

DISTRIBUTION AND INHERITANCE OF MIDDLE PHALANGEAL HAIR IN A WHITE POPULATION OF SÃO PAULO, BRAZIL

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SINCE 1921, when Danforth suggested that the presence of middle phalangeal hair is hereditary, the results of many investigations have shown that the character presents striking racial variation. The frequency of individuals without middle phalangeal hair in different populations varies from 21.6% to 98.0% (*cf.* table 1). In the families investigated, the absence of middle phalangeal hair seems to be recessive (Bernstein and Burks, 1942; Bernstein, 1949). However, the findings of exceptions to this rule (Chopra, 1953; Matsunaga, 1956; Beckman and Böök, 1959) and differences due to age (Büchi, 1957) and sex (Garn, 1951a; see also table 1) indicate that new investigations are needed

The purpose of the present paper is to report some population and sibling data.

POPULATION DATA

During an investigation of the genetical effects of immigration in a white population of the state of São Paulo, Brazil (Saldanha, 1959), the presence or absence of middle phalangeal hair among 289 individuals, 131 males and 158 females, was determined by means of a pocket lens. The mean ages of the individuals investigated were 16.2 for males and 15.6 for females. In the examination of the fingers for middle phalangeal hair of both hands, the parental origin of the individuals was also recorded.

National origin. Since a large number of European immigrants arrived in the community investigated about two generations ago, individuals were classified according to the nationality of their ascendants in four groups: (a) descendants of Brazilians; (b) descendants of Italians, the largest immigrant stock; (c) descendants of Brazilians and Italians (mixed); and (d) descendants, "pure" or mixed, of immigrants of other nationalities, mainly Syrian, Austrian, Swiss, German and French (remainder group).

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TABLE 1
Incidence of individuals without middle phalangeal hair in different populations

SAMPLE	LOCATION	MALES		FEMALES		BOTH SEXES		AUTHOR
		N	%	N	%	N	%	
Whites (mostly of north European derivation)	U. S. A.	—	—	—	—	111	21.6	Bernstein and Burks, 1942
Dutch *	São Paulo, Brazil	96	16.7	95	31.2	191	24.1	Saldanha <i>et al.</i> , 1960
Whites (general population)	Baltimore, U. S. A.	—	—	—	—	541	27.0	Glass <i>et al.</i> , 1952
Spaniards	Madrid	601	25.0	—	—	—	—	Valls, 1960
Swedish	Sweden	100	30.0	100	28.0	200	29.0	Beckman and Böök, 1958
Basques	Guipuzcoa, Spain	167	31.7	—	—	—	—	Valls, 1960
Germans	San Sebastian	25	36.0	53	26.4	78	29.5	Boyd and Boyd, 1937
Whites (general population)	Germany	253	28.5	244	32.8	497	30.2	Matsunaga, 1956
Jews	Boston, U. S. A.	239	33.1	—	—	—	—	Garn, 1951b
Syrians *	Baghdad	69	29.0	136	40.4	205	36.6	Boyd and Boyd, 1941a
Armenians	Boarij and Meshgara	287	33.8	143	45.4	430	37.7	Boyd and Boyd, 1941b
Arabs *	Beirouth and Ghazir	165	37.6	172	38.4	337	38.0	Boyd and Boyd, 1941b
	Baghdad	281	33.1	146	48.6	427	38.4	Boyd and Boyd, 1941a

Whites (mostly of Irish derivation)	U. S. A.	—	—	—	38	44.7	Bernstein and Burks, 1942
Whites (mostly of Italian derivation)	U. S. A.	—	—	—	58	44.8	Bernstein and Burks, 1942
Aleuts *	Aleutian Islands	42	33.3	36	58.3	78	Garn, 1951b
Whites (general population) *	U. S. A.	180	38.9	193	54.0	373	Danforth, 1921
Whites (mostly of Italian derivation) *	São Paulo, Brazil	131	40.5	158	54.4	289	Present paper
Russians *	Moscow, Tiflis and Kharkov	355	44.5	422	55.7	777	Boyd and Boyd, 1937
Hindus (Bengalis)	India	427	46.4	—	—	—	Büchi, 1954
Egyptians *	Cairo and Assiut	535	47.7	523	56.6	1058	Boyd and Boyd, 1937
Whites ("Dunker" Isolate)	Baltimore, U. S. A.	—	—	—	—	234	Glass <i>et al.</i> , 1952
Hindus (Nokte Naga)	Assam, India	111	54.1	—	—	—	Kumar, 1955
Japanese	Japan	503	55.7	494	61.1	997	Matsunaga, 1956
Hindus	India	—	—	—	—	250	Chopra, 1953
Indians (Shinnecock and Penobscot)	U. S. A.	83	72.3	67	79.1	150	Danforth, 1921
Negroes	U. S. A.	74	83.7	103	90.3	177	Danforth, 1921
Eskimos	Labrador and Baffin Islands	—	—	—	—	201	Sewall, 1939

N = sample size.

* = significant sex difference.

Table 2 presents the distribution of the number of fingers with middle phalangeal hair among the four groups. The average number of fingers with hair is higher among descendants of Brazilians but this difference is significant only when Brazilian, Italian, or mixed group is compared with the remainder group. The frequency of individuals without middle phalangeal hair is not significantly heterogeneous among the four groups (table 2). However, the low frequency found among the (a), (b) and (c) groups, that can be considered as Mediterranean because of the Portuguese origin of Brazilian whites, differs significantly from the remainder

TABLE 2

Distribution of middle phalangeal hair of 289 individuals according to their parental origin

GROUP	NO. OF INDIVIDUALS	INDIVIDUALS WITHOUT PHALANGEAL HAIR (%)							HETERO- GENEITY
		NO. OF FINGERS WITH PHALANGEAL HAIR							
		0	1	2	3	4	MEAN $\pm$ s. e.		
Desc. Brazilian	57	26	8	9	8	6	1.30 $\pm$ 0.19	45.6	$\chi^2 = 5.17$
Desc. Italian	91	38	21	16	12	4	1.15 $\pm$ 0.13	41.8	d.f. = 3
Mixed group	70	33	12	12	9	4	1.13 $\pm$ 0.15	47.1	P = 0.15
Remainder group	71	42	13	5	7	4	0.85 $\pm$ 0.15	59.2	
Total	289	139	54	42	36	18	1.10 $\pm$ 0.08	48.1	

group that mainly includes immigrants from Central Europe ($\chi^2 = 4.61$; d.f. = 1; $P = 0.03$). The total frequency of individuals without middle phalangeal hair is similar to that found among whites in the United States (44.8%), mostly of Italian derivation (Bernstein and Burks, 1942).

Sex and age differences. From the examination of table 1, it appears that there may be sex differences in the frequency of individuals with middle phalangeal hair. However, these differences are not evident in every population studied. This situation suggests that sampling heterogeneity should account for a large part of sex differences. Table 3 shows that sex difference in the frequency of middle phalangeal hair is highly significant and sampling heterogeneity in the present study is practically absent. In spite of this result it can be seen in table 1 that only 8 out of 16 investigations in which sex was recorded showed a significant sex difference. Most of these findings cannot be due to

sampling heterogeneity. Sum of χ^2 values obtained for 16 samples in table 1 was 68.37 (d.f. = 16, $P < 0.0001$) and pooled χ^2 was 54.73 (d.f. = 1, $P < 0.0001$), so that the difference between these figures is not significant ($\chi^2 = 13.64$, d.f. = 15, $P = 0.65$).

Similarly, age differences have been detected in investigations of middle phalangeal hair (Büchi, 1957). It is interesting that such

TABLE 3

Comparisons of frequencies of individuals with middle phalangeal hair between males and females, according to their origin

GROUP	SEX	TOTAL	INDIVIDUALS WITH PHALANGEAL HAIR		χ^2 (*)	P
			NO.	%		
Brazilian descendants	Male	27	17	63.0	1.52	= 0.20
	Female	30	14	46.7		
Italian descendants	Male	43	29	67.4	2.84	= 0.10
	Female	48	24	50.0		
Mixed Group	Male	27	17	63.0	1.80	= 0.17
	Female	43	20	46.5		
Remainder Group	Male	34	15	44.1	0.29	= 0.60
	Female	37	14	37.8		
Total	Male	131	78	59.5	5.60	= 0.02
	Female	158	72	45.6		

* Sum of four χ^2 values = 6.45, d.f. = 4, $P = 0.17$.

Difference (heterogeneity) between sum and pooled χ^2 values = 0.85, d.f. = 3, $P = 0.85$.

differences are greater among males than among females. Since Garn (1951b) showed that the frequency of individuals with middle phalangeal hair among castrated males is lower than among controls from the general population, hormonal differences to be found among individuals of different ages might reflect a variation of phalangeal pilosity with aging. To test this hypothesis table 4 presents the distribution of number of fingers and frequency of individuals with middle phalangeal hair by the development of puberty. The beginning of puberty was taken at 15 for males and 13 for females. The average number of fingers and the frequency of individuals with phalangeal pilosity for both males and females are higher after the beginning of puberty. The increase

TABLE 4
Sex distribution of the numbers of fingers and individuals with middle phalangeal hair at periods before and after the beginning of puberty

SEX	AGE GROUP	TOTAL	NO. OF FINGERS WITH HAIR							INDIV. WITH PHALANGEAL HAIR		χ^2 (2)	AVERAGE NO. OF FINGERS WITH HAIR	<i>t</i>
			0	1	2	3	4	NO.	%					
Males	before puberty	65	32	11	13	6	3	33	50.8		4.12	1.03 $\pm$ 0.15	2.42	
	after puberty	66	21	15	11	13	6	45	68.2	P = 0.04	1.52 $\pm$ 0.17			
	all ages	131	53	26	24	19	9	78	59.5 $\pm$ 4.3		1.27 $\pm$ 0.11		P = 0.007	
Female	before puberty	45	26	11	3	5	0	19	42.2		0.28	0.71 $\pm$ 0.15	1.86	
	after puberty	113	60	17	15	12	9	53	46.9	P = 0.65	1.05 $\pm$ 0.13			
	all ages	158	86	28	18	17	9	72	45.6 $\pm$ 4.0		0.96 $\pm$ 0.10		P = 0.06	
Both sexes	before puberty	110	58	22	16	11	3	52	47.3		1.53	0.90 $\pm$ 0.11	2.41	
	after puberty	179	81	32	26	25	15	98	54.8	P = 0.20	1.22 $\pm$ 0.10			
	all ages	289	139	54	42	36	18	150	51.9 $\pm$ 2.9		1.10 $\pm$ 0.08		P = 0.007	

(1) The beginning of puberty was considered as 15 years for males and 13 years for females.

(2) Sum of χ^2 for both sexes = 4.40, d.f. = 2, P = 0.11; heterogeneity, χ^2 = 2.87, d.f. = 1, P = 0.09.

of phalangeal pilosity with the development of puberty for males is significantly marked. This fact suggests that the pilosity on the middle phalanges is influenced by hormonal changes. Since these changes are appreciably more pronounced among males, probably they are due to the variation of androgens with sex and age.

The frequency of individuals of both sexes with middle phalangeal hair before and after the beginning of puberty is not statistically significant ($\chi^2 = 1.53$, d.f. = 1, $P = 0.20$). Since difference in average number of fingers with phalangeal hair between sexes was found ($t = 2.41$, $P = 0.007$), sampling heterogeneity ($\chi^2 = 2.87$, d.f. = 1, $P = 0.09$) in the frequency of individuals with middle phalangeal hair could be due to different changes of androgen rates among males and females.

Other factors. The distribution of the combination of the fingers

TABLE 5

Distribution of combinations of fingers with middle phalangeal hair (left hand)

SEX	TOTAL	FINGER WITH PHALANGEAL HAIR								
		NONE	IV	III	II	V	III+IV	IV+V	III+IV+V	II+III+IV+V
Males	131	63	15	3	2	0	21	2	19	6
Females	158	93	25	2	1	1	16	0	12	8
Both No.	289	156	40	5	3	1	37	2	31	14
sexes %	—	54.0	13.8	1.7	1.0	0.4	12.8	0.7	10.7	4.9

with middle phalangeal hair does not seem to occur at random. This distribution shows a pattern similar to those observed in other populations (Danforth, 1921; Bernstein and Burks, 1942; Garn, 1951a; Matsunaga, 1956; Beckman and Böök, 1959).

In both sexes the presence of middle phalangeal hair in fingers considered individually has the following relative frequency order: IV $\rightarrow$ III $\rightarrow$ V $\rightarrow$ II fingers (table 5). In spite of the variation in relative frequency of combinations of types of fingers, the frequency order of the fingers with middle phalangeal hair is the same in different populations. These findings suggest a morphogenetic bilateral gradient from IV finger. Bernstein (1949) has presented data which suggest that the range of the embryonic areas for middle phalangeal hair might be determined by different allelic genes.

Differences between left and right hands present another set of problems. The distribution of fingers with middle phalangeal hair is not exactly the same for both hands. Table 6 shows the distribution found in the present sample. The difference in distribution of phalangeal pilosity between right and left hands is small. When both hands are considered, the frequency of individuals without middle phalangeal hair decreases. The importance of these differences which should be due to constitutional and environmental factors can be evaluated on statistical

TABLE 6
Distribution of the number of fingers with middle phalangeal hair in right and left hands

HAND		NUMBER OF FINGERS WITH MIDDLE PHALANGEAL HAIR					
CONSIDERED		0	1	2	3	4	Total
Right	no.	152	50	39	40	8	289
	%	52.6	17.3	13.5	13.8	2.8	—
Left	no.	156	49	39	31	14	289
	%	54.0	17.0	13.5	10.7	4.8	—
Both hands	no.	139	54	42	36	18	289
	%	48.1	18.7	14.5	12.5	6.2	—

grounds. The average number of fingers with phalangeal pilosity in left hands (0.955 ± 0.073) is lower than that in right hands (0.969 ± 0.071) but the difference is not significant ($t = 1.40$, $P = 0.20$). The coefficient of correlation between the number of fingers with middle phalangeal hair in both hands is $+0.893 \pm 0.012$, being highly significant ($z = 1.436 \pm 0.059$; $z/s.e. = 24.3$, $P < 0.001$). However, distribution of fingers with phalangeal hair is clearly skewed.

Moreover, the frequency distribution of individuals according to the four types of combinations between right and left hands with phalangeal hair is:

both hands	Middle phalangeal hair present on				total
	left hand	right hand	no hands		
120	17	13	139		289

This distribution shows that the association between right and left hands (Yule's coefficient of association, $Q = 0.974 \pm 0.010$) is highly

significant ($\chi^2 = 181.20$, d.f. = 1, $P < 0.0001$). Table 7 shows that the number of fingers with middle phalangeal hair on the right is lower than that on the left hand. However, the frequency of asymmetries between both hands should not be important in population investigations. From table 7, it can be seen that the frequency of asymmetrical combinations among females is lower than among males. This also may be caused by hormonal differences.

TABLE 7

Frequencies of asymmetrical combinations between fingers with middle phalangeal hair of right (R) and left (L) hands

SEX	NO. OF INDIVIDUALS	ASYMMETRICAL COMBINATION							
		SYMMETRICAL COMBINATION		LESS NO. OF FINGERS WITH HAIR ON R.		LESS NO. OF FINGERS WITH HAIR ON L.		ATYPICAL COMBINATION	
		no.	%	no.	%	no.	%	no.	%
Males	131	91	69.5	13	9.9	21	16.0	6	4.6
Females	158	125	79.1	15	9.5	15	9.5	3	1.9
Both sexes	289	216	74.7	28	9.7	36	12.5	9	3.1

SIB-PAIR DATA

The character was also observed in 47 sib pairs, collected at random from the same population. The sib-pair group includes 40 males and 54 females from 10 to 20 years old. In the present analysis only the presence or absence of middle phalangeal hair is considered.

On the grounds of family observations, Danforth (1921) suggested that the absence of middle phalangeal hair might be determined by recessive genes. Genetical analysis of sibling and family data (Bernstein and Burks, 1942; Bernstein, 1949) seems to confirm this hypothesis. However, it should by no means be accepted as a too rigid scheme since 69 Japanese matings of parents without middle phalangeal hair produced 8 children with phalangeal pilosity (Matsunaga, 1956). Similarly, a single exception was observed among Hindu (Chopra, 1953) and Swedish (Beckman and Böök, 1959) family data.

Cotterman (1937) developed a method for monogenic analysis based on sib-pair type distribution. To apply Cotterman's single generation method, presence (A) or absence (B) of middle phalangeal hair was

postulated as determined by allelic genes, frequencies of which in the population are p and $(1 - p)$, respectively. Assuming the character A to be dominant over B , the expected proportions of sib-pair types would be:

- Both sibs with the character A (AA)
— $f_{aa} = \frac{1}{4}p(4 + 5p - 6p^2 + p^3) \cdot n$
- One sib with the character A and other with B (AB)
— $f_{ab} = \frac{1}{2}p(1 - p)^2(4 - p) \cdot n$
- Both sibs with the character B (BB)
— $f_{bb} = \frac{1}{4}(1 - p)^2(2 - p)^2 \cdot n$

where n stands for the number of sib pairs in the sample.

The most convenient estimate of p is obtained from the proportion of individuals with the recessive character ($\bar{B}$) among the sib-pair group:

$$p = 1 - \sqrt{\bar{B}}$$

The alternative random combination hypothesis should also be tested. Assuming sib combinations as random, the expected frequencies of sib-pair types is obtained by means of the binomial rule:

$$(\bar{A} + \bar{B})^2 \cdot n = (\bar{A}^2 + 2\bar{A}\bar{B} + \bar{B}^2) \cdot n$$

Table 8 shows the observed and expected frequencies of sib-pair types,

TABLE 8
Frequencies of types of sib pairs observed and expected from monogenic recessivity and random combination hypothesis (A indicates presence and B absence of middle phalangeal hair in both hands)

TYPE OF SIB-PAIR COMBINATION	OBSERVED FREQUENCY	EXPECTED FREQUENCY			
		RECESSIVITY HYPOTHESIS	χ^2 (d.f. = 1)	P	RANDOM COMBINATION HYPOTHESIS
AA	11	13.8	3.61; > 0.05		47.0
AB	18	12.3	0.57		8.6
BB	18	20.9	2.64		23.0
Total	47	47.0	0.40		15.4
		A = 42.6%	B = 57.4%	p = 0.242	

on the alternative hypothesis of monogenic recessivity and random combination. The expected values for both hypotheses do not differ from the observed ones, at 5% level of probability. However, the observed value for AB combination in the case of monogenic recessivity is in excess. Since, in the sample, 26 sib pairs are heterosexual and 21 include sibs in pre- and post-puberty periods, departure from expected ratio considering age and sex differences analysed in table 3, need not be in disagreement with a main pair of allelic genes. Similarly, the exceptions among the Japanese, Swedish and Hindu family data could be caused by differences to be found especially between two different generations.

SUMMARY

From the present analysis and discussion it seems to be permissible to draw the following conclusions:

1. The frequencies of individuals without middle phalangeal hair show striking population differences. The range among North Europeans varies from 20 to 30%; among the Mediterranean, from 30 to 50%. Among Japanese, American Indians and Negroes, the figures vary between about 60 and 90%. The trait is virtually absent among Eskimos.
2. The frequency of individuals without middle phalangeal hair presents sex and age differences. Sex differences found in samples from different populations show great heterogeneity which could be a reflection from other factors such as sampling, environmental conditions, and, mainly, age distribution. However, the variation of male hormone rates with age and sex should be counted as the main factor in determining intrapopulation heterogeneity.
3. The frequencies of fingers without middle phalangeal hair among right and left hands are slightly different. Since right hands present a higher frequency of fingers with phalangeal pilosity, this does not seem to be caused by environmental factors. However, because of its smallness, this difference may be discarded in population studies.
4. The frequency order of the types of fingers with middle phalangeal hair: IV $\rightarrow$ III $\rightarrow$ V $\rightarrow$ II fingers seems to be universal. It is possible that such a morphogenetic gradient is under the action of different allelic genes with variable frequencies among different ethnic groups.
5. The lack of middle phalangeal hair, in its fundamental scheme, may be determined by a pair of recessive genes. However, the occurrence of sex, age, and possibly environmental differences make difficult the

genetical analysis of the trait, mainly in data from different generations (family data).

6. From the above, it is of interest in the collection of future population, sibling, and family data that age and sex be recorded in order to make possible a more accurate population and genetical analysis. While the presence of middle phalangeal hair is a character of anthropological importance, it is not ideal for genetical investigations.

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