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The Use of Mass Miniature Radiographs of the Chest in Anthropology

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Introduction

Roentgen anthropometry using teleroentgenograms has been extensively used in investigations designed to study the correlation of certain dimensions of the heart with such physical characteristics as height and weight.[1,2,3,4,5,6] The same technique has also been widely used in studies involving the measurements of body composition.[7,8] In contrast, however, only limited use seems to have been made of miniature radiography in anthropometry. As part of an anthropometric survey, Best and Kuhl[9] correlated measurements from miniature X-ray photographs of chests with certain other measurements of soft tissue and bone, but rejected the use of mass miniature radiography as too cumbersome for routine field surveys. Garn[10] suggested that mass miniature radiography might be used for the estimation of subcutaneous fat and, in 1960, Comstock and Livesay[11] carried out determinations of the degree of obesity of individual subjects using X-ray films taken during a survey of the incidence of tuberculosis in 1946. They correlated the results of their measurements with the race, sex, age and socio-economic status of the individuals concerned.

The present study was designed to discover from miniature radiographs of the chests of a population of individuals examined at an interval of a year, first, the accuracy with which the measurement of a number of selected parameters could be repeated from the miniature radiographs; and second, the reliability of the technique in providing a constant picture for an individual after the interval of a year. Dependent on the answers to these two preliminary questions would rest the decision whether or not it would be worthwhile proceeding, within the limitations of the material to hand, to a further study designed to provide a body of information concerning (a) measurements of the normal adult thorax and its contents and (b) similarities and differences, if any, that exist in respect to the shapes of chests in several groups of peoples.

The material used in the present study was a small part of the large collection of mass miniature X-ray photographs taken over a period of six years in the Municipal Clinic, Market Square, Salisbury, Rhodesia. These films, which number about 350,000 have up till now been used by the Medical Officer of Health only to determine whether or not a particular individual suffered from tuberculosis or some other potentially incapacitating condition. The films have not hitherto been used in analyses to provide information of an anthropological nature.

The radiographs were taken by a Watson machine which had a 40 cm. screen photographed by an Odelca camera using 100 mm. film. The tube-screen distance was 90 cms. and the tube was aimed at a point 5 cms. below the centre of the screen. The subject was posed in the erect position with the backs of his hands on his hips and his shoulders drawn forward. His chest was placed against the screen and he was meant to be at maximum inspiration when the picture was taken.

Method

Use was made of the miniature X-ray photographs of the chests of about one hundred adult males of several race groups comprising Africans born in Rhodesia, Malawi, Zambia and Mozambique, who had been X-rayed on two occasions separated by an interval of about a year. The radiographs were projected by a photographic enlarger (the X-ray photograph being increased linearly 3.67 times), traced, and the parameters listed on a form (Appendix I) were measured. Four separate tracings of the chest were made

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for each of the individuals in this study i.e. two independent tracings were drawn from each of the two X-ray photographs and four sets of measurements made, one set of measurements for each tracing. All measurements were rechecked by an independent observer.

Before starting to measure the twenty-one parameters that had been decided upon, a vertical line was drawn through the spines of the cervical and thoracic vertebrae for use as a datum line from which various subsequent measurements were made.

1. Vertebrae (maximum width):

The maximum width of the first thoracic vertebra and of the seventh cervical vertebra were taken as the distances between the midpoints on the right and left lateral borders of the transverse processes of the appropriate vertebra (Appendix I: 1a and 1b; Fig. 1).

2. Soft tissues (maximum width):

The outlines of the superior borders of the soft tissues of both shoulders at the levels of the first thoracic and seventh cervical vertebrae were projected and traced. The maximum width of the soft tissues was taken as the distance between the points where the horizontal lines drawn through the centres of the bodies of the first thoracic and seventh cervical vertebrae intersected the outlines of the soft tissues of the right and left shoulders. (Appendix I: 2a and 2b; Fig. 2).

3. Clavicles:

Measurements were made of the distances between the mid-points of the appropriate medial and lateral borders of the clavicular shadows. (Appendix I: 3a i, 3a ii, 3b i and 3b ii; Fig. 2).

4. Heart shadow and vascular pedicle:

(a) The area of the shadow cast by the heart and vascular pedicle was delineated as follows: The right and left lateral borders of the heart were traced to their intersections with the diaphragm. Then, on the left side, a horizontal line was drawn from the junction of the arch of the aorta with the left side of the mediastinum to the right lateral margin of the mediastinum (Appendix I: 4a; Fig. 2). The cardiac area enclosed by these four lines, which included the outline of the diaphragm, was measured with a planimeter.

(b) The greatest transverse diameter of the heart shadow was measured as the sum of the maximum horizontal distances from the midline to the right and left lateral extremities of the heart shadow (Appendix I: 4b; Fig. 3).

(c) The long diameter of the heart shadow was measured as the distance between the junction of the right atrium with the superior vena cava and the junction of the left ventricle with the diaphragm (Appendix I: 4c; Fig. 3).

(d) The broad diameter of the heart was measured as the greatest diameter of the cardiac shadow perpendicular to the long diameter. Occasionally it was found necessary to extend the right cardiac margin inferiorly along the natural curvature of the heart shadow to delineate the lower extremity of this diameter. In order to prevent the inclusion of the vascular pedicle the upper end of the broad diameter of the heart was always measured at or below the junction of the left atrium with the pulmonary trunk (Appendix I: 4d; Fig. 3).

(e) The length of the intersection of the heart shadow with the diaphragm was measured as the distance between the points of intersection of the right and left margins of the heart with the diaphragm. (Appendix I: 4e; Fig. 3).

(f) The distance between the aortic arch and the diaphragm was measured as the vertical distance between the intersection of the aortic arch with the left border of the mediastinum and the diaphragm (Appendix I: 4f; Fig. 3).

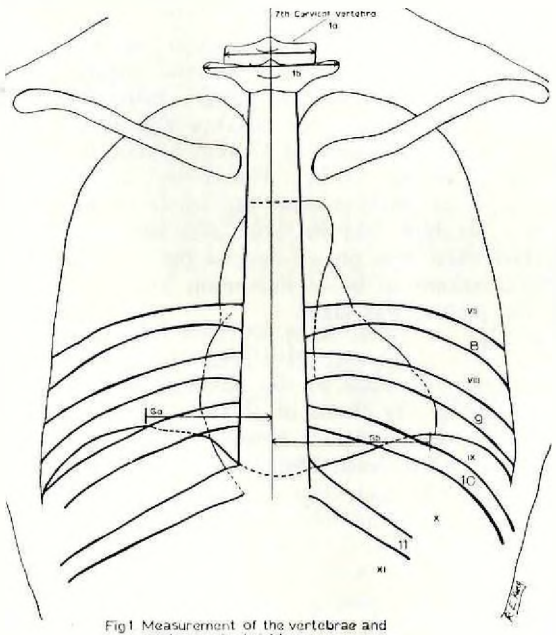

Fig 1 Measurement of the vertebrae and diaphragmatic height.
(See appendix I)

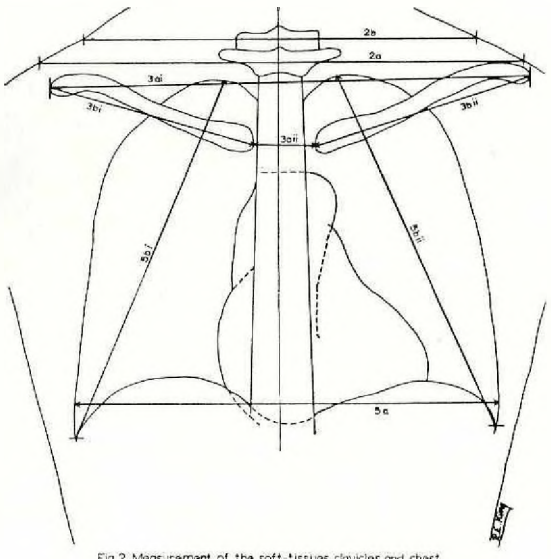

Fig 2 Measurement of the soft-tissues, clavicles and chest.
(See appendix I)

5: Chest:

(a) The greatest internal diameter was taken as the maximum horizontal distance between the lateral borders of the pleura (Appendix I: 5a; Fig. 2).

(b) The maximum length of the lung shadow on each side was taken as the distance between the highest point on the lower border of the first rib and the point at which the superior border of the diaphragm met the line corresponding to the internal border of the ribs (Appendix I: 5b i and 5b ii; Fig. 2).

(c) The area of the lung shadow on each side was outlined (i) along the lateral border of the mediastinum to the intersection of the lateral border of the heart shadow with the diaphragm, (ii) laterally following the superior border of the diaphragm to its junction with the inner border of the thoracic cage, (iii) upwards along the inner border of the thoracic cage and (iv) medially on the lower border of the first rib to the lateral border of the mediastinum. The area thus circumscribed on both sides was then measured with a planimeter and the measurement taken as the area of the right and left lung shadows (Appendix I: 5c i and 5c ii; Fig. I).

6. The height of the domes of the diaphragm were measured by reference to the rib level at the vertebral column (Appendix I: 6a and 6b; Fig. 1).

The data were analysed by means of 't' (student distribution) tests.

RESULTS: (See Table I).

1. *The first X-ray.*—Comparison of the measurements made from the first tracing with the corresponding measurements made from the second tracing.

The results of the "t" tests revealed that it was possible to repeat accurately the tracing and measurement of all but one of the nineteen parameters. The exception was a failure to repeat accurately the measurement of the maximum width of the seventh cervical vertebra. (The value of "p" in this case lay between 0.02 and 0.01). The ability to repeat the measurement of three other parameters viz. (i) the intersection of the heart shadow and diaphragm; (ii) the maximum length of the lung shadow on the right side, and (iii) the maximum length of the lung shadow on the left side, came close to being suspect in the statistical sense. In the case of each of these three measurements the value of "p" lay between 0.10 and 0.05.

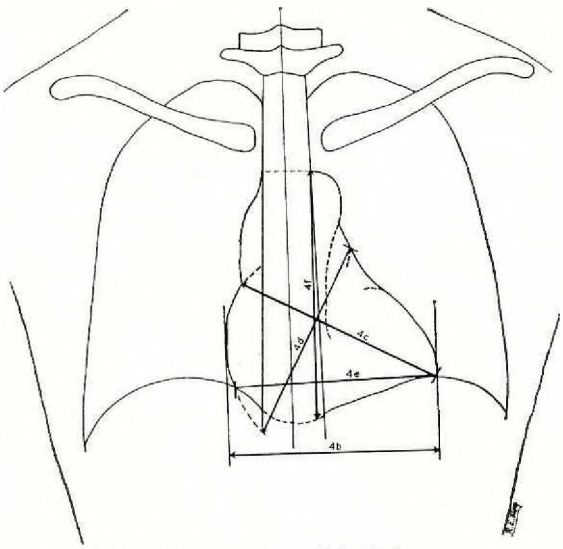

Fig.3. Measurement of the shadow of the heart and vascular pedicle. (See appendix I)

2. *The second X-ray.*—Comparison of the measurements made from the first tracing with the measurements made from the second tracing.

The results of the "t" tests again revealed that it was possible to repeat accurately the tracing and the measurement of all but one of the nineteen parameters. The exception was a repetition of the failure to repeat accurately the measurement of the maximum width of the seventh cervical vertebra (the value of "p" in this instance lay between 0.025 and 0.020). The ability to repeat accurately the measurement of four other parameters in this series again came close to being suspect in the statistical sense. These measurements were (i) the width of the soft tissues at the level of the seventh cervical vertebra; (ii) the distance between the lateral ends of the clavicles; (iii) the greatest internal diameter of the chest and (iv) the maximum length of the lung shadow on the left side. For each of these four measurements the value of "p" lay between 0.10 and 0.05.

3. *The first X-ray and the second X-ray.*—Comparison of the averaged measurements made from the first X-ray with the corresponding averaged measurements made from the second X-ray taken after the lapse of a year.

By means of "t" tests a comparison of the measurements made from tracings of the projections of both sets of X-ray films which had been taken at an interval of a year revealed that the techniques, used in the clinic, produced radiographs that were statistically reliable as far as all but two of the nineteen parameters were concerned. The exceptions were (i) the distance between the lateral ends of the clavicles and (ii) the area of the shadow of the heart and vascular pedicle. In these two cases the value of "p" lay between 0.02 and 0.01 and between 0.01 and 0.005 respectively. The comparison of four other parameters gave values for "p" which lay between 0.10 and 0.05. These were (i) the maximum width of the soft tissues at the level of

TABLE I

Measurements	*1st X-ray photograph.* The values of t and p from the comparison of the measurements made from the first tracing with the corresponding measurements made from the second tracing.			*2nd X-ray photograph.* The values of t and p from the comparison of the measurements made from the first tracing with the corresponding measurements made from the second tracing.			*Both 1st & 2nd X-ray photographs.* The values of t and p from the comparison of the averaged measurements made from the first X-ray photographs with the corresponding averaged measurements made from the second X-ray photograph taken after the lapse of a year.		
	Degrees of freedom	t	p	Degrees of freedom	t	p	Degrees of freedom	t	p
1. *Vertebrae* (maximum width):									
(a) first thoracic vertebra.	95	.4143	0.70—0.60	94	.11462	0.20 —0.10	94	1.3176	0.20—0.10
(b) seventh cervical vertebra.	84	2.4262	0.02—0.01+	87	2.3396	0.025—0.02+	79	.7448	0.50—0.40
2. *Soft Tissues* (maximum width): At level of—									
(a) first thoracic vertebra.	64	.2603	0.80—0.70	71	1.368	0.20 —0.10	56	1.935	0.10—0.05
(b) seventh cervical vertebra.	73	.0635	0.95—0.90	72	1.8506	0.10 —0.05	62	1.5034	0.20—0.10
3. *Clavicles:*									
(a) Distance between the—									
i. lateral ends.	90	.4858	0.70—0.60	89	1.8986	0.10 —0.05	85	2.568	0.02—0.01 +
ii. medial ends.	96	.3649	0.80—0.70	96	.338	0.80 —0.70	96	1.9795	0.10—0.05
(b) Maximum length—									
i. right clavicle.	89	1.651	0.20—0.10	89	1.614	0.20 —0.10	85	1.9438	0.10—0.05
ii. left clavicle.	96	.1222	0.95—0.90	96	.517	0.70 —0.60	96	.6803	0.50—0.40
4. *Heart Shadow and Vascular Pedicle:*									
(a) Area of heart and pedicle shadow.	96	1.494	0.20—0.10	96	.349	0.80 —0.70	96	2.6541	0.01—0.005 +
(b) Greatest transverse diameter.	96	1.617	0.20—0.10	96	.452	0.70 —0.60	96	1.7752	0.10—0.05
(c) Long diameter.	96	.334	0.80—0.70	96	1.611	0.20 —0.10	96	.6397	0.60—0.50
(d) Broad diameter.	95	1.324	0.20—0.10	95	1.269	0.30 —0.20	94	.9540	0.40—0.30
(e) Intersection of heart shadow and diaphragm.	96	1.831	0.10—0.05	96	.805	0.50 —0.40	96	1.3071	0.20—0.10
(f) Aortic arch to diaphragm.	96	1.123	0.30—0.20	96	.415	0.70 —0.60	96	1.2719	0.30—0.20
5. *Chest:*									
(a) Greatest internal diameter.	96	1.197	0.30—0.20	96	1.949	0.10 —0.05	96	1.1973	0.30—0.20
(b) Maximum length of lung shadows—									
i. right side.	96	1.921	0.10—0.05	96	.819	0.50 —0.40	96	.186	0.90—0.80
ii. left side.	96	1.713	0.10—0.05	95	1.877	0.10 —0.05	95	.4348	0.70—0.60
(c) Area of lungs—									
i. right side.	95	.336	0.80—0.70	96	.2023	0.90 —0.80	95	.8545	0.40—0.30
ii. left side.	95	.411	0.70—0.60	96	.990	0.40 —0.30	95	1.3216	0.20—0.10

the first thoracic vertebra; (ii) the distance between the medial ends of the clavicles; (iii) the maximum length of the right clavicle and (iv) the greatest transverse diameter of the heart shadow. All the other comparisons gave values for "p" that were greater than 0.10.

Comment

It is interesting to notice that of the nineteen parameters involving lengths and areas we failed to repeat accurately only the projection and measurement of the maximum width of the seventh cervical vertebra. This was probably due to the density of the surrounding tissues which frequently obscured the processes of this vertebra.

Comparing the measurements made from the first radiograph with the measurements made from the second radiograph taken a year later it was discovered that neither the distance between the lateral ends of the clavicles nor the area of the shadow of the heart and vascular pedicle, could be repeated accurately. This apparent inconsistency in the dimensions affecting the clavicles may be due to differences in the subject's pose and in the position he took up relative to the X-ray machine.

There was an increase in the area of the shadow of the heart and vascular pedicle of the order of 1.8% between the first and second X-ray examinations in the present series of individuals. The differences in each individual of the projected area of the heart and vascular shadow was compared by a "t" test with the height of the domes of the diaphragm as recorded for the two X-ray pictures. The result showed a negative correlation between the area of the cardiac shadow and the height of the diaphragm in each individual, the value of "p" lying between 0.30 and 0.20. There are, of course, several possible explanations for an inconsistent size of the heart shadow in the same individual e.g. increasing weight [1]; height of diaphragm [1, 12]; heart rate [2]; and progressive cardiac lesions. This aspect of the work is being pursued further in a study of the size of the cardiac shadow in a series of 60 or so individuals who have been X-rayed four times at intervals of a year.

Conclusion

We conclude that mass miniature chest radiographs can be used in roentgenologic anthropometry. Of the nineteen linear and areal parameters we devised, only six, namely the maximum width of the seventh cervical vertebra, the distances between the lateral and medial ends of the clavicles, the maximum length of right and left clavicles, and the area of the shadow cast by the heart and vascular pedicle, may not be useful in the comparative study we now propose to make into the similarities and differences, if any, that exist in respect to the shapes of the chests in the several groups of peoples who were X-rayed in Salisbury.

REFERENCES

1. Bardeen, C. R. (1918). *Amer. J. Anat.*, **23,** 423.
2. Hodges, P. C. & Eyster, J. A. E. (1924). *Amer. J. Roentgenol*, **12,** 252.
3. Hodges, F. J. & Eyster, J. A. E. (1926). *Arch. int. Med.*, **37,** 707.
4. Newcomer, E. & Newcomer, N. (1936). *Radiology*, **27,** 521.
5. Ungerleider, H. E. & Gubner, R. (1942). *Amer. Heart J.*, **24,** 494.
6. Neiss, A. (1962). *Fortschr. Roentgenstr.*, **97,** 57 (German).
7. Garn, S. M. (1959). *Radiographic Analysis of body composition. Techniques for measuring body composition.* Conference at Quartermaster Research and Engineering Centre, Massachusetts, January 22/23.
8. Garn, S. M. (1962). *Amer. J. Clinical Nutr.*, **11,** 418.
9. Best, W. R. & Kuhl, W. J. Jr. Report of physical, roentgenologic and chemical anthropometry in basic trainees. *Army Med. Nutr. Lab.*, pl.-33. Project No. 6-60-11-019. Report No. 157, 23rd March, 1955.
10. Garn, S. M. (1957). *Science*, **125,** 550.
11. Comstock, G. W. & Livesay, V. T. (1963). *Ann. N.Y. Acad. Sci.*, **110,** 475.
12. Personal communication from Dr. I. L. Briggs, Medical Superintendent of the Health Department of the City of Salisbury, Rhodesia.

We also referred to the following books:

Cooley, R. N. & Sloan, R. D. (1956). *Radiology of the heart and great vessels.* The Williams & Wilkins Company.

Meschan, I. & Farrer-Meschan, R. M. F. (1959). *An atlas of normal radiographic anatomy.* W. B. Saunders Company, 2nd. edition.