Mandibular Measurements and Discrete Nonmetric Traits Compared in Distance Studies of Six Non-tribal Indian Skeletal Samples

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Abstract Seven metric and six nonmetric traits have been used to describe and discriminate mandibular characteristics of six non-tribal populations of India. Analyses of the six samples indicate that while metric traits possess a slightly better discriminating power than nonmetric traits in differentiating populations in the present investigation, both kinds of traits reveal a similar pattern of interpopulation differences. It is felt that both metric and non-metric traits should be utilized, whenever possible, to derive maximum information in population studies.

Keywords Mandible, Metric-nonmetric traits, India

Introduction

The use of minor skeletal variants to differentiate between human populations, archaeological or extant, has assumed importance in the past few years. A survey of literature reveals that studies on non-metric traits have exclusively been conducted on European, American, Australian or Japanese populations (BERRY and BERRY, 1967; ARDITO, 1977; CORRUCINI, 1974; FINNEGAN, 1972; OSSENBERG, 1976; KELLOCK and PARSONS, 1970a and b; DODO, 1974; MOURI, 1976; ROTHHAMMER *et al.*, 1984). Previous researches in this area involving skeletal material of Indian populations have been mostly descriptive, limited in most

cases to the recording of usually single morphological traits (KAUL *et al.*, 1979a). KAUL *et al.* (1979b) studied discrete cranial variation in four Indian populations (three living and one extinct) and measured the degree of divergence between them.

The relative worth of metric and non-metric skeletal variants as biological indicators in population studies has also been discussed recently. Several workers, including BERRY and BERRY (1967, 1972), OSSENBERG (1970) and PIETRUSEWSKY (1971) assert the superiority of nonmetric variants over metrical ones for ascertaining biological distances between populations. Others, like JANTZ (1970), HOWELLS (1970, 1972) and RIGHTMIRE (1972) are critical of the worth

of nonmetrical variants and defend the traditional metrical methods in population studies.

Apart from documenting the extent and nature of variation among six non-tribal population samples from India on the basis of metric and nonmetric morphological traits of the mandible, the present study attempts to evaluate the anthropological significance of nonmetric in comparison to metric skeletal variation.

Material and Methods

The present study is based on the 668 adult mandibles of six different non-tribal population samples from India. This material examined in various medical schools (colleges) and other institutions in the country, is distributed according to the State of origin as follows: Uttar Pradesh (UP)-186; Andhra Pradesh (AP)-121; Madhya Pradesh (MP)-125; Karnataka (Ka)-105; Maharashtra (Ma)-106; and, Bihar (Bi)-25.

Cremation of the dead is a common ritual among the people of India. This makes it difficult to obtain human skeletal material for research purposes. However, osteological museums and laboratories in various medical institutions (schools) and anthropology departments in some universities in the country have their own collections of human skeletal material. This material is obtained either from excavations done at archaeological sites or from unclaimed cadavers, and in many cases collected from river banks (KAUL and PATHAK, 1984).

Human skeletal parts collected from river banks are mostly of people of low socio-economic status. These people cannot afford the cost of cremation. Therefore, instead of being cremated the body is usually weighed with a heavy load and submerged in the nearest river. Soft parts of the body

either disintegrate or are eaten away by aquatic animals. The hard bony parts of the body wash ashore where they may be collected. The source, ethnic background, and other details of the material are given elsewhere (PATHAK, 1983). In the absence of authentic background information and with the poor state of preservation of the material, determination of sex of the mandibles (and skulls) was difficult.

The following seven measurements and six nonmetric traits were used in the present study:

Metric Traits: (1) Gonion-menton length, (2) Bicondylar breadth, (3) Bigonial breadth, (4) Ramus height, (5) Ramus breadth, (6) Corpus thickness, and (7) Symphyseal height.

Nonmetric Traits: (1) Mandibular torus, (2) Genial tubercles, (3) Accessory mental foramen, (4) Mylohyoid bridge, (5) Accessory mylohyoid foramen, and (6) Gonial eversions.

Measurements were taken according to TREVOR (1957) and MARTIN and SALLER (1957). The definitions and present-absent criteria for nonmetric traits follow CORRUCCINI (1974). Whereas measurements were taken on the left side of the mandible only, both sides were considered for recording the nonmetric traits, thus giving a sample size equal to 2N for the latter.

Inter-population differences were calculated by applying 'student's *t*-test' and ' χ^2 -test' to metric and nonmetric data, respectively. SOKAL and ROHLF's (1969) method of 'combining probabilities from tests of significance' was used for a comparison of the two groups of traits.

Results

Metric Traits

The mean, standard deviation and coefficient of variation for mandibular measure-

Table 1. Mean, standard deviation and coefficient of variation for mandibular measurements in six Indian populations.

Measurement	Population	N	Mean (cm)	SD	CV
Gonion-menton length	UP	186	7.40	.41	5.52
	AP	121	7.30	.43	5.90
	MP	125	7.36	.41	5.64
	Ka	105	7.14	.45	6.35
	Ma	106	7.31	.45	6.17
	Bi	25	7.56	.48	6.30
Bicondylar breadth	UP	186	11.15	.59	5.33
	AP	121	10.87	.64	5.92
	MP	123	11.08	.59	5.35
	Ka	105	11.07	.63	5.66
	Ma	104	11.05	.59	5.34
	Bi	25	11.02	.73	6.63
Bigonial breadth	UP	186	8.64	.65	7.55
	AP	121	8.46	.56	6.57
	MP	125	8.66	.52	6.06
	Ka	105	8.54	.61	7.17
	Ma	106	8.69	.63	7.29
	Bi	25	8.60	.58	6.77
Ramus height	UP	186	5.64	.59	10.50
	AP	121	5.52	.60	10.83
	MP	125	5.81	.52	9.03
	Ka	105	5.50	.58	10.55
	Ma	106	5.58	.68	12.26
	Bi	25	5.47	.53	9.73
Ramus breadth	UP	186	3.09	.27	8.69
	AP	121	3.01	.32	10.71
	MP	125	3.06	.28	9.27
	Ka	105	3.00	.32	10.76
	Ma	106	2.99	.33	10.91
	Bi	25	3.21	.31	9.56
Corpus thickness	UP	186	1.07	.15	14.49
	AP	121	1.08	.15	13.67
	MP	125	1.01	.16	16.32
	Ka	105	0.98	.14	14.59
	Ma	106	1.01	.15	14.75
	Bi	25	1.08	.14	12.82
Symphyseal height	UP	186	2.52	.38	15.17
	AP	121	2.45	.41	16.76
	MP	125	2.86	.37	12.98
	Ka	105	2.62	.43	16.29
	Ma	106	2.60	.37	14.14
	Bi	25	2.51	.39	15.52

ments in the six Indian populations are given in Table 1, and the *t*-values between different population combinations for each measurement presented in Table 2. No consistent pattern of differences between the seven mandibular metric traits of the six population groups is revealed. However, corpus thickness and symphyseal height show maximum inter-population variation, followed by gonion-menton length, ramus breadth and ramus height. Bicondylar and bigonial breadths discriminate only a few population pairs.

Nonmetric Traits

The frequency of incidence of nonmetric traits for the six samples is given in Table 3. Mandibular torus has the lowest and genial tubercles the highest frequency in all the populations. Table 4 lists the χ^2 -values between pairs of populations for each of the six nonmetric traits. No consistent pattern of inter-population differences are seen. However, genial tubercles, followed by mylohyoid bridge and gonial eversion emerge as the most discriminating traits between the populations, whereas accessory mylohyoid foramen turns out to be the least discriminating trait in the mandible.

Metric vs Nonmetric Traits

Out of a total of 105 *t*-values for metric traits (Table 2) 44.76 per cent values are significant, while out of 90 χ^2 -values for nonmetric traits (Table 4) only 30 per cent values are statistically significant. This seems to show that, in comparison to nonmetric traits, metric traits are better indicators of differences between the populations considered in the present study.

In Table 5 are presented the differences between group values of metric and nonmetric characters based on probabilities from the two tests of significance applied earlier.

Table 2. Population differences (*t*-values) for each mandibular measurement.

Traits/ Populations	Gonion menton length	Bicondylar breadth	Bigonial breadth	Ramus height	Ramus breadth	Corpus thickness	Symphyseal height
UP-AP	2.027*	-3.811***	2.548*	-1.763	2.446*	-0.777	1.403
UP-MP	0.782	0.929	-0.237	-2.640**	0.912	3.293***	-7.859***
UP-Ka	5.016***	1.034	1.305	1.970*	2.720**	4.638***	-2.202*
UP-Ma	1.613	1.317	-0.632	0.813	2.804**	3.189***	-1.809
UP-Bi	-1.821	0.944	0.325	1.367	-2.023*	0.393	0.026
AP-MP	-1.143	-2.643**	-2.902**	-4.119***	-1.398	3.720***	-8.169***
AP-Ka	2.743**	-2.321*	-1.051	0.241	0.300	5.098***	-3.074**
AP-Ma	-0.265	-2.147*	-2.954**	-0.709	0.375	3.701***	-2.831**
AP-Bi	-2.702**	-1.039	-1.128	0.373	-2.859**	0.331	-0.696
MP-Ka	3.893***	-0.154	1.577	4.308***	1.675	1.213	4.479***
MP-Ma	0.808	0.399	-0.435	2.951**	1.750	-0.059	5.332***
MP-Bi	-2.133*	0.435	0.522	2.979**	-2.329*	-2.083*	4.210***
Ka-Ma	-2.841**	0.226	-1.765	-0.908	0.073	-1.299	0.442
Ka-Bi	-4.141***	0.322	-0.423	0.229	-3.006**	-3.095**	1.168
Ma-Bi	-2.416*	0.199	0.679	0.741	-3.023**	-2.205*	1.029

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 3. Incidence of nonmetric traits in mandibles of six Indian populations.

Traits	UP	AP	MP	Ka	Ma	Bi
	N=372	N=242	N=250	N=218	N=212	N=46
Mandibular torus	27	18	5	9	10	0
Genial tubercles	274	173	141	143	136	40
Accessory mental foramen	78	24	37	40	34	6
Mylohyoid bridge	38	58	34	38	38	6
Accessory mylohyoid foramen	129	79	98	91	78	14
Gonial eversions	202	126	90	94	106	22

All the fifteen comparisons of metric traits are statistically significant, whereas only nine out of fifteen comparisons for non-metric traits are significant. The last column in Table 5 gives the differences in χ^2 -values between the two trait categories. Though only two *t*-values are statistically significant, metric traits seem to exhibit a clear preference over the nonmetric traits.

Discussion

There is a continuing debate on the validity of employing nonmetric discrete skeletal traits instead of metric variables and vice versa. A number of authors have focussed their attention on this issue but the final resolution appears elusive. RIGHTMIRE (1972), GAHERTY (1974), CORRUCINI (1974) and

Table 4. Population differences (χ^2 -values) for each mandibular trait.

Traits/ Populations	Mandibular torus	Genial tubercles	Accessory mental foramen	Mylohyoid bridge	Accessory mylohyoid foramen	Gonial eversions
UP-AP	0.01	0.35	12.92***	21.02***	0.27	0.29
UP-MP	8.47**	20.05***	3.77	16.74***	1.32	20.11***
UP-Ka	2.35	4.31*	0.59	6.73**	2.98	6.87**
UP-Ma	1.47	5.83*	2.12	7.48**	0.26	1.00
UP-Bi	1.86	3.87*	1.60	0.35	0.33	0.69
AP-MP	8.16**	12.12***	2.70	8.69**	2.29	12.89***
AP-Ka	2.27	1.85	6.81**	2.97	4.07*	3.68
AP-Ma	1.45	2.80	3.80	2.47	0.86	0.35
AP-Bi	1.74	4.80*	0.40	2.67	0.09	0.28
MP-Ka	1.82	4.13*	1.07	1.32	0.31	2.47
MP-Ma	2.70	2.87	0.14	1.63	0.29	9.21**
MP-Bi	0.01	15.27***	0.10	0.01	1.27	2.31
Ka-Ma	0.09	0.10	0.40	0.02	1.10	2.05
Ka-Bi	0.40	8.15**	0.74	0.53	2.03	0.34
Ma-Bi	0.60	9.07**	0.26	0.64	0.67	0.07

* $p < .05$ ** $p < .01$ *** $p < .001$ **Table 5.** Statistical parameters of significance differences between populations for metric and nonmetric traits.

Traits/ Populations	Metric			Nonmetric			Metric vs. Nonmetric				
	χ^2	d. f.	p	χ^2	d. f.	p	<i>Weighed χ^2-values*</i>		<i>F-value</i>	p	
UP-AP	60.880	14	.001	35.496	12	.001	4.349	vs.	2.958	1.47	.50
UP-MP	55.019	14	.001	74.944	12	.001	3.930	vs.	6.245	0.63	—
UP-Ka	72.924	14	.001	35.691	12	.001	5.209	vs.	2.974	1.75	.25
UP-Ma	48.547	14	.001	28.300	12	.01	3.468	vs.	2.358	1.47	.50
UP-Bi	28.328	14	.02	16.795	12	.20	2.023	vs.	1.400	1.45	.50
AP-MP	83.283	14	.001	59.769	12	.001	5.949	vs.	4.981	1.19	.50
AP-Ka	60.632	14	.001	33.651	12	.001	4.331	vs.	2.804	1.54	.25
AP-Ma	53.742	14	.001	21.210	12	.05	3.839	vs.	1.768	2.17	.10
AP-Bi	38.249	14	.001	17.691	12	.20	2.732	vs.	1.474	1.85	.25
MP-Ka	73.114	14	.001	20.330	12	.10	5.222	vs.	1.694	3.08	.05
MP-Ma	46.282	14	.001	25.970	12	.02	3.306	vs.	2.164	1.53	.25
MP-Bi	60.742	14	.001	25.762	12	.02	4.339	vs.	2.147	2.02	.25
Ka-Ma	32.499	14	.01	9.153	12	.70	2.321	vs.	0.763	3.04	.05
Ka-Bi	56.212	14	.001	20.119	12	.10	4.015	vs.	1.677	2.39	.10
Ma-Bi	43.236	14	.001	17.996	12	.20	3.088	vs.	1.500	2.06	.25

* χ^2 values divided by d. f.

CARPENTER (1976), among others, have approached this problem by using the congruence of patterns of metrical and non-metrical cranial variation with geography and culture as a criterion. ROTHHAMMER *et al.* (1984) compared the chronologic non-metrical cranial character variation with metrical variables among the prehistoric Andean populations in order to study the microevolutionary dynamics of basically uncorrelated sets of biological characters. Although only a few correlations, derived from a pooled variance-covariance matrix of 23 craniometrical and nonmetrical traits, were significant the authors (ROTHHAMMER *et al.*) consider both sets of traits essentially independent exhibiting congruent patterns of chronologic variation. Furthermore, they note that the rate of change with time of both metric and nonmetric variables is relatively constant and notably similar. While examining the anatomical association between metrical and nonmetrical traits, CORRUCINI (1976) concluded that "a low but observable general influence" is exerted by one set of characters upon the other.

ROSENBERG *et al.* (1983) used fifteen metric traits and seven discrete traits to describe and discriminate the biological characteristics of the mandible of three indigenous populations in Israel and Sinai. Analyses of the three samples revealed small differences between metric and nonmetric traits. However, no significant statistical advantages of one over the other were found. This was interpreted to indicate that metric and non-metric traits were affected by the genetic process of isolation and by environmental factors to a similar degree.

In the present study, analyses of six non-tribal samples reveal that while metric traits exhibit a slightly better discriminating power

than nonmetric traits in differentiating various populations, both sets of traits show a similar pattern of differences between various population combinations considered. This receives corroboration from the fact that the metric χ^2 and nonmetric χ^2 values (Table 5) bear a significant association with each other ($r=0.54$, $p<0.05$; $df=13$). This can be interpreted to show that the two kinds of skeletal variants are not completely independent. In the opinion of CHEVERUD *et al.* (1979), both kinds share a moderate to high degree of developmental determination and there is no biological reason to favour either kind of trait for use in population studies. While statistically metric traits may be more tractable, and in matters of fragmented and small sample, nonmetric traits may be preferable, the authors feel that whenever possible both kinds of traits (i.e., metric and nonmetric) should be utilized simultaneously to derive maximum information in population studies.

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抄 録

下顎骨の計測値と非計測的形質による
インド人6集団間の差の比較

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インド人6集団の下顎骨について7項目の計測と6項目の非計測的形質の出現率調査をおこない、集団間の差を検定した結果、計測値の方が非計測的形質に比して差の検出力にややすぐれていることが明らかになったが、集団間の差のパターンには著しい差は認められ

なかった。集団研究において最大の情報を引き出すためには、可能なかぎり、計測と非計測的形質の両者を活用すべきであると考えられる。

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