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# *The American Journal of* Orthopedic Surgery

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## I.

### CONCLUSIONS DRAWN FROM A COMPARATIVE STUDY OF THE FEET OF BAREFOOTED AND SHOE-WEAR- ING PEOPLES.

PHIL. HOFFMANN, M.D., ST. LOUIS.

Ample opportunity for the study of feet of individuals that had never worn footwear was furnished by the Philippine exhibit and by the Central African or Pigmy group at the Louisiana Purchase Exposition. Such studies were made on one hundred eighty six pairs of feet.

Objects of the work:

1. General observations on the foot in barefooted races compared with the same in shoe-wearers, including its shape, functions, range of voluntary and passive motion, and relative length as a whole and of its component parts.
  2. Height and shape of the longitudinal arch and its bearing on the usefulness of the foot.
  3. Relationship or coincidence, if any, between the height of the arch and the gait.
  4. Collection of specimens.
- Measurements were made of the body-height and of the length of the foot and its component parts; record was made of the gait whether straight or everted and the degree of eversion; footprints on smoked paper were taken to record the weight-bearing area of the foot and, in many instances to show the extent of foot expansion and arch depression under pressure,

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two plaster of Paris casts of the same foot were made, one in repose and the other bearing the body-weight. The camera also was used to record toe action in climbing and grasping and habitual foot posture in standing and walking.

From observations on the field and subsequent study of the material gathered there, I feel justified in reporting the following conclusions:—

The relative length of the foot to body-height and of the phalanges to foot length are practically the same in barefooted as in shoe-wearing races. *This is true of both the infant and adult.*

The shape of the foot and its range of voluntary and passive motion are practically the same in barefooted and shoe-wearing races *up to the time* of the use of footwear that compresses and splints the foot, usually about the end of the first year, after which, in shoe-wearers, there is progressive narrowing of the anterior portion of the foot and diminution in the range of motion of its phalangeal, tarsal and ankle joints.

The lasts over which the footwear of civilization is shaped are rarely modeled in the spirit of truth that would make them conform to the contour of a normal foot. The whim of society and the manufacturers' enterprise alone regulate their shape. Society, apparently, agrees that the human foot as formed by nature is coarse, vulgar and unsightly, and that its width, especially at the toes, is entirely too great. It regards the small, especially the narrow foot, as the beautiful one. The dictum of fashion has greater influence than reason. Perhaps the statement that society admires the small foot is not exactly true, for society, as such, never sees the naked foot; but what it so commonly does admire is the dainty little shoe that hides its own handiwork—the distorted, cramped, calloused and repulsive foot. Here beauty is less than skin deep, or at most lies no deeper than the calfskin product of the cobbler's art. The manufacturer through ignorance and self interest fits the desires of his patrons rather than their feet, and places upon the market footwear that more or less crowds the front of the foot.

The widest part of an undistorted foot corresponds to a line drawn from the end of the little toe to the base of the great one. (Fig. 1 and Fig. 11 B.) It is just at this point that the conventional shoe is made narrowest. In the normal foot the phalanges are in line with their metatarsals, and when bearing the body-weight the toes separate and widen the base of support.

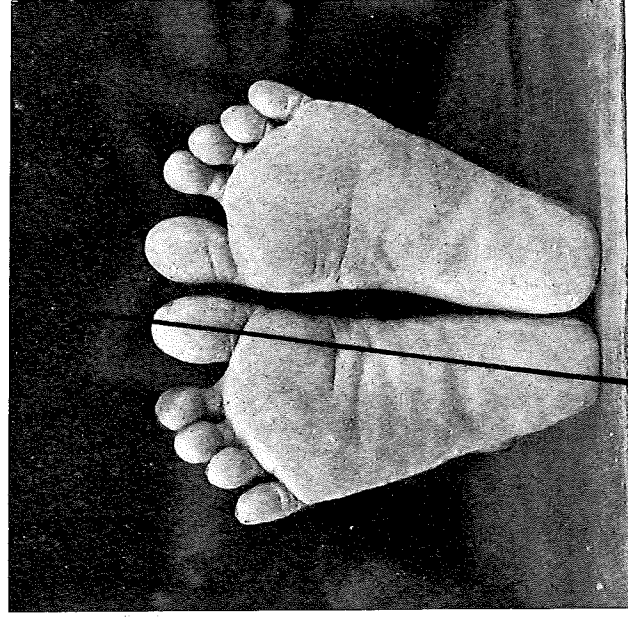


FIG. 1.—PLANTAR VIEW OF FEET OF NEGRO, SHOWING STRAIGHTNESS AND SEPARATENESS OF TOES; TRANSVERSE FOLDS IN SKIN OF SOLE; WIDEST PART OF FOOT AT TOES; LONG AXIS OF GREAT TOE PROLONGED BACKWARD STRIKES CENTER OF HEEL.

Especially is this true of the great toe, which is separated from its neighbor by a considerable interval, and in this position assists in keeping the foot adducted and is a considerable factor in the work of leverage. This is universal among barefooted races. (Figs. 2, 21, 22, 23, 24 and 25.) As evidenced by classic sculpture, this toe separation was the rule also in ancient sandal-wearers, whose footwear did not compress the feet.

(Figs. 3 and 4.) The same is likewise true of modern sandal-wearers as found among the Cingalese and Japanese. (Fig. 5.) A condition that may be considered almost universal among shoe-wearing adults, is one of more or less crowding of the toes,



FIG. 2.—DORSAL VIEW OF WEIGHT-BEARING FEET OF A BAGOBO, SHOWING TOE SEPARATION, ADDUCTION OF GREAT TOE AND MINUTE FOLDS IN SKIN.

especially of the great toe, which either underlies or overlaps its neighbor. Fig. 6 shows a pair of such feet compared to the shoes worn on them. The relative size of the two photographs corresponds to the originals. Observe the compression of the

toes and narrowing of the front of the foot and that the line prolonging the long axis of the great toe backward falls well to the inner side of the heel. The degree of shoe deformity shown in these feet, while slightly greater than the average, is not at all uncommon, especially among women. It will be seen that the shoes are not only of an improper shape but that they are entirely too small, even for feet already so much distorted, and one can readily imagine the crowding necessary to adjust the foot to the shoe. A single pair of shoes was not the sole

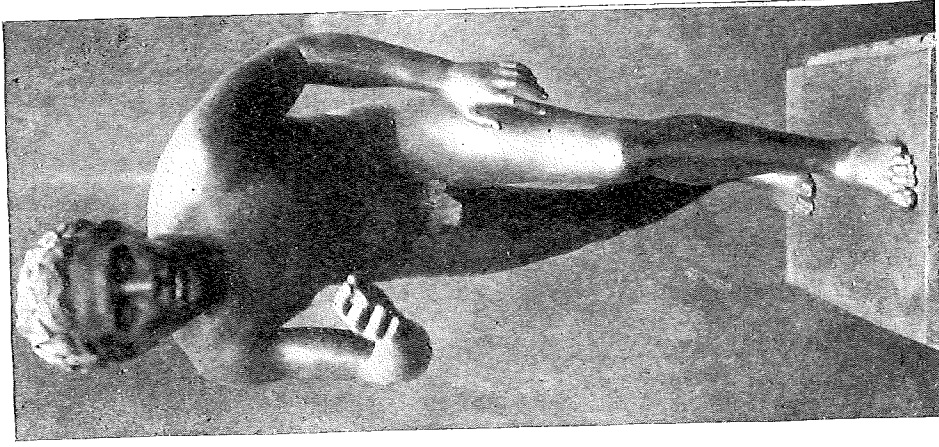


FIG. 4.—ANCIENT BRONZE FROM HERCULANEUM, SHOWING ADDUCTION OF FOOT AND OF GREAT TOE.



FIG. 3.—FOOT OF HERMES OF PRAXITELES, SHOWING STRAIGHTNESS AND SEPARATENESS OF TOES.

cause of the distortion, but the condition could have been brought about only by years of such abuse. The illustrations are



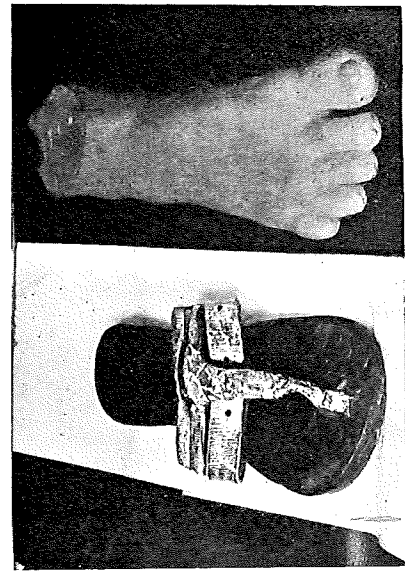


FIG. 5.—PHOTOGRAPH OF CAST OF WEIGHT-BEARING FOOT OF CINGALESE AND SANDAL WORN ON FOOT. SHAPE OF FOOT SIMILAR TO THAT FOUND IN MODERN BAREFOOTED RACES AND IN ANCIENT SANDAL-WEARERS.

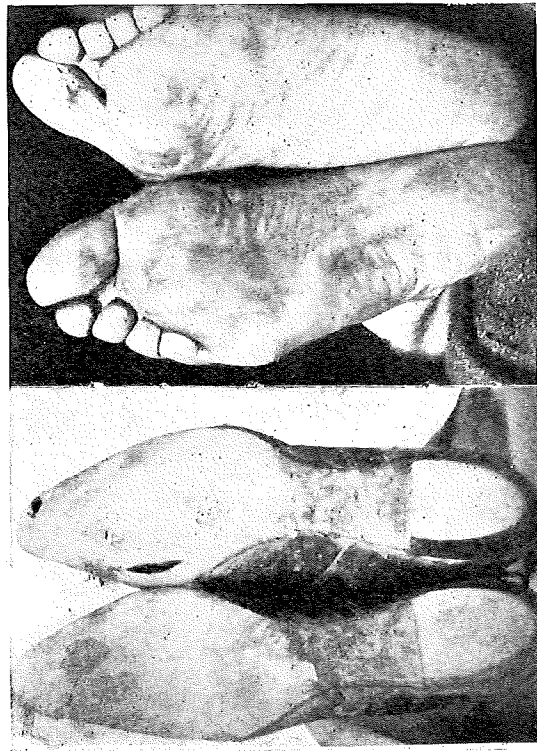


FIG. 6.—A PREDOMINANT TYPE OF FOOTWEAR AND ITS INEVITABLE EFFECT. THE SHAPE OF THE FOOT CONFORMS TO THAT OF THE SHOE.

of interest as showing a predominant type of footwear and its inevitable effect.

Examine the feet of young children before they have been crippled by shoes. Observe how distinct and separate each toe is: no one crowding its neighbor, the great and lesser toes in line with their metatarsals, and the inner border of the foot a straight line. The long axis of the great toe prolonged backward will, in the normal foot, strike about the center of the heel. That this condition would continue throughout life in an unhampered foot is proved by the shape of adult feet among barefooted races. (Fig. 1 and Fig. 11, B.)

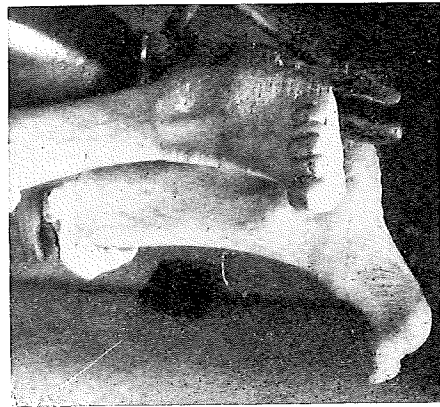


FIG. 7.—PERMANENT METATARSO-PHALANGEAL HYPEREXTENSION AND INTER-PHALANGEAL FLEXION.

The high heel, especially the one placed well forward, compels the wearer to stand largely on the front of the foot, which must bear more than its proportionate share of the body-weight. The habitual wearing of high-heeled shoes leads to shortening of the calf muscles through accommodation to the continually assumed attitude. This is probably the reason that a large percentage of middle-aged women cannot dorso-flex the foot to quite a right angle without relaxing the calf muscles by bending the knee.

The permanent hyperextension of the metatarso-phalangeal

joints, common in shoewearers, is but the fixation of a position necessarily assumed by the heel elevating the posterior end of the foot. The spring or turning upward of the front of the sole of the conventional boot tends to intensify the hyperextension, while crowding of the toes by a too short or narrow shoe adds to this deformity one of interphalangeal joint flexion. (Fig. 7.)

A foot showing no compression deformity must be exceedingly rare among shoewearing adults. I have never seen it except in instances where it had been impossible to wear an ordinary shoe, as in certain congenital clubfeet that had worn coverings that did not compress the toes. As an illustration of how accustomed civilization has become to certain foot deformities, and how unaware the average individual is of deformity present in his own feet, I will mention a photograph of the naked body of a well-known instructor of physical culture, which was displayed in show windows as an advertisement. In one corner of the card was printed: "One of the finest-formed athletes in the world"; yet, absolutely no attempt was made to hide the right foot, the toes of which presented shoe deformities developed far beyond the average.

The foot, especially in the young, is very plastic; continued pressure can give it almost any shape. A familiar example is the foot of the high caste Chinese lady. By a system of bandaging, begun at the fifth or sixth year, the anterior half of the foot, by extreme flexion at the mid-tarsus, is made to approach the posterior, so that the toes and heel may fit into a dainty little shoe no larger than a teacup. Fig. 8 is a photograph of a pair of such feet, and Fig. 9, a photograph of shoes worn on them. What matters it if the lady can not stand still, but must constantly step backward and forward to retain her balance, or that she can barely walk at all without support if, only, she possesses a pair of "golden lilies," as such feet are fancifully called? But why smile at the absurdity of the Chinese lady? How about some women, and men too, outside of China, who increase their "golden lilies" in shoes that are little more than half as wide as nature indicated they should be and often much too short? What matters it if they do suffer from deformed, weak-

ened and painful feet if, only, they can place them in shoes much too small with toes that vanish into nothingness and perch them on a fancy, slender, high and insecure heel? Here, too, the binding begins at a very tender age. The difference is not so much in kind as in degree.

Interesting examples of what a few weeks of shoe compression will do to young feet were encountered in the Bagobo village. On September 22, I made impressions and tracings of the feet of a few of these people, among them a boy of twelve and a girl of eight. On November 16, I made impressions and tracings of all the members of the Bagobo household, including the above-mentioned boy and girl.

Comparing the tracings, marked difference was observed between the old and the new, the latter showing narrowing of the front of the foot, and the direction of the long axis of the great toe somewhat changed. (Fig. 10.) The cause of this was not hard to find. Late in October, the weather becoming too cold for the tropic-born Bagobos to wear their native costumes with any degree of comfort, most of them, including these two children, began wearing shoes, which, made over the conventional American lasts, were, of course, much too



FIG. 8.—FEET OF HIGH CASTE CHINESE LADY, SHOWING TYPICAL DEFORMITY FROM BANDAGING.



FIG. 9.—SHOES WORN ON THE FEET PICTURED IN FIG. 8.

114 FEET OF BAREFOOTED AND SHOE-WEARING PEOPLES.

narrow for their feet of pristine form. Another Bagobo boy of twelve, who had worn shoes for a number of months before leaving his native island, presented well advanced shoe deformity. Fig. 11 shows a photograph of a plaster cast of one of his feet contrasted with that of an adult Bagobo male that had never worn shoes.

Though shoe-wearing evidently made some of the primitive Filipinos very uncomfortable, it was remarkable that the ma-

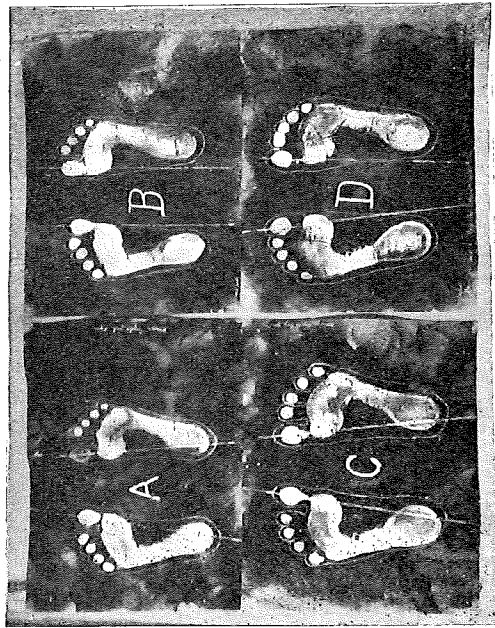


FIG. 10.—FOOT IMPRESSIONS AND TRACINGS OF BAGOBO CHILDREN, SHOWING THE EFFECT OF A FEW WEEKS OF SHOE-WEARING. A AND C BEFORE, AND B AND D AFTER SHOE-WEARING. NOTE NARROWING OF FRONT OF FOOT AND CHANGE IN DIRECTION OF LONG AXIS OF GREAT TOE.

jority appeared but little inconvenienced by their first trial of footwear, which was not, in many instances, much over half the normal width of the foot it concealed. This led me to determine to what extent it was possible to painlessly compress their feet. Two records of these experiments, one in a Moro and the other in a Bontoc Igorrote, both adult males, are shown in Fig. 12. The solid lines show the normal foot outlines and the dotted ones show outlines of the same feet manually compressed without pain. In Fig. 13 are shown the results of similar experiments

on adults of a shoe-wearing community. The range of painless compression, while not as great as in the barefoot, is considerable. If foot compression always led to immediate and severe discomfort, it would not, perhaps, be quite so common. Never-

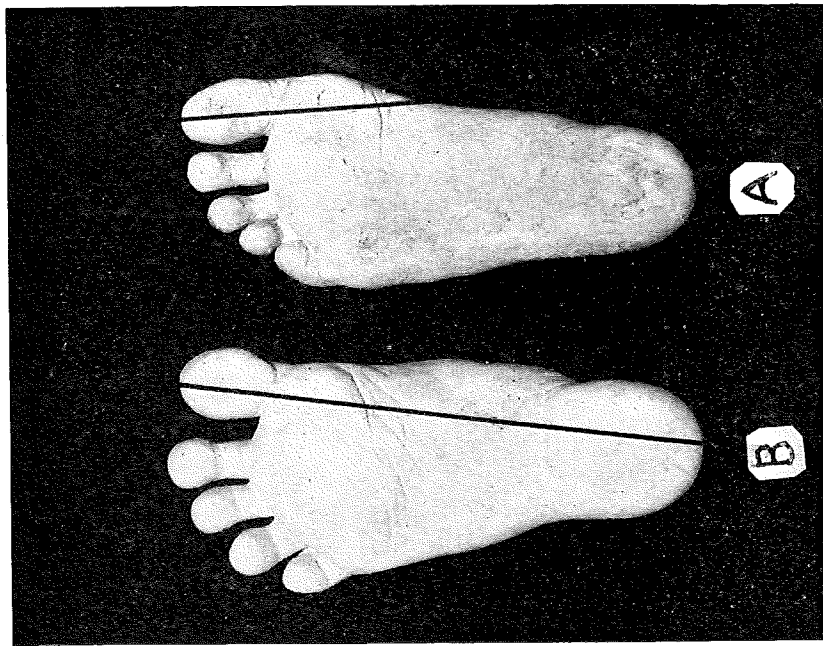


FIG. 11.—A, PHOTOGRAPH OF PLASTER CAST OF FOOT OF BAGOBO BOY THAT HAD WORN SHOES A FEW MONTHS, CONTRASTED WITH B, PHOTOGRAPH OF AN ADULT BAGOBO THAT HAD NEVER WORN SHOES.

theless, painful or painless, when long continued, it must result in irreparable damage.

Fig. 14 represents outlines of feet and their coverings as found in shoe-wearing communities. The solid lines show those of the

feet and the dotted ones those of their respective shoes. These are not exceptional but average illustrations, and fairly indicate the pressure to which millions of human feet are subjected day after day through a lifetime. The feet in time become so used to compression that they cease to be conscious of it.

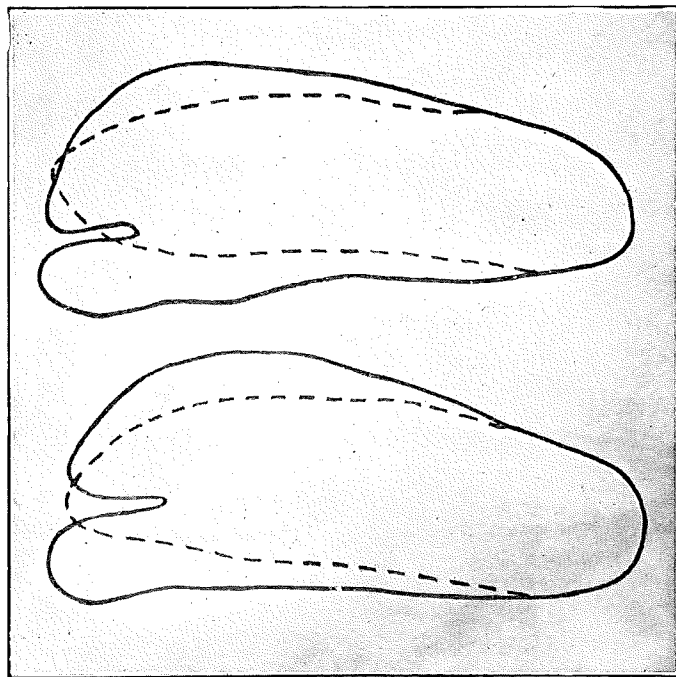


FIG. 12.—RANGE OF PAINLESS COMPRESSION OF FEET IN BAREFOOTED PEOPLES. BONTOC IGORROTE AND MORO. SOLID LINES SHOW NORMAL FOOT OUTLINES; DOTTED ONES, OUTLINES OF SAME FEET MANUALLY COMPRESSED WITHOUT PAIN. COMPARE WITH FIG. 13.

Shoes as they are usually worn, not only deform but interfere with the functions of the foot by restricting the movements of its many small joints. Their action is more or less that of a splint. Normally, the toes can be hyperextended to nearly a right angle and flexed well beyond one. The range of adduction at the medio-tarsal articulation should be between 30 and 40 degrees. In watching the naked foot of an infant, it will be seen

that there is a considerable range of lateral motion of the toes which permits their voluntary separation. This persists in older children whose feet have not been injuriously compressed by shoes, and was found also in nearly all adults among the barefooted tribes. These movements are rarely so free in shoe-wearing adults, and their range largely depends upon the type of shoe that has been worn, especially during childhood. It is rare to find an adult in a shoe-wearing community that retains even slight power of laterally separating the toes.

In most adult shoe-wearers the toes, beyond giving additional

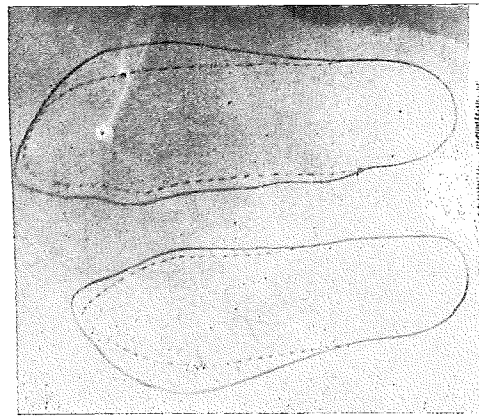


FIG. 13.—RANGE OF PAINLESS COMPRESSION OF SHOE-WEARING FEET. COMPARE WITH FIG. 12.

length to the foot, are practically functionless, while in barefooted peoples they serve a variety of functions, as in climbing and grasping. (Figs. 15, 16, 17 and 18.) This difference in function is not due to a congenital difference in structure, but is dependent upon daily use and development of such functions in the bare foot and their inhibition in the shoe-wearer. The same development of toe function could undoubtedly be attained by individuals of shoe-wearing races. I remember seeing a young man, who, born without hands, had so thoroughly trained his toes to perform many of those functions for which



## 118 FEET OF BAREFOOTED AND SHOE-WEARING PEOPLES.

fingers are ordinarily considered indispensable, that he could use knife and fork, comb and brush, and pen and ink; could wash and dress himself, perform on the piano and do many other things with considerable ease. This was very unusual, but it well illustrates to what extensive intricate uses the commonly cramped and abused foot may be put.

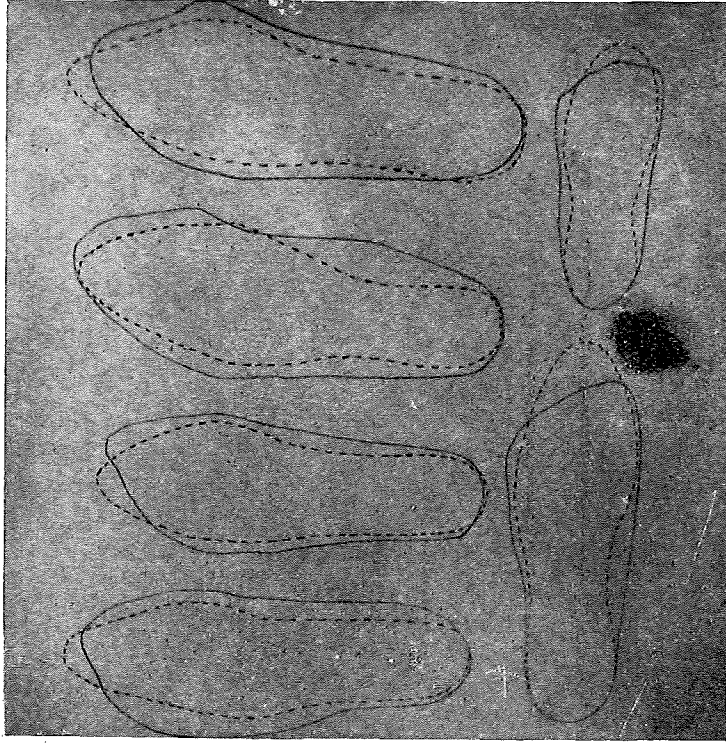


FIG. 14.—OUTLINES OF AVERAGE FEET AND FOOTWEAR. SOLID LINES SHOW OUTLINES OF FEET; DOTTED ONES, OUTLINES OF SHOES WORN ON THESE FEET.

The ancient sandal did not compress the toes or interfere with their independent movements. The result of this freedom is shown in classic sculpture, which represents strong toe action in many of its athletic figures. An especially good example is the right foot of the famous Discus Thrower, attributed to

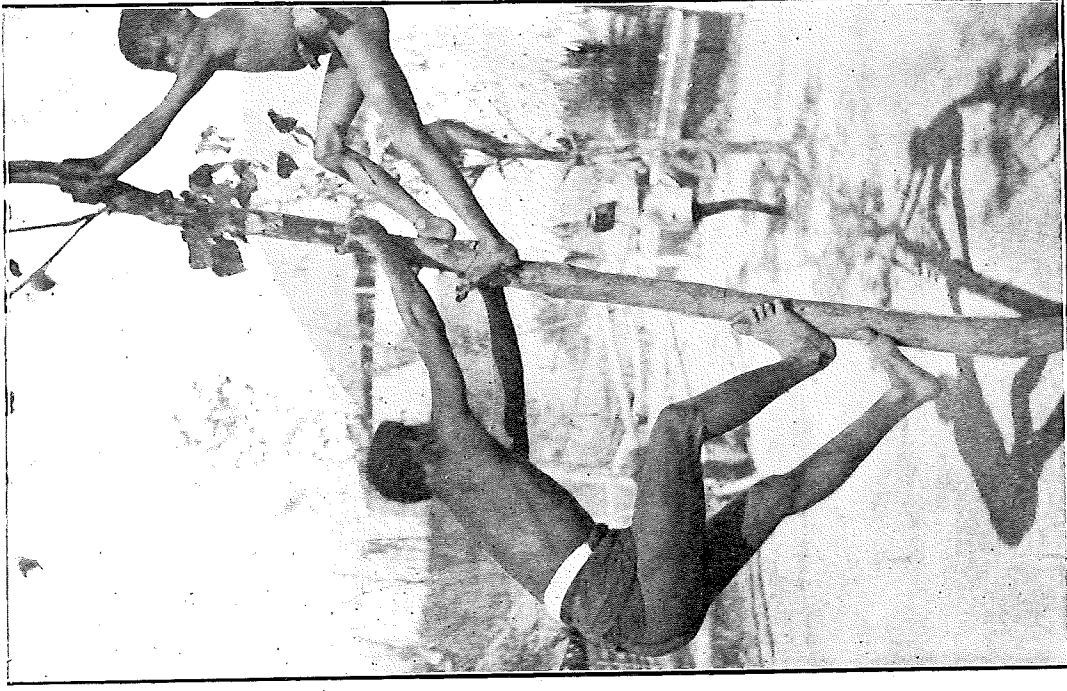


FIG. 15.—NEGROS, USING TOES IN CLIMBING.

to continued friction of the boot, common in shoe-wearers. It is marked by deep transverse folds corresponding to the lines of joint flexion, similar to those universally present in the palm of the hand. (Fig. 1 and Fig. 11, B.) The skin of the dorsum presents numerous, minute, though well marked, folds, such as may be seen on the back of the hand. (Fig. 2.) The depth and distinctness of these folds in the barefooted is probably due to

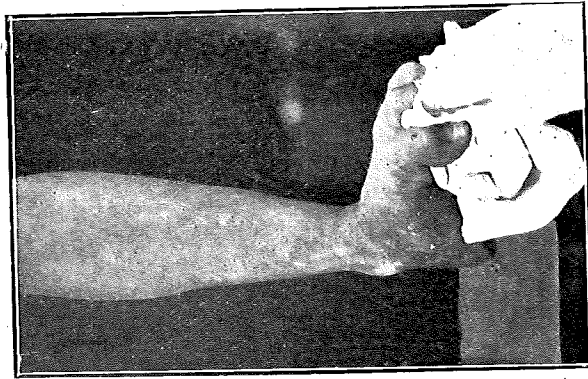


FIG. 17.—PREHENSILE FUNCTION OF PRIMITIVE FOOT.

the almost constant movements of the phalangeal and tarsal joints with the concomitant intermittent folding of the skin.

Observations on the longitudinal arch of the foot led to the conclusion, contrary to common opinion and teaching, that its height and shape are of little or no value in estimating the usefulness of the foot, and that there is no one type as the normal, but that normal feet present high, medium and low arches. While it is true that the moderately high arch is in preponderance, the very low arch, when present, seems to be no indication

2

#### 120 FEET OF BAREFOOTED AND SHOE-WEARING PEOPLES.

Myron (Fig. 19), the toes of which fairly grasp the ground to aid in steadying the athlete at the moment of supreme effort when he is straining every muscle to begin the forward motion of the arm.

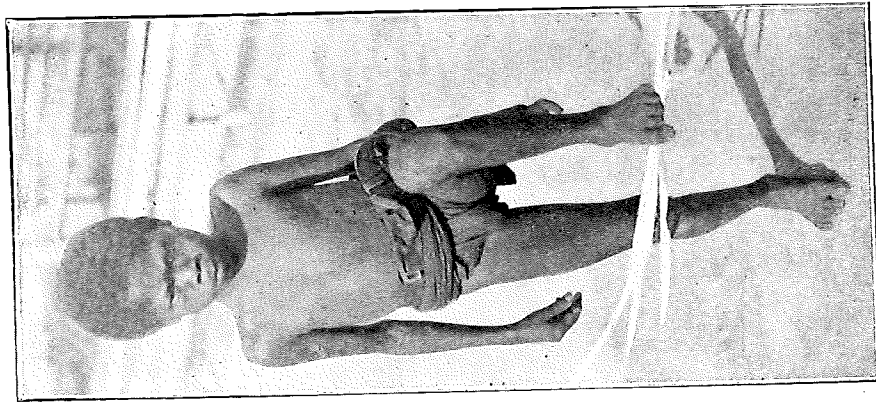


FIG. 16.—NEGrito BOY, USING TOES IN GRASPING.

My attention was especially attracted to the condition of the skin covering the primitive foot; to a remarkable degree it resembles that of the hand. The skin of the sole is thick and tough, though very pliable, and free from the callous spots due



of weakness, and in the many instances where it was found in the primitive Filipino or African, it was associated with a foot that was strong and flexible. The lowness of the arch was real and not merely simulated by an underlying pad of fat. The impression records of the longitudinal arch, commonly made by surgeons, are, apparently, of no value in the diagnosis of the so called flat foot, whose symptoms are dependent upon a weak-



FIG. 18.—BAGOBO WOMAN, USING TOES AS A THIRD HAND TO HOLD YARN TAUT.

ened arch and not upon its lowness, except in so far as this lowness is a transition from an original higher condition with concomitant change in the relationship of the tarsal bones and strain of ligaments and muscles. Such transition, in my opinion, rarely occurs. It is not uncommon to find the same symptoms associated with arches of good height and I have frequently found them associated with an extraordinarily high

arch. It is equally as common to find low arches in symptomless feet.

It is very significant that in the one hundred eighty six pairs of primitive feet examined, I did not find a single foot associated with the symptoms of weakness so characteristic and common in adult shoe-wearing feet, which are weakened by the restraint

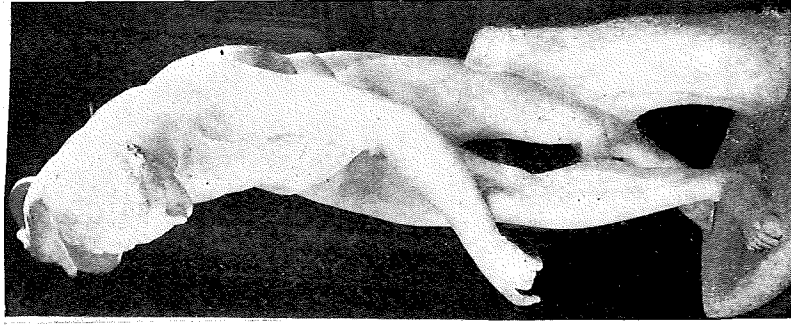


FIG. 19.—DISCOBOLUS OF MYRON, SHOWING STRONG TOE ACTION.

the shoe exerts over function. Through interpreters I made careful inquiry in regard to this, especially whenever I found an arch that was exceptionally low.

Fig. 20 illustrates some of the types of arches found in normal feet. These impression records, which were made by the common method of weight-bearing on smoked paper, do not really

different types occurred in the 186 barefooted subjects examined. Of course there were many intermediate grades, which are included in the types they most nearly resemble.

Table 1. Frequency of different types in 46 Moros, Philippine Islands, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	4	8 $\frac{1}{2}$
B.....	6	13 $\frac{1}{3}$
C.....	7	15 $\frac{1}{2}$
D.....	7	15 $\frac{1}{2}$
E.....	9	19 $\frac{1}{2}$
F.....	13	28 $\frac{1}{2}$
	46	100

Table 2. Frequency of different types in 27 Bagobos, Philippine Islands, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	2	7 $\frac{1}{2}$
B.....	6	22 $\frac{1}{2}$
C.....	5	18 $\frac{1}{2}$
D.....	4	14 $\frac{2}{3}$
E.....	5	18 $\frac{1}{2}$
F.....	5	18 $\frac{1}{2}$
	27	100

Table 3. Frequency of different types in 3 Mangyans, Philippine Islands, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
C.....	1	33 $\frac{1}{3}$
E.....	2	66 $\frac{2}{3}$
	3	100

Table 4. Frequency of different types in 70 Igorrotes, Philippine Islands, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	6	8 $\frac{1}{2}$
B.....	2	2 $\frac{1}{2}$
C.....	8	11 $\frac{1}{2}$
D.....	24	34 $\frac{1}{2}$
E.....	18	25 $\frac{1}{2}$
F.....	12	17 $\frac{1}{2}$
	70	100

show the height of the longitudinal arch, but show how much of the sole comes in contact with the ground in weight-bearing. This, however, usually bears a relationship to the height of the arch, and I speak of height in connection with these records in this sense only. Comparison of smoked imprints with plaster casts of the same feet, taken while bearing the body-weight, showed a correspondence in each instance to the flattened area

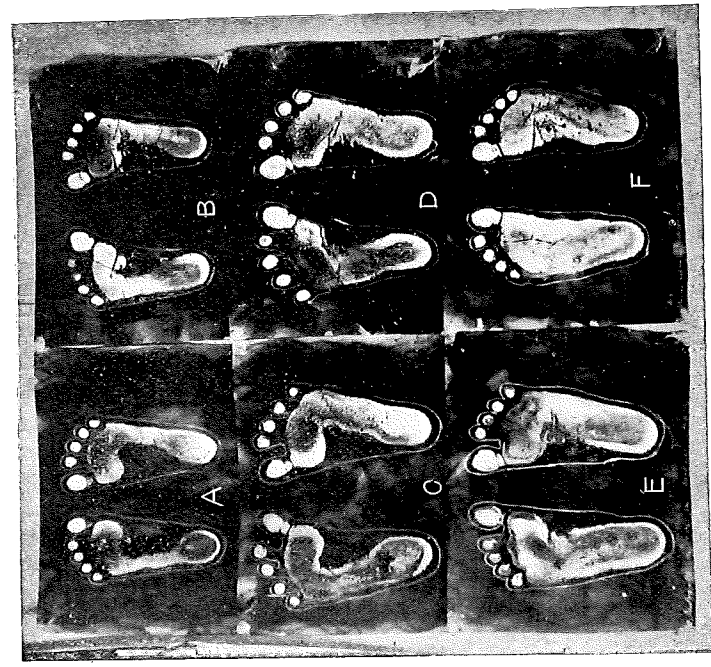


FIG. 20.—A FEW OF THE TYPES OF ARCHES FOUND IN NORMAL FEET.

of the sole of the cast caused by body-weight compression. This showed that the weight-bearing area could be accurately determined by this method. The casts also showed that there was an almost constant relationship between the extent of this area and the arch height; that is, the farther the imprint extended inward, the lower was the arch.

The following tables illustrate the frequency with which the

126 FEET OF BAREFOOTED AND SHOE-WEARING PEOPLES.

In addition to the 186 barefooted individuals forming the basis of these statistics, I examined 45 South African Negroes, *i. e.*, Matabele, Zambesi, Hottentot, etc., all adult males who had gone barefooted up to early manhood and had worn shoes during the last five or six years only. Table 9, which tabulates records of their foot impressions, may be of interest as showing the frequency of the different types of arches in this group.

Table 9. Frequency of different types in 45 South African Negroes, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	6	13 $\frac{2}{3}$
B.....	7	15 $\frac{1}{3}$
C.....	8	17 $\frac{2}{3}$
D.....	7	15 $\frac{1}{3}$
E.....	11	24 $\frac{2}{3}$
F.....	6	13 $\frac{2}{3}$
	<hr/> 45	<hr/> 100

That as great variation in the height and shape of the longitudinal arch exists in Caucasian shoe-wearers as in barefooted peoples, is shown in Table 10, which is based upon the examination of 200 pairs of normal, or at least symptomless, feet.

Table 10. Frequency of different types in 200 Caucasian shoe-wearers, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	27	13 $\frac{1}{2}$
B.....	20	10
C.....	27	13 $\frac{1}{2}$
D.....	53	26 $\frac{1}{2}$
E.....	40	20
F.....	33	16 $\frac{1}{2}$
	<hr/> 200	<hr/> 100

That the same is true of the American shoe-wearing Negro is shown in Table 11, which is based upon the examination of 100 pairs of symptomless feet.

Table 5. Frequency of different types in 33 Negritos, Philippine Islands, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	3	9 $\frac{1}{3}$
B.....	4	12 $\frac{1}{3}$
C.....	5	15 $\frac{1}{3}$
D.....	6	18 $\frac{1}{3}$
E.....	6	18 $\frac{1}{3}$
F.....	9	27 $\frac{1}{3}$
	<hr/> 33	<hr/> 100

Table 6. Frequency of different types in all Philippine tribes, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	15	8 $\frac{1}{2}$
B.....	18	10
C.....	23	14 $\frac{1}{2}$
D.....	41	22 $\frac{1}{2}$
E.....	40	22 $\frac{1}{2}$
F.....	39	21 $\frac{1}{2}$
	<hr/> 179	<hr/> 100

Table 7. Frequency of different types in 7 Central African Negroes, *i. e.*, Pigmy, Baluba, Chiri Chiri and Bakuba, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	2	28 $\frac{1}{2}$
B.....	1	14 $\frac{1}{2}$
D.....	2	28 $\frac{1}{2}$
E.....	1	14 $\frac{1}{2}$
F.....	1	14 $\frac{1}{2}$
	<hr/> 7	<hr/> 100

Table 8. Frequency with which the types of arches shown in Fig. 20 occurred in all barefooted subjects examined. Feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	17	9 $\frac{1}{3}$
B.....	19	10 $\frac{1}{3}$
C.....	26	14
D.....	43	23 $\frac{1}{3}$
E.....	41	22
F.....	40	21 $\frac{1}{3}$
	<hr/> 186	<hr/> 100

Table 13. Frequency of different types in 560 Caucasian shoe-wearing feet that presented symptoms of weakness of the longitudinal arch.

TYPE OF ARCH.	NUMBER OF FEET.	PERCENT.
A.....	64	11½
B.....	72	12½
C.....	76	13½
D.....	92	16½
E.....	108	19½
F.....	148	26½
	<u>560</u>	<u>100</u>

Table 14 shows the comparative frequency with which the different types of arches shown in Fig. 20 occurred in Philippine Malays (Barefooted); Central African Negroes (Barefooted); South African Negroes (Barefooted up to last six years); American Negroes (Shoe-wearers); Caucasians (Shoe-wearers); Ainus, Caucasians, Northern Japan (Sandal-wearers); all presenting symptomless feet; and in Caucasians (Shoe-wearers) under treatment for symptoms of weakness of the longitudinal arch.

TABLE 14.

TYPE	PHILIPPINE MALAYS, BARE-FOOTED, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 179.	CENTRAL AFRICAN NEGROES, BARE-FOOTED, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 7.	SOUTH AFRICAN NEGROES, BARE-FOOTED UP TO LAST SIX YEARS, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 45.	AMERICAN NEGROES, SHOE-WEARERS, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 100.	CAUCASIANS, SHOE-WEARERS, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 200.	AINUS, CAUCASIANS, NORTHERN JAPAN, SANDAL-WEARERS, FEET SYMPTOMLESS, INDIVIDUALS EXAMINED, 5. NUMBER TOO SMALL FOR RELIABLE CONCLUSIONS.	CAUCASIANS, SHOE-WEARERS, UNDER TREATMENT FOR SYMPTOMS OF WEAKNESS OF THE LONGITUDINAL ARCH, INDIVIDUALS EXAMINED, 560.
Type A.....	8½%	28½%	13½%	18%	13½%	—	11½%
" B.....	10	14½	15½	13	10	—	12½
" C.....	14½	28	17½	19	13	—	13½
" D.....	22½	28	15½	21	26½	—	16½
" E.....	22½	14½	24	16	20	—	19½
" F.....	21½	14½	13½	13	16½	—	26½
	<u>100%</u>	<u>100%</u>	<u>100%</u>	<u>100%</u>	<u>100%</u>	<u>100%</u>	<u>100%</u>

FOR TYPES SEE FIG. 20.

Analysis of Table 14 shows that in the 536 individuals of different races, with symptomless feet, the American and primitive

Table 11. Frequency of different types in 100 American shoe-wearing Negroes, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
A.....	18	18
B.....	13	13
C.....	19	19
D.....	21	21
E.....	16	16
F.....	13	13
	<u>100</u>	<u>100</u>

Table 12 shows the variation in five sandal-wearing Ainus.

Table 12. Frequency of different types in 5 Ainus, Caucasian Sandal-wearers; Northern Japan, feet symptomless.

TYPE OF ARCH.	NUMBER OF INDIVIDUALS.	PERCENT.
B.....	1	20
C.....	1	20
D.....	1	20
E.....	2	40
	<u>5</u>	<u>100</u>

It is probably true that weakness of the structures composing and maintaining the longitudinal arch is in some instances accompanied by depression of the arch, and that on account of this depression a greater area of the sole of the foot comes in contact with the ground. However, it was demonstrated by examination of imprints on smoked paper of 560 feet treated by me, all presenting more or less typical symptoms of weakness of the longitudinal arch, and nearly all deriving benefit from arch supports, that arch depression is not as frequent and marked as is commonly taught; in fact, that the average character of the imprints commonly made for diagnostic purposes does not differ much from the average character of those found in symptomless feet. The result of this examination is shown in Table 13.

Negroes presented a smaller percentage of low and a larger percentage of high arches than did the Caucasians. This contra-

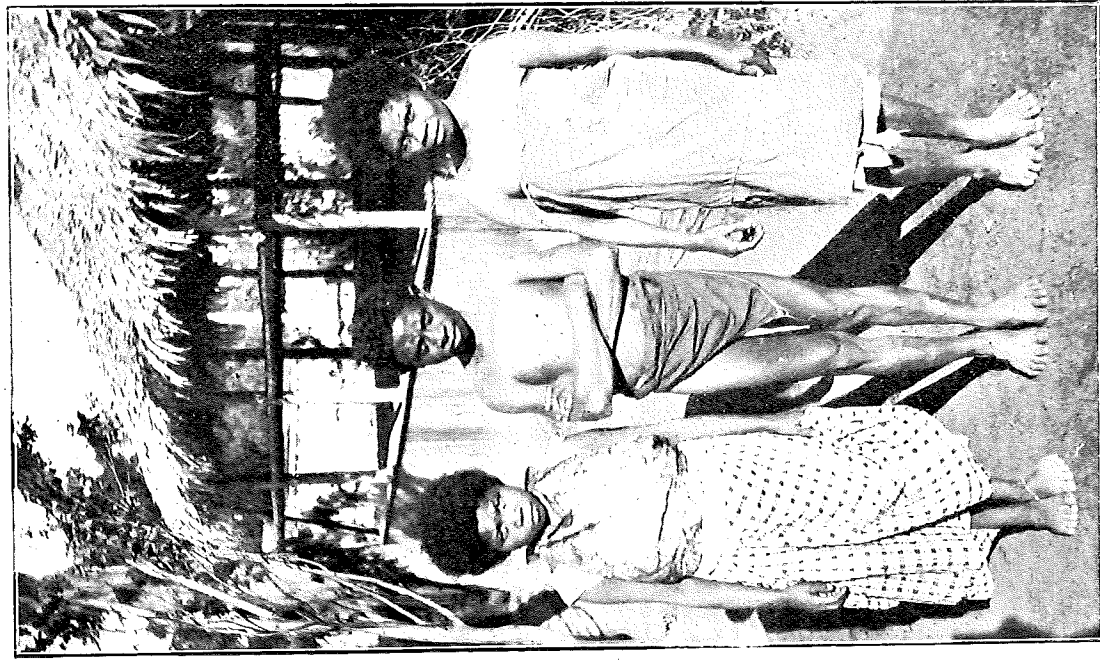


FIG. 21.—PHOTOGRAPH OF NEGROS, SHOWING HABITUAL FOOT POSTURE IN STANDING.

dicts a commonly accepted view. The Philippine Malay showed a somewhat larger percentage of low arches than did either the Negro or Caucasian. Another thing shown in this table is that the 560 Caucasian feet with symptoms of weakened arches, did not present a much larger percentage of low arches than did the *symptomless* Caucasian feet. The histories accompanying these 560 impression records, show that the feet with long stand-

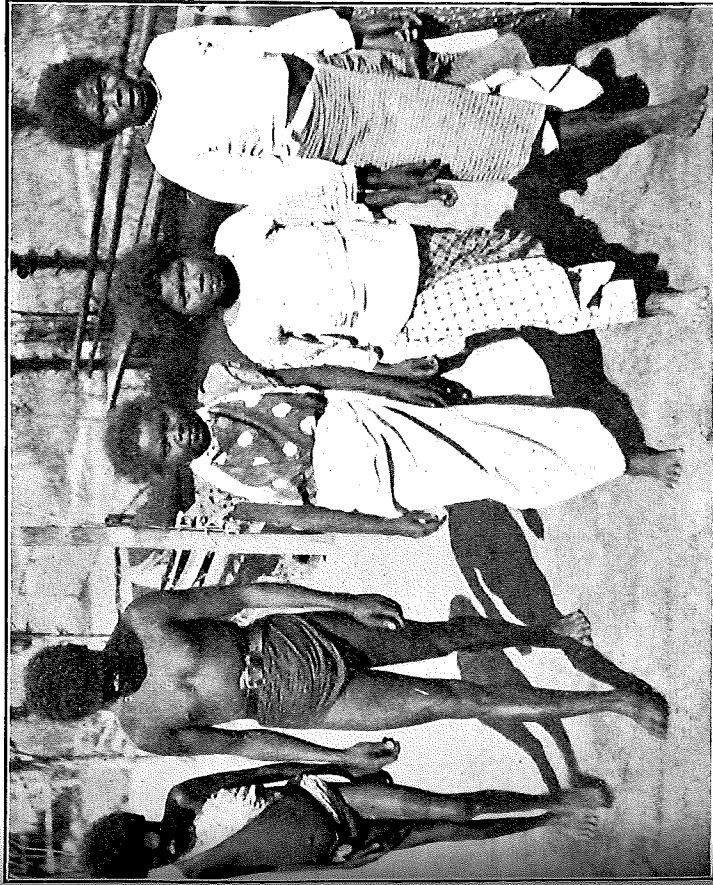


FIG. 22.—PHOTOGRAPH OF NEGROS, SHOWING HABITUAL FOOT POSTURE IN WALKING.

ing or severe symptoms did not occur oftener among the lower arch-types than did those whose symptoms were mild or of short duration.

If these statistics are a fair index for all feet, the conclusion is justified that weakness of the longitudinal arch rarely results in its depression, and that *flat foot* as a *pathological* entity hardly exists.



and joint motion. To avoid the performance of this work, the weakened foot is everted. The more it is everted, the less is its leverage function used, and, finally, it degenerates into a mere pedestal that bears the body weight. Among the Negritos who practically all have a very straight walk, *i. e.*, the toes pointing forward or even slightly inward, very low arches were common, while among the Bagobos it was just as common to find high arches associated with more or less eversion.

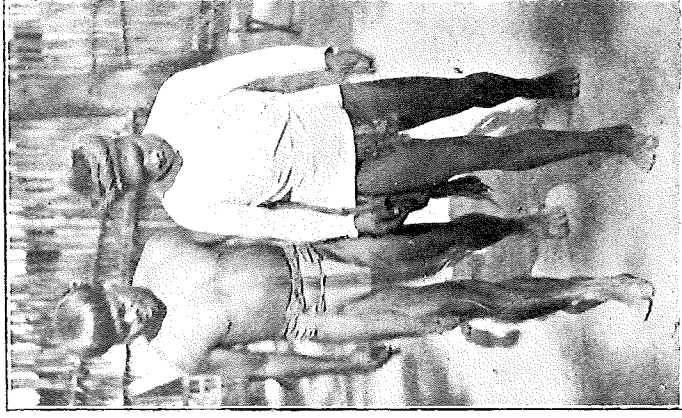


FIG. 24.—BONTOC AND SUYOC IGORROTES WALKING.

I must say that I was somewhat disappointed at not finding the straight or leverage gait as common among primitive peoples as I had supposed, though, on the whole, it is far more common than among shoe-wearers. As mentioned it was found practically universal in the Negritos (Figs. 21 and 22); in the Bontoc Igorrotes it was the rule (Figs. 23 and 24); in the Suyoc Igorrotes

#### 132 FEET OF BAREFOOTED AND SHOE-WEARING PEOPLES.

The height of the arch appeared to bear no relationship to the gait. In shoe-wearers, the affection commonly called flat foot is often associated with more than ordinary eversion of the foot on standing and walking. This eversion is due not to the low

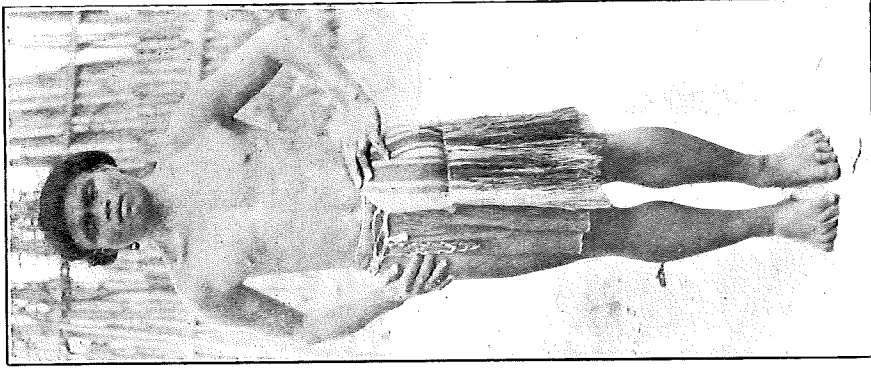


FIG. 23.—BONTOC IGORROTE STANDING.

arch, but to the associated weakness or stiffness of the joints of the foot and weakness of the muscles controlling them. To walk with the toes pointing forward is to use the foot as a lever that raises and propels the body. This means muscle exertion



it was less common and in the Moros much less so, while in the Bagobos the *everted* gait, often very marked, was predominant. (Fig. 25.)

The position of the feet on standing in most instances cor-

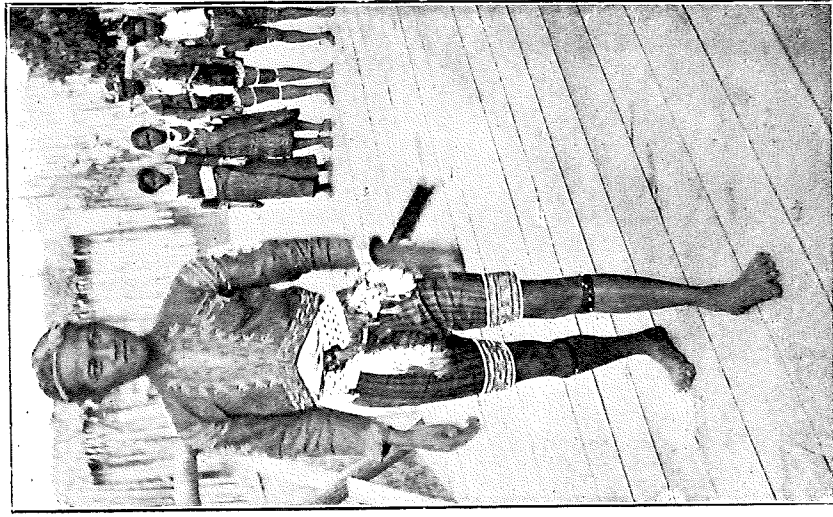


FIG. 25.—BAGOBO WALKING AND GROUP OF BAGOBOS IN BACKGROUND STANDING.

responded to that of the leisurely gait; on rapid walking, the toes were turned more inward in those individuals that everted when walking slowly.

Among the Central African group eight individuals were examined; namely, four Pygmies, two Bakubas, one Chiri

Chiri and one Baluba. All had fine arches except the Baluba, who had a strong and symptomless foot though practically no arch. He everted twenty degrees, *i. e.*, each foot ten degrees from the median line; the same degree of eversion was noted in one of the Pygmies, who had a very good arch. Three of the group had a very straight walk, one everted three degrees, one sixteen and one eighteen degrees. By the degree of eversion is meant the angle between the inner borders of the feet. This, of course, makes the eversion of each foot only half of the record.

The foot structure suggested nothing as to the cause of the difference in gait. Mode of life or local terrestrial conditions may have something to do with it, but I must confess that my inquiries in these directions were not very diligent.

#### SUMMARY.

The relative lengths of the foot and its component parts are practically the same in barefooted and shoe-wearing races.

Its form, functions and range of voluntary and passive motion are the same in both up to the time of shoe-wearing, after which progressive characteristic deformation and inhibition of function ensue. Here, as in other instances, acquired characteristics are not transmitted. The children of shoe-wearers inherit the same type of foot as do those of barefooted races, and this type is changed only in so far as footwear modifies it.

The height and shape of the longitudinal arch have no bearing on the strength or usefulness of the foot. Weakness of the arch is rarely, if ever, accompanied by breaking or lowering, and *flat foot* as a *pathological* entity hardly exists.

There is no relationship or coincidence between the height of the arch and the character of the gait.

These studies were by no means as thorough as I would like to have made them, though they represent the congenial work of many hours stolen from the humdrum of practical existence. I am deeply indebted to Dr. W J McGee, Chief of the Department of Anthropology, Louisiana Purchase Exposition, and Dr. W. P. Wilson, President of the Philippine Exposition Board, through whose aid these studies were rendered possible.

## DISCUSSION.

Dr. HENRY LING TAYLOR, of New York, wished to express his deep interest and appreciation of this work and the interesting results which had been obtained. Such information should be more largely disseminated so that the public might know of it. There are many points about the shape of the feet and their relation to shoe-wearing, and about postures in standing and walking, which when known and applied by experts in various fields, especially in gymnastics, military drill, and in shop and factory work, will result in increased efficiency and diminished suffering.

Dr. A. H. FREIBERG wished to know how long the tracings were taken after the shoe was removed from the foot. He thought that more compression would be shown by the tracing immediately upon removing the shoe than some time afterward. He asked also what was considered a negro in making a study of the feet of negroes. He said that there were a good many shades of negroes and very few that are actually black, in Cincinnati. These latter were the only ones that he used in his investigations unless otherwise specified. He thought it important in the result to know how much Caucasian blood was mixed with the black blood.

Dr. T. HALSTED MYERS, of New York, said that with regard to the statement that the height of the arch and general shape of the foot were not a measure of symptoms that he believed the same to be true in the white races and that one can not always judge from the shape of the foot what the symptoms might be.

Dr. JOHN RUDLOX said that the question of diagnosis of the condition being a flat foot, or beginning flat foot, because it was relieved by a steel support, was not necessarily so. A steel support might relieve pain in the foot, or pain might be due not to the flat foot, but to a lack of normal dorsal flexion which might be due to a shortening of the calf muscles or what Schaffer has called non-deforming club-foot.

Dr. PHIL. HOFFMANN, in closing, said that all the cases included in the analysis of primitives were barefooted except the five Ainus, who were sandal-wearers. Later, for comparison, he had taken 200 white and 100 black shoe-wearers. In examining the latter he had endeavored to secure those of as nearly pure African blood as possible. Among the shoe-wearers nearly every case had presented a certain amount of hallux valgus, but no special attention had been paid to this relationship. The group presenting symptoms were selected from Caucasians for the purpose of comparing with symptomless Caucasian feet. He did not find one primitive foot with symptoms. All had good strong feet. The diagnosis of weakened arch was based upon the symptom-complex, and not upon the fact of relief by an arch support.

## II.

## CONCERNING PATTERNS OF THE SPINAL CURVE OF PATIENTS WITH POTT'S DISEASE WEARING PLASTER JACKETS. HOW THESE MAY BE USED TO DETECT SLIGHT CHANGES OF CURVATURE WITHOUT DISTURBING THE JACKET.

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In a paper presented last year I attempted a comparison of three different methods for applying jackets in the recumbent position,—the "hammock," the Goldthwaite frame, and the Lovett frame. I tried to make a comparative estimate of the amount of corrective alteration in the angle of the Kyphos obtained in each; while a year was too short a time in which to form a fair judgment, the succeeding year just gone has not changed the opinion then advanced: that the Goldthwaite frame with the patient lying on the back gave a greater amount of correction of the Kyphotic angle and also a greater amount of lordosis. This was unsatisfactory because the deformity seemed in the dorsal spine as great or greater than before on account of the increased lordosis even when a considerable number of degrees of straightening had really been effected.

I also alluded to a modification of the hammock method devised by Dr. Snow, of Newburyport, to obviate this. The Lovett method had been distinguished by putting on the lower segment of the jacket first, with the lumbar spine as straight as possible, and allowing it to harden, then correcting the deformity and applying the rest of the jacket. Dr. Snow simply used this method on the ordinary hammock. The patient lying on a tightly stretched hammock and suitably padded, a jacket is applied from the lower third of the sacrum to the summit of the

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