent. equal.

(8) Where the sex of these was known—

**Males**
- In 68.52 per cent. right humeri longer.
- 31.48 per cent. left longer.
- 0.00 per cent. equal.

**Females**
- In 76.19 per cent. right humeri longer.
- 14.29 per cent. left longer.
- 9.52 per cent. equal.

There are several points which are suggested by examination of these tables. The first is the wide variation in some directions, which is most probably due to the fact that the percentages have been constructed from an insufficiency of large number; a larger series would in some extent smooth out those variations. In spite of this, however, there are certain conclusions suggested. If the length of the humerus is for the moment accepted as the criterion of handedness, then it would seem that, on the average, about 17 per cent. or one-sixth of the population is left-handed. And further, this figure is rather higher in the case of males, and much lower in the case of females. If the capitular measurements are taken, there is a considerable alteration in the proportions. The average number of left-handers is increased to 22.9 per cent. or rather more than one-fifth. This affects both male and female, the figure for males being as high as 26 per cent., which is more than one-fourth.

It is interesting to see how far these conclusions are upheld by a consideration of the human remains described in the Report of the Archaeological Survey of Nubia. From this report I have collected accounts of 132 skeletons in which the measurements of both humeri were recorded. In 75 (56.8 per cent.) the right humerus was longer than the left. In 41
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(31 per cent.) the left humerus was longer than the right. In 16 (12.1 per cent.) the humeri were of equal length. In 129 of these the sex was known: 81 were male and 48 female. In 53.1 per cent. of cases of the males, the right humerus was the longer, and in 37 per cent. the left. Of the females, in 62.5 per cent. the right humerus was the longer, and in 22.9 per cent. the left. In this series the percentage of left-handed people is much higher, but it is still, as in the Edinburgh series, higher in males than in females.

From these two series one gets estimates of left-handedness varying from 17 per cent. to 37 per cent. Even the lowest of these estimates seems rather higher than the figure one would expect from one's own experience of left-handed people. And this introduces the question as to the number of left-handed people. There have been various estimates made at different times, and they differ very widely. Thus, Baldwin and Hyrtl gave 2 per cent. as their estimate, Ballard 2.7 per cent., Lombroso and W. F. Jones 4 per cent., and Gould 6 per cent. There have been some others a little higher than these, but the majority have been more or less in agreement with these older estimates. Of later years these estimates have been considerably increased; thus Ramaley stated that one-sixth of the population was left-handed. Then Jordan gave 20 per cent. as his estimate, and finally Bardeleben gave the number of left-handed children as 6.8 per cent. and the number of left-handed children who have been changed to right-handedness, as 26 per cent. All these estimates as far as one can ascertain were based either upon clinical examination, or upon a questionnaire. B. S. Parson approached the subject from an entirely new standpoint. He showed that handedness was dependent upon "eyedness." He maintained that binocular vision was a curiosity, and that the usual mechanism was to use one eye, and one eye only, as the "fixing" eye, and that handedness follows the fixing eye. Pursuing this line of investigation further, he introduced the Manuscope to determine the fixing eye, and, as he maintained the handedness at the same time. Thus he estimated that there were 4.1 per cent. confessed left-handers, and 25.66 per cent. left-eyed who used the left hand to a greater or less extent according as they had been taught to use the right or not. These figures are in striking agreement with Bardeleben's. It will be seen from this, that the number of cases in which the left humerus
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is longer than the right does not agree very closely with these estimates, but that it favours the larger estimates rather than the smaller. The explanation of the discrepancy would seem to lie in education. It would seem reasonable to suppose that education of the child to use the right hand in preference to the left might well cause a reversal of the original skeletal conditions. This reversal would depend for its completeness on the degree of skill acquired with the right hand. One would therefore expect an estimate of congenital left-handedness based on examination of skeletons to be rather under the correct figure.

It appears probable that in many cases the length of the humerus would give an indication as to the handedness of the owner of the skeleton, but that any further particularisation is out of the question.

The clavicles should, according to the original postulate, show a definite correlation to the humeri: on the side upon which the humerus is the longer and stronger, the clavicle should be shorter and stronger. As a matter of fact, in the Edinburgh series, this correspondence existed in only 12.4 per cent. of cases, and further, in not one single case was there this correspondence on the left side. If the question of strength is not stressed unduly, and one takes the lengths alone, then this percentage can be increased up to about 35 per cent. Even so, the correspondence is not sufficiently close to be of any great value. The Nubian series also supports this lack of agreement. Of all the skeletons in which the measurements of both humeri and clavicles were recorded, in only 45.8 per cent. do the clavicles follow the humeri as they should do.

Nor does the radius help to determine the handedness; for the variation with the radii is as great as with the clavicles. In the Edinburgh series the radii were not examined, but in the Nubian bones the radii were in agreement with the humeri in only 52.3 per cent. of the cases.

When the radii and clavicles show such a high percentage disagreement with the humeri, it is only to be expected that the number of cases in which all three bones are in agreement, and pointing definitely to one side or the other, will be small. And such is actually the case; for, of the Nubian series, in only 20 out of 72 skeletons in which there were measurements of both radii, clavicles, and humeri, were all
three bones in agreement; that is to say that the humerus on one side was longer than that on the other, that the longer radius was on the same side as the longer humerus, and that the clavicle was shorter on the side which had the longer radius and humerus. This is only 27.7 per cent.; and in only 3 of these cases did the condition of the bones point to left-handedness. The clavicles and radii, therefore, would seem to be of very doubtful assistance in determining the handedness of any skeleton. Further, the large number of disagreements makes it seem very unlikely that in cases where these bones do agree with the humerus they really lend any additional weight; for agreement or disagreement would seem to be a purely fortuitous occurrence.

Still, assuming that the humerus gives an indication as to handedness, let us consider the data concerning the relation of the occipital lobe impressions on the occipital bone to the length of the humeri of corresponding skeletons.

In 20 cases in which the interior of the skull was examined and an intracranial cast taken, the left occipital lobe made the larger and more definite impression upon the occipital bone: theoretically, therefore, the owners of these skulls should have been right-handed, and should have possessed right humeri which were longer and stronger than the left. In 9 out of the 20 the right humerus appeared to be the stronger bone. In 3 out of those 9 it was longer both by trochlear and capitular measurements, and it was also heavier than the left. In 4 cases the right was longer by both measurements, but was lighter than the left. In one case it was longer by trochlear measurement, but both shorter by capitular measurement, and was lighter. In the one remaining case it was shorter than the left by both measurements, but was heavier.

In 8 out of the 20 cases the right and left humeri appeared to be equally strong. In 7 of the 8 the right humerus was the longer by both trochlear and capitular measurement, and was also the heavier. In one the left was less in trochlear length, equal in capitular, and was lighter than the right.

In the 3 cases that remain out of the 20 the left humerus appeared to be stronger than the right. In 2 of these it was longer by both measurements and was heavier, whilst in the remaining one the left humerus equalled the right by trochlear measurement, was longer by capitular, and was the heavier.

Now if the length of the humerus is an indication of
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handedness, then the first 2 out of these last 3 were congenitally left-handed, for it can scarcely be supposed that they were left-handed by education. And the third was probably left-handed too. Yet in all 3 the impression of the left occipital lobe on the occipital bone was definitely larger than that of the right. The evidence is not convincing because the numbers are too small, but it does show quite clearly that there are exceptions to this rule of Professor Elliot Smith's, and that it is impossible to draw any definite inference from the examination of any one skull.

There were 10 cases in this series of skulls in which the right occipital lobe impressions were the larger and more marked. In 4 of these 10 the right humerus was longer than the left by both trochlear and capitular measurements; and in the other 6, the right humerus was the longer by trochlear, and the left the longer by capitular measurement. In 9 out of the 10 the right humerus looked the stronger bone. In only one case did the left look the stronger bone, and that was one of those which were the longer by capitular measurement. The right humerus was the heavier in 8 out of the 10 cases. The 2 cases in which the left humerus was the heavier bone were the one in which the bone, though shorter by capitular measurement, was longer by trochlear, and the case in which the right humerus seemed the stronger, and was the longer by trochlear but not by capitular measurement. In only one out of the 10 did the left humerus seem to be the stronger bone. In 4 of the remaining 9 the right seemed to be the stronger, and in the other 5 there was no detectable difference.

If the impressions of the occipital bone are to be taken as a certain criterion of handedness, then all of these 10 should have been left-handed, and their left humeri should have been longer and stronger than their right. But the results in this group are not nearly as conclusive as those of the previous one. For here it may well be argued that this seeming incompatibility is due to usage under educational influence, congenital left-handedness being thus converted into right-handedness.

It may well be objected that in this paper undue stress has been laid on the humerus, whereas Professor Elliot Smith himself states emphatically that the most important thing is the occipital lobe impression. The reason for this is simple enough. The statement that a skull with a larger and more definite right occipital lobe impression is that of a left-hander
is based purely upon the hypothesis that the occipital lobe impressions bear some relation to handedness. The corroborative evidence that is cited to show that the skeleton was that of a left-hander is the condition of the superior extremity. If then it can be shown that this so-called corroborative evidence is not conclusive, then the relation of the occipital lobe impression to handedness remains purely hypothetical.

The evidence here adduced may be considered to justify the following conclusions:—

If the newer and later estimates of the prevalence of left-handedness are accepted, and it is admitted that education may play a part, which varies in each individual, in modifying the original relations of the bones to one another, then the humerus may be taken as giving some general indication of the handedness of the skeleton to which it belonged; but it is impossible to narrow this generalisation down to any one particular skeleton, for too many factors, about which one is of necessity ignorant, have to be taken into account and satisfactory additional evidence is not given either by clavicles or by radii, for the condition of both those bones is too variable.

In the absence of any other definite data by which to check it, the relationship of occipital lobe impressions to handedness is at present simply an interesting speculation.

The only evidence which could be considered conclusive would be that furnished by the post-mortem examination of skulls and superior extremities of bodies whose handedness was definitely determined before death.