

THE USE OF MIDDLE-PHALANGEAL HAIR IN POPULATION STUDIES

STANLEY MARION GARN

Forsyth Dental Infirmary for Children, Boston

INTRODUCTION

Danforth ('21) was the first to call attention to the hair on the middle segments of the fingers in man and other anthropoids, and the first to investigate the mode of inheritance of this trait in man.¹ His conclusion, based on family-line studies, that the presence of hair on the middle phalanges is dominant, in a Mendelian sense, over its absence, has been confirmed by other family-line investigations. Moreover, it has been shown that middle-phalangeal hair on a greater number of digits is dominant over a lesser number. The hypothesis has been offered that multiple alleles, with graded dominance account for this phenomenon (Bernstein and Burks, '42; Bernstein, '49).

Danforth also noted that the percentage of individuals exhibiting middle-phalangeal hair varies from population to population. He observed that middle-phalangeal hair is rare in some American Indian groups, more common among American Negroes, and still more common among American Whites. Population differences have also been demonstrated by other authors. Sewall ('39) reported that it was very rare among Eastern Eskimo, while the extensive investigations of the Boyds have shown a high incidence of middle-phalangeal hair among various European and Near-Eastern peoples (Boyd and Boyd, '37, '41a, '41c; Boyd, '50).

¹ Danforth referred to the trait as "hair on the middle segments of the digits." Subsequently it was termed "mid-digital hair." Since mid-digital hair properly refers to hair on the third digit, and not to the middle segment or phalanx, the author now suggests the term "middle-phalangeal hair" and uses this term throughout the present article.

So far, it has not been possible to correlate middle-phalangeal hair with other traits (Boyd and Boyd, '37), nor is there evidence of linkage (Boyd and Boyd, '41b; Kloepper, '46).

Since this trait has a known mode of inheritance, and since the incidence appears to vary from population to population, it is a potentially useful tool in population studies, as has been pointed out (Boyd, '50; Garn, '50). But before it can be used extensively, its limitations must also be known. Is this trait unaffected by age and sex, or are age and sex differences sufficiently great to limit its utility? Is observational error minimal, or is it seriously large? Can population frequencies be transformed into gene frequencies, or is this step premature? Finally, are there variables other than the presence or absence of middle-phalangeal hair and the number of digits affected that should be considered in making routine observations?

It is the purpose of this paper to discuss age and sex differences in the incidence of middle-phalangeal hair, to provide additional data on the subject, and to discuss sources of observational error. Finally, it is the purpose of this communication to provide data on the combination of digits affected.

AGE AND SEX DIFFERENCES

Whenever data on males and females have been tabulated separately (and many workers have failed to do this), sex differences in the incidence of middle-phalangeal hair have been observed. In Danforth's original paper, data on males and females are given separately for each of 6 groups investigated: in all 6, such sex differences exist (Danforth, '21, p. 202). Boyd ('50, p. 285) has recently brought together data on 14 groups: in 12 of the 14 groups the percentage of males with middle-phalangeal hair exceeded that in females. In 3 of the 14 groups the sex differences approximated or exceeded 20%. Thus, the incidence in East Georgian males (at Tiflis) was 56.4%, in contrast to 33.8% in the females of the same

group. In the author's own data on 78 adult Aleut from the Aleutian Islands, middle-phalangeal hair was observed in 66.7% of 42 males, and in 41.7% of 36 females (table 1). Clearly, sex differences in the incidence of this trait do exist and must be considered.

Surprisingly, little attention has been given to possible age differences in the incidence of this trait. Without examining the situation further, workers have either combined data on adults and children, or have failed to give any indication of the age range included. Thus, in Kloepper's linkage study, "offspring" aged 3 to 36 years were included. In Bernstein's

TABLE 1

Middle-phalangeal hair in Aleut adults and children, in Boston males, and in castrate males and controls

GROUP	NUMBER OBSERVED	PER CENT WITH MIDDLE-PHALANGEAL HAIR
Aleut males	42	66.7
Aleut females	36	41.7
Aleut children	72	21.5
Boston males	239	66.9
Male castrates	81	48.1
Male controls	82	58.5

study, age and sex can only be inferred from the description of subjects, and in Boyd's tabulations age is not stated. Boyd informs the author that both adults and children, "but not very young children," were included (personal communication).

Actually, there is evidence that middle-phalangeal hair, like much of the hirsute covering of the body, is affected by age as well as by sex. In the author's Aleut series, middle-phalangeal hair was present in only 21.5% of 42 Aleut children under 16 years of age, in contrast to 41.7% in adult females, and 66.7% in adult males (table 1). Such an age difference also exists in Whites. In a pilot series of 100 Boston children at the Forsyth Dental Infirmary for Children, middle-phal-

langeal hair was noted in 45% in contrast to 67% observed in adult males from the same community (Garn, '50). It may be noted that Kloepper's raw data also suggest an age difference, though smaller than those noted here. Therefore, age as well as sex appears to influence the expression of this trait.

Since the incidence of middle-phalangeal hair varies with age and sex, it is not unreasonable to suspect that this trait is hormone-mediated, as well as genetically determined. Naturally, direct experimental confirmation is presently out of the question, but there is excellent indirect evidence that this assumption is correct.² The incidence of middle-phalangeal hair is less in castrate males than in normal controls.

Dr. M. M. Gertler and the author examined 81 castrate males and 81 controls from the same institution. Although the castrate males averaged 9 years older than the controls, middle-phalangeal hair was present in 47 of the 81 controls (58.1%) and in 39 of the 81 castrates (48.1%). Moreover, the luxuriance of the growth in the controls exceeded that in the castrates, with a modal score of one in the controls (on a scale of 0 to 4) and zero in the castrates (Garn and Gertler, '51).

It is likely then that steroids of both adrenal and testicular origin stimulate the growth of middle-phalangeal hair, and that the presence of this trait is a function of steroid output as well as genetic make-up.

OTHER SOURCES OF OBSERVATIONAL ERROR

In occasional matings reported in the literature both parents appeared to lack middle-phalangeal hair, yet some of the offspring exhibited this trait, contrary to expectation. This finding has prompted several authors to consider possible sources of observational error. It was realized that "active" follicles might be overlooked, resulting in an "incorrect diag-

² In women with virilizing ovarian tumors, with *excessive excretion* of 17-keto-steroids, middle-phalangeal hair production may be marked. One such individual (a nurse) observed by the author, had centimeter-long middle-phalangeal hair in the 3-4 combination. According to her, neither parent possessed the trait in question.

nosis." It was also noted that certain occupations subjected the fingers to abrasion, and hence to loss of the hair on the middle phalanges. In particular, housewives and carpenters have been considered unduly subject to loss of the middle-phalangeal hair.

It should also be noted that individuals may be mistakenly diagnosed, not because their middle-phalangeal hairs were lost in the dishwater or the sawdust, but because the hairs were unilaterally present (and only one hand was examined), or because the follicles were in the replacement stage.

As an example of the former possibility, in the author's Aleut series 4 out of 43 adults exhibited middle-phalangeal hair on one hand only. (In the Boston adult series the exact incidence of asymmetries was not recorded.) But in either series, if the data had been based on the routine observation of the left hand only, the incidence would have been lower than that reported.

It is well known that hair follicles are not continuously active. For any hair, there is a growth stage and a resting stage, followed by loss and eventual replacement. Where the total number of middle-phalangeal hairs are few, the process of growth and replacement may affect the diagnosis. In the author, for example, there is presently one middle-phalangeal hair on digit IV of the right hand. This was absent less than a year ago, but a single hair, comparably-located, was present prior to that time. At the present time, the author would be recorded as having middle-phalangeal hair, with the presumed A_1 genotype. Earlier he would have been recorded as having no middle-phalangeal hair.

Hence, in population studies, failure to record observations on both hands, or failure to correct for the process of hair loss and replacement, may spuriously lower the observed incidence of middle-phalangeal hair.

COMBINATION OF DIGITS AFFECTED

In the majority of the investigations, attention has been centered upon the presence or absence of middle-phalangeal

hair. In a few studies, interest has extended to the number of digits affected (Danforth, '21; Bernstein, '49 Bernstein and Burks, '42). These studies have shown that the modal number of digits affected differs from population to population, and that multiple alleles must be considered rather than a simple mendelizing pair.

However, it should also be pointed out, that middle-phalangeal hair does not occur on any digit, or any combination of digits at random. If any digit is affected, it is most likely to

TABLE 2
Combinations of digits with middle-phalangeal hair

DIGIT COMBINATION	120 ALEUT ¹		146 WHITE ² MALES		81 CASTRATES ³		81 CONTROLS ³	
	no.	%	no.	%	no.	%	no.	%
0	68	56.7	55	37.7	42	51.9	34	42.0
III	2	1.7	2	1.4	1	1.2	4	4.9
IV	14	11.7	18	12.3	9	11.1	10	12.3
III-IV	23	19.2	31	21.2	10	12.3	9	11.1
III-IV-V	11	9.2	37	25.3	19	23.5	22	27.1
II-III-IV-V	1	0.8	3	2.7	0	0.0	0	0.0
IV-V	1	0.8	0	0.0	0	0.0	2	2.5

¹ Adults and children combined to show digital combinations, not for population frequencies.

² Data from Gertler, Garn and White ('51).

³ Data from Garn and Gertler ('51).

be the 4th. When combinations of digits are affected, the 4th is always affected. All combinations include the 4th digit, and next in order, usually include the 3rd. In less than 2% of the author's cases (and 1% of Danforth's cases) where middle-phalangeal hair was present at all, was the 4th digit *not* affected.

In the author's data (on 522 individuals) random digital combinations such as 2-4, 2-5, or 3-5 were never found, and only combinations involving the 4th digit were found (as

shown in table 2). The most common combinations were 3-4-5, and 3-4, and the least common were 2-3-4-5 and 4-5³ (table 2).

Evidently hair centers about the 4th digit, and in extension tends to affect the 3rd digit twice as often as it affects the 5th. This is shown not only by the combinations, in which the combination 3-4 is much more common than the combination 4-5, but also by the fact that middle-phalangeal hair may be present on the 3rd digit alone, but has never yet been observed (by the author) on the 5th digit alone.

These facts suggest that the trait, middle-phalangeal hair, centers about the 4th digit, and extends field-like, with a gradient heaviest on the radial side.

DISCUSSION

The ideal trait, from the point of view of population genetics, is affected neither by age nor by sex, so that all of the individuals in the population can be utilized in the study. Middle-phalangeal hair, however, fails to come up to this ideal, for it is affected both by age and by sex, and even in the adult male the phenotype may not be equated with the genotype. Hence, middle-phalangeal hair, despite its advantages, has many of the limitations of the more commonly used morphological traits.

It should be obvious that population frequencies obtained by combining data on males and females, adults and children, are of no particular use. Some of the tabulations in the literature are so made. Others present data on the incidence of middle-phalangeal hair in males and females separately, but without regard to age. Rarely are tabulations given for adult males or adult females alone. Hence the tabulations, made as they are in various ways, are not comparable. It is indeed unfortunate that the precautions ordinarily taken by physical

³ The digital combination 3-4 is far more common than the combination 4-5. While both are represented by the same notation (A_2) and are presumed to represent the same genotype, it is doubtful that this assumption is correct.

anthropologists have not been employed by geneticists interested in this trait.

Since the observed frequency of middle-phalangeal hair is ordinarily highest in the adult male, it would seem that estimates of gene frequency (if made at all) should be restricted to data on adult males. However, observational error may be large, and in populations where the observed frequency is well below unity, little would be gained by this procedure.

But in considering this trait, which does possess a number of advantages, and which can even now be used in comparing populations, one should not neglect the number of digits affected, or the combination of digits. Bernstein's data indicate that the number of digits affected, as well as the presence or absence of middle-phalangeal hair varies from group to group. The combinations do not occur at random; the trait centers about the 4th digit, and all combinations include the 4th digit. Hence the number of digits affected may be explained by the extension of a primitive embryonic "field" and the size of the field (and hence the number of digits affected) may be associated with the degree of dominance.

In short, middle-phalangeal hair requires additional study, and improvement of techniques, before it can serve as a really useful tool in population studies. But data on the incidence of middle-phalangeal hair is not difficult to obtain, and this trait should be a routine observation in anthropometric studies.

ACKNOWLEDGMENTS

Data on the Aleut included in this paper were obtained during the 1948 Peabody-Harvard Aleutian expedition sponsored by the Office of Naval Research and the Viking Fund of New York. The Commonwealth Fund of New York and Mr. Dorsey Brown provided support for research on males mentioned herein. The Hood Fund sponsored research at the Forsyth Dental Infirmary for Children. The author expresses his acknowledgment to Mrs. Lois S. Hutchinson for assistance in preparing the manuscript.

LITERATURE CITED

- BERNSTEIN, M. M., AND B. S. BURKS 1942 The incidence and Mendelian transmission of mid-digital hair in man. *J. Hered.*, **33**: 45-53.
- BERNSTEIN, M. M. 1949 The middigital hair genes. Their inheritance and distribution among the white race. *J. Hered.*, **40**: 127-131.
- BOYD, W. C. 1950 Genetics and the Races of Man. Little Brown and Co., Boston.
- 1951 Personal communication.
- BOYD, W. C., AND L. G. BOYD 1937 New data on blood groups and other inherited factors in Europe and Egypt. *Am. J. Phys. Anthropol.*, **23**: 49-70.
- 1941a Blood groups and types in Baghdad and vicinity. *Human Biol.*, **13**: 398-404.
- 1941b Data for testing for linkage on 500 pairs of sibs. *Ann. Eugen.*, **2**: 1-9.
- 1941c Blood groups and inbreeding in Syria. *Am. J. Phys. Anthropol.*, **28**: 319-330.
- DANFORTH, C. H. 1921 Distribution of hair on the digits in man. *Am. J. Phys. Anthropol.*, **4**: 189-204.
- GARN, S. M. 1950 Types and distribution of the hair in man. *In* Growth, Replacement and Types of Hair. *Ann. N. Y. Acad. Sci.*, **53** (3): 498-507.
- GARN, S. M., AND M. M. GERTLER 1951 The castrate status in the male (in preparation).
- GERTLER, M. M., S. M. GARN AND P. D. WHITE A Study of One Hundred Young Persons after Myocardial Infarction. Unpublished Mss.
- KLOEPFER, H. W. 1946 An investigation of 171 possible linkage relationships in man. *Ann. Eugen.*, **13**: 35-71.
- SEWALL, K. W. 1939 Blood, taste, digital hair and color of eyes in eastern Eskimo. *Am. J. Phys. Anthropol.*, **25**: 93-99.



BREEDING OF LABORATORY ANIMALS.—“The Care and Breeding of Laboratory Animals,” edited by Edmond J. Farris, 1950, has been described by a psychologist experimenting with primates and rodents as follows: “This volume will be welcomed by experimental biologists in a variety of fields. The basic techniques in workaday animal maintenance for 15 widely used types are outlined by a panel of experienced investigators. Separate chapters are written on: rhesus monkey, rat, mouse, guinea pig, hamster, rabbit, dog, cat, ferret, opossum, domestic fowl, reptiles, amphibia, fish, and drosophila. Sufficient detail is presented to induce an intrepid attitude toward colonizing an unfamiliar form. The level of detail is not precisely uniform from chapter to chapter (104 pages are devoted to fish), but this is inevitable in a collection, even one as well edited as this.

CHEMICAL DATING OF BONE.—The experiments performed with radioacting tracers warrant the conclusion that the diffusible anions, phosphate and carbonate, can enter and leave dead or fossil bone with very great facility. It is further probable that such movement is based upon an interchange of ions between the bone substance and the external solution rather than upon a unidirectional accumulation or depletion of a single ion species. Fossil bone, therefore, behaves in a manner fundamentally similar to living bone.

Analyses of more than 400 samples of fossil bone of different ages and from widely separated localities show a remarkable constancy in content of calcium as referred to the total inorganic matter. At the same time, the relative quantities of phosphate and carbonate fluctuate over a much wider range, although the sum of these two components is fairly constant.

For these reasons, therefore, it may be maintained that the primary participation of the major mineral components in the process of fossilization involves an exchange or replacement of substance rather than an accumulation or depletion, although the existence of depletion processes on a secondary scale cannot be denied.

It must be recognized that, so far as the determination of the age of fossil bone is concerned, the inorganic constituents (save, perhaps, fluorine) are of little immediate value. The composition of any particular specimen as it comes into the laboratory will have been determined, not by the lapse of time since the death of the person or animal, but by the mutual interaction between the bone and the substances in the soil surrounding it, together with the physical conditions characteristic of the environment subsequent to the bone's burial. If a temporal sequence based on changes in inorganic components is to be established, a combined study of the bones and the corresponding soil chemistry will be necessary.—S. F. Cook. The fossilization of human bone: Calcium, phosphate, and carbonate. Univ. Calif. Publ. Am. Arch. Ethnol., vol. 40, no. 6, 1951, pp. 263–279.