

Influence of Ethnicity, Geography and Climate on the Variation of Stature among Indian Populations

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ABSTRACT

This paper analyzes the variation in the mean stature of adult males of a variety of population groups in India and examines the influence of geographical, climatic and ethnic factors on it. A considerable variation in mean stature has been found with respect to these three attributes. Variation »between« ethnic groups compared with »within« ethnic groups was found to be much more than that of geographical and climatic zones. Scheduled Castes (SC) and Scheduled Tribes (ST) populations have much low average height than that of General Castes (GC). Climatically dry and semiarid zones have a tendency to have higher stature than in the Monsoon areas. The mean height has been found to be the highest in north India. It is closely followed by west India. An interesting feature is that as one goes towards east and south the mean height gradually decreases. It is the lowest in islands. The mean heights have been regressed on geographical, climatic and ethnic factors, after converting these factors into binary variables. The regression analysis has strengthened the findings, that there is a highly significant relationship between height and geographical, climatic and ethnic factors.

Key words: caste, tribe, geography, climate, variation of stature, India

Introduction

The pattern of variation of adult (male) stature among human populations in different regions of the world is influenced by several factors that can be recognized as – local, regional and global. The local factors that influence stature include heterosis¹⁻², socio-economic status³, diet and nutrition etc.⁴. On the other hand globally, geographical clines, allometry⁵ and climatic influences⁶ have been observed in variation of stature across continental populations. For example, in an analysis to find the geographical gradients of stature with respect to climatic environmental variation in Japan, it was observed that taller stature is found in the arid belt of the northern and northwestern sectors, while short stature occurs in the humid regions of the eastern and southern zones⁷. Association between body size and mean temperature is also found to follow the climatic model^{8,9}. In continental populations, anthropometric characters e.g. stature etc show wide variation and it is influenced by local, regional and global factors. In this regard Indian subcontinent presents diverse climatic conditions in different regions and

mimic global and continental conditions. It also contains diverse human populations and a unique population structure (for the majority of its population) of hierarchical caste system and several religious and migrant ethnic groups: each maintaining high degree of endogamy and cultural identity in wide geographical regions of variable climatic conditions.

In Indian situation, in view of endogamy, the variation in some of the anthropometric traits such as stature is perhaps more influenced by population structure and less by climate and geography. This is because nearly eighty percent of stature is genetically regulated, and non-genetic factors such as geography, climate, nutrition and socioeconomic factors together account for the remaining twenty percent. Accordingly, a positive association between caste hierarchies was studied in some regional populations^{10,11}, where it has been observed that in a region general caste populations are, on an average, taller compared to Scheduled Castes and Scheduled Tri-

bes. Whereas, Buchi¹² had observed geographical gradients of stature from northwest to east and south positions. Majumdar and Rao¹³ observed that affinity in caste hierarchy does not often show the biological (anthropometric) similarity in eastern region. Again, Singh et al.¹⁴ found an inverse relationship between average rainfall of an area and mean stature of its inhabitants. Majumder et al.¹⁵ have found significant variation in seven anthropometric traits among 82 populations. But such variations have not been observed across geographical regions. These studies are sporadic and limited to particular region covering a few populations and do not consider the influence of its concomitant factors of geography, climate and ethnicity. Therefore the results showed differential pattern of variation of stature. Mahalanobis and Olivier^{10,11} observed positive relationship between caste hierarchy and stature from a single geographical or climatic zone; the inter-ethnic relationship is also highly correlated. However, based on a large sample size drawn from different regions and wide ethnic groups, a recent study had shown that all the three factors are associated with the variation of mean stature¹⁶. In the present study we have considered variation in adult male stature in population samples from different parts of the country, across different geographical and climatic regions; and comprehensive statistical analyses have been attempted to detect spatial patterns with respect to ethnic, geographic and climatic backgrounds.

Subjects and Methods

Data

The sample of the present study constitutes 601 populations of different ethnic groups from different geographical and climatic zones of the country. The data were obtained from »People of India« project, conducted during October 1985 and March 1992, by the Anthropological Survey of India¹⁷. This national project also compiled the data that were published during 1879 to 1991. Only average adult male stature and associated cultural affiliations of the populations have been considered for the present study.

(a) Identification of populations

The data belonged to different caste or ethnic groups in different regions and it was necessary to identify the geographical location and climatic zones of the studied populations. In majority of the cases, it was possible to link a particular population to its geographical location, and therefore to a specific climatic region, from the recorded name and place of the respective caste or community.

Accordingly, the data were divided into four groups, such as:

- (i) Scheduled Tribe (ST) – supposed to be the original settlers and are distinct from all other religious and ethnic groups living in the country.

- (ii) Scheduled Caste (SC) – groups which lie in the lowest position of the hierarchical caste Hindu society.
- (iii) General Caste (GC) – includes various castes and sub-castes, above the scheduled castes, of the Hindu society.
- (iv) Others (Oth) – which includes some of the minority groups of the country, outside the Hindu (GC and SC) and the Tribal societies.

(b) Geographical and climatic variation

The Indian subcontinent represents a variety of geographic and topographical regions with high altitude mountains, vast seacoast, rivers, jungles, delta, desert etc. with their characteristic climates.

(i) Geographical zones

India is divided into seven geographical zones in this paper, such as:

North zone: Jammu & Kashmir, Uttar Pradesh, Himachal Pradesh, Uttarakhand, Delhi, Punjab and Hariyana.

North-East zone: Assam, Meghalaya, Arunachal Pradesh, Tripura, Manipur, Nagaland and Sikkim.

East zone: Bengal, Bihar, Jharkhand and Orissa.

Central zone: Madhya Pradesh and Chattisgarh.

West zone: Gujarat and Maharashtra.

South zone: Andhra Pradesh, Tamil Nadu, Karnataka, Pondichery and Kerala.

Island zone: Andaman and Nicobar Islands and Lakshadweep and Minicoy Islands.

(ii) Climatic zones

Based on monthly values of temperature and precipitation as per Koppen's method (cited in Bhasin et al.¹⁸ p.17) the country can be divided into eight climatic zones, such as: (1) Tropical Savannah, (2) Monsoon with a short dry season, (3) Monsoon with a dry season in the high sun period, (4) Semi-arid and steppe climate, (5) Hot desert, (6) Monsoon with dry winters, (7) Cold humid winter with a shorter summer, and (8) Polar.

(c) Limitations of the data

The samples were limited to some specific regions and the available data do not represent all the regions. Again, the population samples do not always represent all the castes or sub-castes of a region. Thus the ethnic representation of the sample does not exhaust all the categories of caste and community. Further, several authors collected the data at different time periods and, therefore, it may involve inter-observational errors.

Methods

Mean stature (cm) has been broadly classified according to standard anthropometric method¹⁹ such as: Very short (130.0–149.0), Short (150.0–159.0), Below medium (160.0–163.9), Medium (164.0–166.9), Above medium (167.0–169.0), and Tall (170.0–179.9). The number, mean, range and standard deviation (SD) were calculated for each geographical and climatic zone; and also

for each ethnic group in each geographical zone. It is to be noted here that in Indian populations we rarely come across a group with »above medium« or »tall« categories of height of this classification.

One way ANOVA has been performed to investigate the between-group variations compared to within-group variation for each of the three characteristics *viz.*, geographical zones, climatic zones and ethnic groups.

The main difficulty in analyzing this data is the qualitative nature of the characteristics taken to explain the statures or rather mean statures of the different population groups. In this case, the usual correlation and regression analysis is inappropriate. However, the association between different characteristics can be seen through bivariate tables. It is possible to introduce binary (i.e., dummy) variables to see the influence of the factors on stature. But if the number of factors is too many, then one usually faces the problem of multicollinearity in such cases. After inspecting the closeness of mean values we have been able to classify each characteristic into two groups, and thereby able to define one binary variable for each characteristic. It enables us to find the influence of these variables on stature using regression technique: the binary variables of the value »1« for the cases where average heights were higher, and »0« for others. It facilitates the interpretation of the correlation coefficients and the regression coefficients in the usual manner.

Results

Table 1 describes the mean and standard deviation (SD) of statures of the sampled populations according to geographical regions of the country. The highest value of stature (165.05 cm) is found in the North zone. The next highest mean stature (163.12 cm) was found in west zone. It seems, northern and western zones have taller people and the height gradually decreases towards east and south. The lowest mean stature (154.57 cm) has been observed in the islands.

Table 2 shows the mean (\bar{X}) and standard deviation (SD) values of stature among different groups based on ethnic criteria against each geographical zone. It is seen that »GC« category shows highest average statures almost in all zones except in west zone, where the »Other« category shows higher average stature than GC. However this is based only on four groups. Otherwise the mean heights of the »Other« category remain in between those of GC and the SC, ST categories. The overall mean height of the ST category is slightly below that of SC.

Table 3 reflects the average stature of the sampled populations by their respective climatic regions. Here the variations of mean values over different climatic regions are more compared to that of the geographical zones. Mean values have been found to vary from the range of »Above medium« to »Short«, and the highest value (167.11 cm) occurs in the »Semi-arid Steppe« zone and

TABLE 1
GEOGRAPHICAL VARIATION OF MEAN STATURES OF DIFFERENT POPULATION GROUPS IN INDIA

Name of the zone	No.	Range	\bar{X}	SD	Form of stature
North	72	148.97–182.50	165.05	5.93	Medium
North-East	169	147.83–168.80	160.37	3.48	Below medium
East	148	142.50–169.17	159.77	5.28	Short
Central	22	157.50–164.35	160.46	2.08	Below medium
South	94	134.18–175.50	159.43	5.66	Short
West	76	151.17–168.80	163.12	2.46	Below medium
Island	20	147.78–161.66	154.57	5.33	Short
India	601	134.18–182.50	160.80	5.09	Below medium

TABLE 2
GEOGRAPHICAL ZONE WISE ETHNIC VARIATION OF MEAN STATURES OF DIFFERENT POPULATION GROUPS IN INDIA

Name of the zone	ST			SC			GC			Other		
	N	\bar{X}	SD	N	\bar{X}	SD	N	\bar{X}	SD	N	\bar{X}	SD
North	26	162.37	1.60	4	161.32	2.07	34	167.66	6.90	8	164.55	7.30
N. East	120	159.49	3.56	5	160.60	0.64	32	162.69	1.75	12	162.90	2.72
East	76	156.63	5.18	17	160.80	1.21	52	164.01	2.67	3	159.96	1.61
Central	20	160.21	1.96	—	—	—	2	162.95	1.98	—	—	—
South	46	157.26	4.44	14	157.89	4.50	25	163.45	2.44	9	161.79	11.10
West	12	161.93	1.38	2	160.52	0.24	58	163.17	2.42	4	167.20	1.13
Island	17	153.40	4.91	—	—	—	3	161.16	0.44	—	—	—
India	317	158.53	4.51	42	159.84	3.06	206	164.05	3.88	36	163.22	6.71

TABLE 3
CLIMATIC VARIATION OF MEAN STATURES OF DIFFERENT POPULATION GROUPS

Name of the zone	No.	Range	\bar{X}	SD	Form of stature
Tropical Savannah	222	142.50–169.17	160.28	4.95	Below medium
Monsoon (Short dry season)	90	134.18–175.50	159.93	5.50	Below medium
Monsoon (Dry season in high Sun)	12	159.95–165.40	163.09	1.57	Below medium
Semiarid Steppe Type	41	160.02–182.50	167.11	6.38	Above medium
Hot Desert Type	—	—	—	—	—
Monsoon (Dry Winters)	20	147.78–161.66	154.57	5.33	Short
Cold Humid Winter Type	204	147.83–167.90	160.74	3.46	Below medium
Polar Type	12	161.90–168.80	164.32	2.44	Below medium

the lowest value (154.57 cm) is found in »Monsoon with dry winters«. Climatic variation mainly includes temperature, rainfall and humidity. Temperature again depends on the altitude. However we do not have data on temperature, rainfall, humidity or altitude of these places. Thus it is very difficult to get an idea about the effect of these factors on height. It seems that in »dry and hot« areas the mean height is high. The results show one exception that is observed in case of polar region, where average short stature is expected according to the climatic model. However, the higher mean height observed in winter and polar type may be because of ethnic reasons, despite small sample size, which overrides the general influence of climate¹ in this case. This gets supported from the ANOVA results described in Table 5. The ethnic variation of mean heights for each climatic zone is also similar to those of geographical zones. Deviations, if any, are possibly due to the specific nature of the concerned groups or due to small sample size.

Table 4 presents the variation of stature in different ethnic groups with respect to climatic regions. There is no data for any group in »Hot Desert Type« climate. In addition, SC group is not represented in »Monsoon (Dry winter)« and »Polar Type« climates; there is no data for

ST group in »Monsoon (Dry Season with High sun)«; and »Other« group is not found in »Monsoon (Dry winter)« climatic region.

The table shows that both SC and GC have highest mean values in »Semiarid Steppe Type«; and the lowest values in »Monsoon Type« climates. Both ST and »Other« have highest mean stature in »Polar Type« climate, although the lowest values for ST and »Other« are »Monsoon (Dry winters)« and »Tropical Savannah« respectively. Thus it appears that particular types of climate do not have any cognizable relation with average stature of different ethnic groups.

One way analysis of variance (ANOVA) has been performed to test the differences in statures with respect to the geographical zones, climatic zones and ethnic groups (Table 5). The results show a high »between group« variation in stature compared to »within group« variation for each of the three characteristics. The comparative variations are almost same for geographical and climatic zones (F ratio=22.3 and 21.3 respectively). But it is much high between ethnic groups (F ratio=70.3).

If we observe the mean values in Table 1 very carefully, we can separate out north and west zones to have high mean statures. The last row of Table 2 shows that

TABLE 4
CLIMATIC ZONE WISE ETHNIC VARIATION OF MEAN STATURES OF DIFFERENT POPULATION GROUPS IN INDIA

Name of the zone	ST			SC			GC			Other		
	N	\bar{X}	SD	N	\bar{X}	SD	N	\bar{X}	SD	N	\bar{X}	SD
Tropical Savannah	112	157.52	4.92	15	160.31	2.98	88	163.48	2.73	7	164.10	4.06
Monsoon (Short dry)	42	157.73	4.16	9	157.11	4.29	31	163.30	2.64	8	161.56	11.84
Monsoon (Dry season)	—	—	—	3	161.80	0.38	8	163.51	1.69	1	163.59	—
Semiarid Steppe Type	14	162.53	1.52	2	161.93	2.23	24	169.57	6.14	1	182.50	—
Hot Desert Type	—	—	—	—	—	—	—	—	—	—	—	—
Monsoon (Dry Winters)	17	153.40	4.91	—	—	—	3	161.16	0.44	—	—	—
Cold Humid Winter Type	124	159.65	3.40	13	160.42	0.98	51	163.16	3.19	16	161.80	1.21
Polar Type	8	163.53	2.23	—	—	—	1	163.80	.	3	166.60	2.20
India	317	158.53	4.51	42	159.84	3.06	206	164.05	3.88	36	163.22	6.71

¹ The observations are specific to Indian subcontinent and should not be generalized globally.

TABLE 5
RESULTS OF ONE WAY ANOVA OF THE MEAN HEIGHTS BY GEOGRAPHICAL ZONES, CLIMATIC ZONES AND ETHNICITY

Characteristics	Variations	Sum of Squares	Degree of freedom	Mean of Squares	F value	Significance
Geographical Zones	Between	2854	6	475.7	22.3	0.000
	Within	12692	594	21.4		
Climatic Zones	Between	2748	6	458.1	21.3	0.000
	Within	12798	594	21.5		
Ethnicity	Between	4057	3	1352.4	70.3	0.000
	Within	11489	597	19.2		

SC and ST categories have the lowest mean statures. From Table 3 it can be seen that the following climatic zones have very high mean statures: »Monsoon (Dry season in high sun)«, »Semi-arid Steppe type« and »Polar type«. ² Thus we form three »binary« (also known as 'dummy') variables, one for each characteristic as follows:

Climatic Dummy (DClim): 1 for »Monsoon (Dry season in high sun)«, »Semi-arid Steppe type« or »Polar type« and 0 for Others.

Geographical Dummy (Dgeo): 1 for North or West zones and 0 for others.

Ethnic Dummy (Deth): 1 for GC and »Others« and 0 for SC or ST.

To see whether there is any dependency between these variables, one can construct contingency tables and perform χ^2 -test. This is given in Table 6. The χ^2 tests show that the variables are highly dependent on each other with 1 percent significance level.

We have regressed the average heights on these three dummy variables and the result is given in Table 7. All the coefficients have been found to be highly significant. The value of the coefficient of the Geographical zone is

1.67. It means that the stature in North and West zone is more by 1.67 cm, on the average, compared to other zones if other conditions, i.e., climate and ethnicity, remain same. The interpretation is similar for other coefficients. For example, General Caste Hindus (GC) and »Others« have stature higher than that of SC and ST by 4.4 cm, on the average, keeping other things same.

We can also find the interaction effect by regression method. We included all the three interactions namely »climatic zone vs. ethnicity«, »climatic zone vs. geographical zone« and »geographical zone vs. ethnicity«. Only »geographical zone vs. ethnicity« was found to have significant effect on the stature at 10 percent level. We have then carried out the regression analysis taking the three main variables and the interaction term »geographical zone vs. ethnicity«. The result is given in Table 8. Coefficients of the main variables remain similar with high level of significance. The coefficient of the interaction term was found to be negative with value -1.44. It means that the GC and »Others« leaving in North and West zones will have height less by 1.44 cm, on the average, from the expected level implied by the linear relation without interaction.

TABLE 6
CONTINGENCY TABLES OF THE BINARY VARIABLES OF GEOGRAPHICAL ZONES, CLIMATIC ZONES AND ETHNICITY ALONG WITH χ^2 TEST OF INDEPENDENCE

		0	1	Row Total	χ^2 -value	Sig.
Ethnicity						
Geographical Zones	0	315	138	453	73.5	0.000
	1	44	104	148		
	Column Total	359	242	601		
Climatic Zones						
Geographical Zones	0	429	24	453	58.1	0.000
	1	107	41	148		
	Column Total	536	65	601		
Climatic Zones						
Ethnicity	0	332	27	359	10.0	0.002
	1	204	38	242		
	Column Total	536	65	601		

² We include »Polar Type« also in this group to get a better result from further analysis.

TABLE 7
RESULTS OF LINEAR REGRESSION OF STATURE ON GEOGRAPHICAL, CLIMATIC AND ETHNIC VARIATION

Independent Variables	Regression Coefficients	t-value	Significance level
Intercept	158.70*	704.8	0.0000
Geographical zone	1.673*	3.9	0.0001
Climatic zone	4.048*	7.1	0.0000
Ethnicity	4.397*	12.1	0.0000
R-squared	0.352*	108.0*	0.0000

*Significant at 0.1% level; *F-value

TABLE 8
RESULTS OF LINEAR REGRESSION OF STATURE ON GEOGRAPHICAL, CLIMATIC, ETHNIC VARIATION AND INTERACTION TERM

Independent Variables	Regression Coefficients	t-value	Significance level
Intercept	158.07*	681.4	0.0000
Geographical zone	2.57*	3.7	0.0002
Climatic zone	3.93*	6.9	0.0000
Ethnicity	4.75*	11.3	0.0000
Geographic×Ethnicity	-1.44*	-1.7	0.0928
R-squared	0.355*	81.9*	0.0000

*Significant at 0.1% level; *F-value

Discussion

The mean stature of Indian population is »Below Medium« (160.80±5.09 cm). The north zone shows »Medium« stature; the north-east, central and west zones are in the »Below Medium« category; south and east zones lie in the upper border of »Short« stature, while Island zone shows »Short« stature. However the west zone has average stature more than other zones, which are in »Below Medium« category. This geographical pattern of variation of stature may be due to endogamous nature of regionally restricted populations. It seems, as seen from the Table 1, that there is a combined influence of the latitude and the longitude of the places on stature. Northern and western zone have taller people and the stature gradually decreases towards east and south. Unfortunately we do not have data on latitudes and longitudes of these places. Variation of stature is prominently related to caste hierarchy. It is observed that the caste groups of

north and east zones are taller than compared to north-eastern, central and Island zones. In the »Other« group, the people of the west zone show highest stature, which is mainly due to inclusion of »Parsee«, a migrant endogamous community of southwest Asia. In each zone, GC shows the highest stature, except the west zone. In west zone »Other« category has the highest mean stature.

One-way ANOVA has shown that the ratio between »between group« variations and to »within group« variations are almost same for geographical and climatic zones. This relative variation is much high between ethnic groups. This is possibly because the ethnic groups are usually endogamous, maintain similar food habits, and religious and social customs within themselves.

Climatic variation mainly includes temperature, rainfall and humidity. Temperature again depends on the altitude. However, we do not have data on temperature, rainfall, humidity or altitude of these places. Thus it is very difficult to get an idea about the effect of these factors on stature. It seems that the mean height is high in »dry and hot« areas. A high mean height in »Polar Type« and winter or cold humid areas is due to the ethnicity of the groups studied, rather than climatic influence. Overall, in Indian situation, despite diversity in geographic, climatic and other attributes, the mean height is more controlled by the ethnic factor which dominates over the influence of other factors.

Conclusion

Though human stature is determined mainly by genetic factors, but geographical, climatic, ethnic and other factors also have significant roles in it. This is more so in Indian situation because the people here are not only ethnically but also regionally endogamous. It is also believed that climate also influence human stature. All these propositions are verified in this paper by the statistical analysis of a vast number of compiled data sets. Within variation of stature has been found to be much less than between variation separately for geographical, climatic and ethnic factors. The pivotal role is played by the ethnic factors. Each ethnic group in India is highly endogamous. Stature depends also on geographical location within ethnic groups. People in the Semiarid Steppe type regions have the highest stature. The mean height has been found to be the highest in north India. It is closely followed by west India. An interesting feature is that as one goes towards east and south the mean height gradually decreases. It is the lowest in islands.

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UTJECAJ ETNICITETA, GEOGRAFSKOG POLOŽAJA I KLIME NA VARIJACIJE RASTA U INDIJSKOJ POPULACIJI

SAŽETAK

Rad analizira varijacije prosječnog rasta odraslih muškaraca unutar raznolike populacijske grupe u Indiji i istražuje utjecaj geografskog, klimatskog i etničkog čimbenika na isto. Značajna razlika prosječnog rasta uočena je s obzirom na ova tri čimbenika. Uočena je veća raznolikost u usporedbi između etničkih grupa u komparaciji s raznolikošću unutar grupa, nego raznolikost s obzirom na geografske i klimatske zone. Popisane kaste (Scheduled Castes (SC)) i plemena (Scheduled Tribes (ST)) imaju manji prosječni rast od Općih kasti (General Castes (GC)). Klimatski suha i polu suha područja bilježe tendenciju većeg rasta od monsunskih predjela. Najveća prosječna visina zabilježena je u sjevernoj, a slijedi ju zapadna Indija. Zanimljivost je da se prema istoku i jugu prosječna visina postepeno smanjuje. Najmanja je na otocima. Prosječna visina vraćena je ka geografskim, klimatskim i etničkim faktorima, nakon njihovog konvertiranja u binarne varijable. Regresijska analiza ojačala je rezultate istraživanja te potvrdila da postoji značajna povezanost između visine i geografskih, klimatskih i etničkih faktora.