Medicine. — *Somatometric relations between relatives of the first degree.* (Preliminary note.) By J. HUIZINGA. (Communicated by Prof. M. W. WOERDEMAN.)

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With investigation into somatometric relations we enter the domain of genetics.

The factors which impede, if not prevent, the resolution of questions relating to heredity in man are many and sufficiently known. We can approach hereditary problems in man by cyto-genetic research, by study of twins, or by family investigation and statistical analyses of large populationgroups as HARRIS, for instance, did in connection with premature baldness (1946).

We chose for our research a particular type of family investigation. The choice was determined by difficulties which arise specifically with metrical data from age and sex differences. We did not try to solve these difficulties, but knowing they were there, rather sought to avoid them by:

a. entertaining only adults in our research (elimination of age-differences), and

b. comparing solely sons with fathers and daughters with mothers (elimination of sex-differences).

It would be pointless to determine the degrees of resemblance or difference between relatives unless these degrees were also determined between non-relatives and the two results compared.

A certain resemblance between an adult son A and his father B can be accepted in view of the genetical relationship, provided such resemblance does not exist between this son A and a non-related adult man C.

Other investigators might, however, prefer to compare in this case two non-related adults C and D instead of again son A and C.

With regard to the scheme

$$\begin{tikzcd} A \arrow[r, "\mathrm{I}"] \arrow[d, "\mathrm{III}"] & B \\ C \arrow[r, "\mathrm{II}"] & D \end{tikzcd}$$

it would seem most logical to compare the expression for the resemblance obtained by method I with that obtained by method III.

The difficulty is now to obtain an "expression of the resemblance". The protagonists of the biometrical school of PEARSON calculated for each of the many variables, correlation coefficients between fathers and sons, sons and daughters, daughters and mothers, etc.

As far as we can gather from their publications, they do not think it necessary, using this method, to take into account the age and sex differences of the correlated *groups* of relatives.

Their material is very often admirably extensive, so that their results should be thoroughly reliable statistically.

In the hands of the biologist-statistician the correlation coefficients can, moreover, allow of biologically reliable conclusions.

We endeavoured, using a simpler and clearer method, to gain an insight into somatometrical relationships.

Suppose the head length of son A (S/A) is 188 mm, that of his father (F/A) 193 mm, and that of a non-related male adult (F/B) 181 mm, then the *absolute* difference (i.e. the difference which, in contrast to the algebraic difference, takes no account of *direction*) is 5 mm between S/A and F/A and 7 mm between S/A and F/B.

(We always took as "a non-related male adult F/B" the father of the next-examined family. For this reason we chose the symbol F for this man too. As the examination of the families took place in an arbitrary order of succession, there can, in our opinion, be no objection to this method.)

If we determine such differences more than once, then we can also calculate an *average* absolute difference ($A.A.D.$) $S/A.F/A$ and $S/A.F/B$.

As our material consisted of 65 families, we obtained $A.A.D.S/A.F/A$ by adding 65 differences $S/A.F/A$ and dividing by 65. Thus, in the head width there is an $A.A.D.$ of 5.3 mm between S/A and F/A and of 6.3 mm between S/A and F/B.

In view of the genetic connection between S/A and F/A on the one hand and its total absence between S/A and F/B on the other hand, we could expect that the $A.A.D.$ would be less for $S/A.F/A$, or at least not greater, than for $S/A.F/B$.

One could therefore calculate the ratio of the $A.A.D.$ for $S/A.F/B$ and for $S/A.F/A$, and one could expect that this ratio *would be equal to or greater than unity.*

In order to obtain easily manageable results, this expression was calculated as

$$\text{ratio} = \frac{100 \times \Sigma A.D. \text{ for } S/A.F/B}{\Sigma A.D. \text{ for } S/A.F/A}.$$

The same holds for the comparison of an adult daughter (D/A) with her mother (M/A) and with a non-related female adult (M/B).

Among 142 ratios calculated by us (from measured and calculated variables of head and hand for men and women), 126 were found to conform to our expectations, and thus only 16 were less than 100 (viz. 5 of 99, 4 of 98, 1 of 97, 3 of 96, 1 of 93, 1 of 92 and 1 of 91). Considering also the relatively small extent of the material from which the averages were calculated (65 families), we can regard our expectations as substantially fulfilled.

"A variable with a ratio of 100" means that the difference between a son and his father, for this variable, is, on the average, as great as between this son and a non-related adult male.

Such variables have no value for indicating genetical connection.

The extent by which a ratio of a variable deviates from 100 is more or less an index of the importance of this variable for the indication of a genetically determined conformity.

In this manner, the ratio can be calculated for each measurable variable in the two sexes.

Thus, we calculated, after comparison of *S/A* with *F/A* and *F/B*, the ratio for the physiognomical face-height as 127 in males and 106 in females.

Though there is a sex-difference in the head length, for instance, which we have to take into consideration in comparing the head length of a man with that of a woman, this sex-difference in the ratio no longer exists.

This is connected with the factor of sex-relation by which the value of a female variable must be multiplied in order to obtain a figure which is directly comparable to the value of the same male variable (WEBER, 1935).

If we call this factor α, then each absolute difference between two females has been multiplied by α in order to obtain a result directly comparable to a male difference.

The $A.A.D.$ calculated for several female pairs also contains the factor α, which however is eliminated when we divide this difference by a second $A.A.D.$ containing the factor α, calculated from a group of other female pairs. The ratios of the female variables are thus without correction based on a sex-difference comparable with the ratios of the male variables.

An *objection* to the use of the *absolute* differences is that the real significance of a certain difference does not become manifest.

A difference of 4 mm in the mouth width is, of course, relatively more considerable than the same difference e.g. in the face height. This objection can be met by using the percentual difference, calculated from the absolute difference and the average of the two variables between which such difference exists.

A number of percentual differences *S/A . F/A* can again be added and divided by this number, so that the average percentual difference $(A.P.D.)$ is known.

From this difference for *S/A* and *F/A* and for *S/A* and *F/B* a ratio for the variable in question can be calculated as follows:

$$\text{ratio} = \frac{100 \times \Sigma P.D. \text{ between } S/A . F/B}{\Sigma P.D. \text{ for } S/A . F/A}.$$

Theoretically we preferred the $A.P.D.$ to the $A.A.D.$, and we were a priori inclined to attach greater value to ratios calculated by means of the $A.P.D.$, but the 142 ratios, calculated in the two different ways, proved, to our surprise, to be almost identical.

As an example we give in order of magnitude the two ratios of 23 absolute measurements in women.

Nr.	Variable	Ratio $A.A.D.$	Ratio $A.P.D.$
1	face depth	145	146
2	head width	126	126
3	mandibular angle width	124	123
4	upper-lip height	124	124
5	frontal width	123	123
6	nose height	119	121
7	head length	116	116
8	chin height	114	114
9	orbit height	114	114
10	frontal height	113	111
11	frontal depth	111	109
12	ear width	111	111
13	nose width	110	110
14	nose length	108	107
15	head height	106	108
16	physiognomical face height	106	106
17	mouth width	103	102
18	interorbital width	101	103
19	ear length	101	101
20	face width	99	98
21	morphological face height	99	100
22	orbit width (right)	99	99
23	nose depth	96	95

Neither the author nor a mathematician has succeeded in discovering the mathematical grounds of this identity.

Forms representing the mathematical structure of the two ratios are not manageable.

We accepted this identity, though not understood, intentionally, because calculation of the percentual differences would entail considerably more work. For future researches this possibility of substitution is of great practical value.

In 1947 we described fully our investigation on *cephalometric* relations and in 1948 our investigation of *cheirometric* relations.

Now we will throw some light on a particular aspect of the two investigations and consider the results together with some data on *body-measurements*.

We divided the employed measurable variables of the head, the hand and the rest of the body into:

a. *height-measurements* (measurements taken perpendicular to the transversel plane) e.g. orbit height, middle finger length, body height.

b. *width-measurements* (measurements taken perpendicular to the sagittal plane) e.g. mouth width, hand width, shoulder width.

c. *depth-measurements* (measurements taken perpendicular to the frontal plane) e.g. head length, chest depth.

These terms are applied to the erect man, with the face turned forward and the arms straight down along the body with hands supinated.

Depth-measurements are not further considered.

The following tables give the ratios for the relevant variables of head and hand:

	A. *Height-measurements:*	Ratios (*A.D.*) ♂♂	♀♀	Predominant
I	*Neurocranium:*			
	1. head height	111	106	♂
II	*Face:*			
	2. physiogn. face h.	127	106	♂
	3. morphol. face h.	120	99	
	4. front h.	101	113	♀
	5. nose h.	114	119	
	6. upper lip h.	115	124	
	7. chin h.	106	114	
	8. orbit h.	109	114	
III	*Hand:*			
	9. hand length	121	120	♂
	10. metacarpal length	129	112	
	11. length I	98	103	♀
	12. „ II	121	140	
	13. „ III	122	126	
	14. „ IV	126	129	
	15. „ V	122	108	♂
	B. *Width-measurements:*			
I	*Neurocranium:*			
	1. head width	119	126	♀
	2. frontal width	100	123	
II	*Face:*			
	3. face width	108	99	♂
	4. mand. angle width	130	124	
	5. nose width	119	110	
	6. mouth width	129	103	
	7. interorbital width	117	101	
	8. orbit width	97	99	
III	*Hand:*			
	9. hand width	144	119	
	10. width I	133	101	
	11. „ II	132	96	
	12. „ III	144	99	
	13. „ IV	169	96	
	14. „ V	116	91	

We now observe that:

1. The ratios of the *height-measurements* calculated by comparison of *Females* show a fairly strong tendency to be *greater* than those calculated by comparison of Males.

Exceptions: Neurocranium and measurements which more or less concern a totality (physiognomic and morphological face height, hand length), and also metacarpal length and length V.

2. The ratios of the *width measurements* calculated by comparison of *Males* are *greater* than those calculated by comparison of Females.

Exceptions: Neurocranium (the ratios of the orbit width are both smaller than 100 and both are thus of no importance).

3. The neurocranium takes an exceptional position in both cases.

In our 65 families no body-measurements could be determined. In considering how far the above-stated regularity is valid also for body-measurements, we had to be satisfied with computing the ratios obtained by comparison of 9 sons with their fathers etc., and of 6 daughters with their mothers, etc.

These persons form a part — to be considered by us — of a material, collected by DE FROE in Nijmegen (Holland).

The *height-measurements* of the body determined by him were body height, upper arm length, arm length and crista height, for which we calculated the following ratios:

	Ratios (*A.D.*) ♂♂	♀♀	Predominant
1. Body heigt	64/66	47/33	♀
2. Upper arm length	28/25	13/7	
3. Arm length	40/36	30/14	
4. Crista height	57/43	38/27	

Thus, our expectation that ratios of height-measurements for women would be greater are fulfilled.

For the width-measurements of the body, of which only the chest width and shoulder width measurements were available, we find:

	Ratios (*A.D.*) ♂♂	♀♀	Predominant
1. Chest width	17/8	14/8	♂
2. Shoulder width	19/14	18/5	♀

in which thus the shoulder width deviates from the rule that we found to apply to the width-measurements.

It is not easy to explain this (possible) sex-difference existing in the significance of certain directions of growth in heredity problems. In connection with the shoulder width we must note that this is determined chiefly by the length of the clavicle.

The clavicle and the neurocranium constitute exceptions.

In the ossification of the skeleton these two bony structures occupy a special position, in that a large part ossifies primarely.

As the epiphyseal cartilages generally disappear earlier in women than in men, we can think that as exogenous and endogenous influences can act for a longer time in the male, the variability is somewhat greater, and thus a son has more chance to differ from his father as regard measurements taken perpendicular to the epiphyseal cartilage.

A better understanding of this startling problem will be obtained by study of the influence of the sex-hormones on growth-potencies in various directions.

At this stage of investigation any hypothesis is liable to be not only premature but even inconvenient.

The anthropologist will for this purpose have to turn his investigation to subjects with hormonal disturbances, such as eunuchs, girls with agenesis of the ovaries, hermaphrodites, etc., preferably together with their families.

Summary.

The author describes a fairly straightforward method of obtaining quantitative expression of the resemblance between related adults of the same sex (the ratio). There is a ratio for each measured or calculated variable, and the ratios proved, as theoretically expected, to be greater than or equal to 100. The extent by which a ratio of a variable deviates from 100 is more or less an index of the importance of this variable for the indication of a genetically determined conformity. Different groups of variables were found to be of different significance for the two sexes, namely:

1. Height-measurements (taken perpendicular to the transverse plane) tend to be of more significance in expressing the genetic connection between related females.

2. Width-measurements (taken perpendicular to be sagittal plane) are of more importance in expressing the genetic connection between related males.

Some exceptions are discussed.

The author believes that for a better understanding it is necessary to investigate the sex-differences in persons with hormonal disturbances, together with their families.

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