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A Study on Step Distance and Its Relation with Some Morphometric Features in Adult Male

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Walking is an important attribute of man's superiority over others in animal Kingdom. Mode of walking has changed considerably since hominids achieved erect bipedalism. As human species proliferated all over the world as the only surviving subspecies of home, it was quite natural in the course of evolution that walking had undergone modifications in the gait and caused certain structural changes in the musculo-skeletal system. Owing to variety of terrians and surfaces, variation may be found in mode of walking. Besides, there are certain individual variations in the mode of walking. Personal variation may also be due to peculiarities in the musclo-skeletal or neural system, which may be normal or aberrant.

As walking is related to many somatic variations, it needs total consideration. Different populations have evolved in different ecosystems, where terrains are of various types. So, the general mode of walking may be similar for a population confined to a particular locality. As such, a relationship can be assumed to be existing between the stride distance or the space covered in one step with different somatometric features involved in the process of walking.

IMPORTANCE OF THE STUDY

From anthropological point of view, one can relate mode of walking and stride distance as a population character and eco-condition. Bare foot walking, use of foot wear or load carrying habit on different types of surface might have conditioned human walking.

Apart from anatomical provision, human walking appear to be imitative and culture-induced also. Anyway individuals show personal pattern in stride and style. These are very important from forensic anthropological viewpoint. Forensic investigators try to retrieve as many personal information as possible from foot prints.

Napier (1967) discussed at length on human walking in evolutionary perspective, which is of anthropological interest. Nath (1993) stressed forensic implications of various anthropometric items. Quamara et al (1980), Guiles and Vallang-digam (1991), Jasuja and Manjula (1993) indi-cated possibility of estimating stature from foot prints and Robbins (1986) attempted to estimate not only height but also body weight from foot prints. Ghoshmaulik (1993) similarly attempted to correlate stride length with different somato-metric features including stature.

MATERIALS AND METHODS

The present paper examines data on 209 male individuals with no walking defect, in the age group of 20-30 yrs. The samples were collected from two cities – Bhubaneswar and Sambalpur, situated in the eastern and western part of Orissa respectively. Data were collected through direct observation on selected somatometric characters like (i) height vertex (ii)height trochanter (iii) height tibiale (iv) foot length (v) foot breadth and (vi) step distance (between two acropodial points on step impressions). Apart from anthropometric measurements, step impressions were obtained on paper roll by asking each individual to walk over for 10 steps after getting their feet soaked from a soft foot-mat made wet with deep colour. Each length of paper strip was detached for analysis. For the present purpose, only the correlation of metric factors and the statistical variables are considered. Standard statistical methods of processing data and finding out correlations have been used.

RESULTS

Data obtained from various metrical of all the 209 subjects were examined for the following characters by methods explained above: (i) height vertex, (ii) height trochanter, (iii) height tibiale, (iv) bitrochanter breadth, (v) foot length, (vi) striding distance or the distance covered in one step, (vii) stepping linearity, and (viii) foot index.

Statistical values of the variables are given in table 1. The tall men in the sample size are in

Table 1: Statistical values of the variables (n = 209)

S. No.	*Metrical variables*	*Mean*	*S.D.*	*S.E.*
1.	Height Vertex	165.587	4.905	0.339
2.	Height Trochanterion	94.402	4.400	0.304
3.	Height Tibiale	47.228	0.909	0.062
4.	Height Sphyrion	6.143	0.674	0.046
5.	Foot Length	25.036	1.784	0.123
6.	Foot Breadth	9.304	1.141	0.079
7.	Step Distance	61.175	8.602	0.595
8.	Foot Index	37.509	4.005	0.277

the height range of 175-180cm. The mean height vertex is 165.587cm with S.E. of 0.339cm. As trochanterion height is an indicator of leg length, it has been suspected to be important for stride length. The mean trochanterion height is found to be 96.402cm with S.E. of 0.304c. Likewise, the mean and S.E. of height tibiale in the study are found to be 47.228 cm and 0.062cm respectively. Wider bitrochanter breadth in man gives more freedom of legs than narrower one. The sample size has a mean breadth of 28.045 cm with S.E. of 0.164cm. Foot length is closely related to the stature and is an effective component in walking. Mean foot length of the sample size is 25.036 cm with S.E. of 0.123cm.

More than 75% of the sample are having stride distance in the range of 55-70cm. The mean value is found to be 61.175cm with S.E. of 0.595 cm. It is shown in table 2 that Greater stride length of 75-85 cm is achieved by only 2.86% of the total subjects while significant number of sample are putting a very short stride length of 45-50cm.

Table 2: Number and percentile distribution of step distance (n = 209)

Range (in cm)	*No.*	*Percentage*
45-50	18	8.61
50-55	18	8.61
55-60	48	22.96
60-65	67	32.05
65-70	42	20.09
70-75	10	4.78
75-80	3	1.43
80-85	3	1.43

The study observes variation in foot-index value among the individual (Table 3). In 65% of the cases, the value lies between 35-40. The mean foot index is 37.509 with S.E. of 0.277.

Table 3: Number and percentile distribution of Foot Index (n = 209)

Range	*No.*	*Percentage*
20-25	2	0.96
25-30	5	2.39
30-35	29	13.87
35-40	136	65.07
40-45	27	12.91
45-50	10	4.78

A notable aspect of the study is observation on the pattern of stepping among the individuals. They are categorized as straight, convergent and divergent. The number of occurrences were sorted out (Table 4). Also, the angle they made while walking (Fig. 4) was recorded which can be seen in table 5. Majority of individual (about 58%) put their steps in a divergent direction while those having convergent type are the least in the sample. Different angles of deviations are observed. In both the convergent and divergent types, the angle made is in lesser proximity in most of the cases. But unlike divergent type, subjects with convergent type hardly make an angle more than 20^{O} while walking. Variations in stepping are also recorded and it is found that about 56% men put a larger step than the following steps (Table 6).

Table 4: Percentile distribution of different step patterns

Step Pattern	*Percentage*
Straight	29.66
Convergent	12.45
Divergent	57.89

Table 5: Percentile distribution of angles of deviation from linear axis while walking.

Angle of deviation	*Divergent type (%)*	*Convergent type (%)*
$0\text{-}10^{0}$	30.14	4.30
$10\text{-}20^{0}$	21.53	6.22
$20\text{-}30^{0}$	4.30	1.91
$30\text{-}40^{0}$	1.91	-

Table 6: Variation in stepping

i) First step larger than the following steps	55.98%
ii) First step smaller than the following steps	44.02%

Table 7: Correlations of variables

S. No.	*Characters*	*Values of 'r'*	*Previous study*
1.	Stride length x ht. Vertex	-0.520	-0.0193
2.	Stride length x ht. Trochanterion	-0.433	+ 0.1603
3.	Stride length x ht. Tibiale	-0.685	-
4.	Stride length x bitrochanter breadth	-0.017	-
5.	Stride length x foot length	-0.188	+0.0071
6.	Stride length x foot index	+0.014	-

DISCUSSION

Restoration of lost or unknown information is a very useful application of anthropometric knowledge. Very few studies have been done on the present topic and to say the least, observations on stepping linearity is entirely a recent approach, though a number of studies were done on human gait (Robbins, 1986; Quamara, 1989; Jasuja,1991; Ghoshmaulik, 1993).

Jasuja (1993) attempted to estimate stature from stride length. Stride length varies from person to person as per mode of walking. Some tall persons have habit of walking in small steps but frequently may be quicker to ensure space coverage per specific time. Similarly some shorter persons may walk by big steps.

Statistical correlation (r) is calculated to find relation between different variables, as shown in table 7. Interstingly, except for foot index, stride length shares negative correlation with all other characters, which is very high for stature, height trochanterion and height tibiale and less significant for bitrochanter breadth. The positive correlation value between stride length and foot index is also not so significant. A negative correlation of stride length with stature was observed from another sample from Berhampur city of Orissa (Ghoshmalik, 1995).

Observations on stepping linearity reveals high occurence of divergent type of steps. Persons putting convergent steps are indeed few but rarely the angle of deviation surpasses 30^0 in either cases. Also, majority of persons put their first step is larger than the following steps. But as said, this needs more data and elaborate observations to arrive at definitive conclusion.

Inspite of various attempts made by many scholars as mentioned before, to estimate stature from foot length and stride length, the matter is still open to improvement. It is felt that the problem of shorter or larger stepping has to be sorted out, before the stride length can be prescribed as an indicator of height or any other somatometric variable. Also the gender difference has to be investigated.

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ABSTRACT The study presents observations on stepping pattern and correlates stride length or step distance with selected morphometric features e.g. stature, height trochanter, height tibiale, bitrochanter breadth, foot length, foot breadth and foot index. Except for the latter, correlation values in all other cases are negative. observation on stepping linearity reveals predominant occurrence of divergent type of steps while the first step covering a distance larger than the following steps is observed in majority of cases.

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