ANALYSIS OF FOOT SHAPE MEASURED FROM CHINESE MALE AND FEMALE ADULTS

Jing Xian Li [1], Dong Qing Xu [2], Adam Heseng Wang[3], Kai Shao[3], [1] School of Human Kinetics, University of Ottawa,
[2]Department of Sports Science & Physical Education, The Chinese University of Hong Kong, [3]Li-Ning Company Limited

INTRODUCTION

Reliable and definitive data of foot shape is essential to proper design of shoes. It is commonly recognized that correct shoe fit is attained by matching shoe shape to foot shape. Some studies indicated that there were significant ethnic and gender differences in foot shape and consequently there is a need for normative data that describe foot shape, dimension and proportion for discrete population. However, there has been no systematical study on Chinese foot shape, which is a significant roadblock for the footwear industry to Chinese population. The purpose of this study was to characterize Chinese adult male and female foot shape and determine the relationship between some variables.

METHODS

A total of 105 adult males and 96 females participated in this study. The 3D foot shape data were collected through video filming. The measurement protocol was conducted on the right foot in half-weight bearing position. Before video filming, a total 20 reference points were marked using a black marker pen. They were the front end of the longest toe, the first phalangeal head, the fifth phalangeal head, the first, second, fifth metatarsal head, the highest point of the first and fifth metatarsal head, scaphoid lowest point, the highest point of cuneiform bones, tuberosity of fifth metatarsal bone, point where the leg meets the foot, medial malleolus, lateral malleolus, sphyrion, sphyrion fibulare, medial and lateral points of the most protuberant points in the middle area of the heel, pternion, the most posteriorly projecting point of the heel, point where Achilles tendon inserts in the calcaneus. During filming, subjects were asked to straightly stand on a flat board and their body weight equally supported by both feet. The feet distance is equal to the shoulder breadth. Four digital cameras were used to synchronously film the right foot for at least 5 seconds. Meanwhile, 5 variables of circumference are measured by using a flexible tape to nearest 1 mm. The coordinates of the 20 marker points are obtained through automatic digitization using APAS system (Ariel Dynamics, USA). Digitized data are smoothed with a Butterworth filter at 6Hz.

From the coordinates of the 20 markers, 5 length variables (foot length FL; first and fifth metatarsal head length M^1L, M^5L; forefoot length ForeL; tuberosity of fifth metatarsal length TM^5L), 2 breath variables (foot breadth FB; heel breath HB) and 12 height variables (height of the first and fifth phalangeal head P^1H, P^5H; height of the first and fifth metatarsal head M^1H, M^5H; height of inner arch ArH; height of the cuneiform bones CBH; height of the point where leg meets the foot DH; height of medial and lateral malleolus MMH, LMH; height of sphyrion and sphyrion fibulare SphH, SphfH; height of the calcaneus CH) were calculated. Together with the 5 girth variable (metatarsal-phalangeal joint girth MPJH; midfoot girth MFG; heel-Midfoot girth HMFG; heel-instep girth HIG; malleoli girth MG) measured manually, a total of 24 foot shape variable were obtained.

For each variable, mean and standard deviation were calculated. To determine the nature of the relationship between variables, Pearson correlation coefficients were calculated with FL, M^1L, FB, MPJG and ArH as the independent variables. These variables were selected as representative of each category of measurements.

RESULTS AND DISCUSSION

Table 1 shows length variables have a minimum of 64% of variance accounted for by maximum foot length. The explained variance of the girth variables is slightly less ranging between 58-79%, however, the breadth and height measures have a

minimal amount of variance explained by foot length ranging between 14-44%. The first metatarsal head length has a similar relationship to the length and girth variable as FL. This means the relationships between the first metatarsal head and the variables of length and girth are similar to the relationships between FL and these variables. Foot breath accounts for much of the variance of MPJG and HIG while MPJG correlates most highly with FB and all girth variables. Arch height has no obvious relationship with most of variables except of CBH, DH, and LMH. This analysis is in agreement with Hawes and Sovak (1994).

Table1 Coefficient of determination values for foot variables with FL, M^1L, FB, MPJG and ArH as dependent variables

	FL		M^1L		FB		MPJG		ArH	
	R	R^2	R	R^2	R	R^2	R	R^2	R	R^2
With Length										
M^1L	0.95	0.90	-	-	0.65	0.42	0.78	0.61	0.32	0.10
M^5L	0.91	0.83	0.90	0.81	0.55	0.30	0.66	0.44	0.34	0.12
ForeL	0.80	0.64	0.88	0.77	0.67	0.45	0.57	0.32	0.41	0.17
TM^5L	0.87	0.76	0.74	0.55	0.59	0.35	0.69	0.48	0.32	0.10
With *Breath*										
FB	0.66	0.44	0.65	0.42	-	-	0.79	0.62	0.49	0.24
HB	0.56	0.31	0.53	0.28	0.69	0.48	0.60	0.36	0.46	0.21
With Height										
P^1H	0.51	0.26	0.50	0.25	0.68	0.46	0.65	0.42	0.62	0.38
P^5H	0.48	0.23	0.48	0.23	0.62	0.38	0.66	0.44	0.35	0.12
M^1H	0.58	0.34	0.53	0.28	0.70	0.49	0.68	0.46	0.71	0.50
M^5H	0.35	0.12	0.33	0.11	0.5	0.25	0.49	0.24	0.25	0.06
ArH	0.37	0.14	0.32	0.10	0.49	0.24	0.51	0.26	-	-
CBH	0.54	0.29	0.49	0.24	0.65	0.42	0.57	0.32	0.80	0.64
DH	0.59	0.35	0.55	0.30	0.68	0.46	0.63	0.40	0.80	0.64
LMH	0.60	0.36	0.55	0.30	0.66	0.44	0.64	0.41	0.76	0.58
MMH	0.64	0.41	0.59	0.35	0.64	0.41	0.62	0.38	0.58	0.34
Sph H	0.62	0.38	0.54	0.29	0.55	0.30	0.64	0.41	0.75	0.56
Sph f.H	0.60	0.36	0.54	0.29	0.55	0.30	0.62	0.38	0.56	0.31
CH	0.63	0.40	0.61	0.37	0.67	0.45	0.60	0.36	0.25	0.06
With Girth										
MPJG	0.79	0.62	0.78	0.61	0.79	0.62	-	-	0.51	0.26
MFG	0.76	0.58	0.75	0.56	0.70	0.49	0.87	0.76	0.48	0.23
HMFG	0.85	0.72	0.85	0.72	0.66	0.44	0.84	0.71	0.46	0.21
HIG	0.89	0.79	0.87	0.76	0.72	0.52	0.89	0.79	0.52	0.27
MG	0.85	0.72	0.84	0.71	0.70	0.49	0.85	0.72	0.45	0.20

REFERENCE

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