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Glucose 6-phosphate Dehydrogenase Deficiency Among the Kolams of Adilabad, Andhra Pradesh

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ABSTRACT Kolam is a primitive tribal population inhabiting Adilabad district of Andhra Pradesh and practising a high degree of consanguinity. Data are presented here on the incidence of G6PD deficiency, generational variation and the effect of consanguinity on its distribution among them. The sample consisted of 454 individual out of which 226 were males and 228 were females. Overall frequency of Gd^- allele was 0.1151 in males and .0373 among the females. For the generational variation analysis 135 families were included. In the female population of the offspring generation the G6PD deficiency in both homozygous and heterozygous conditions seemed to be higher than that of their mothers in the parental generation.

INTRODUCTION

Not nearly as plentiful as haemoglobin, the red cell enzymes are relatively simple to detect, and because they are many, they give much information about a person's genotype and a population's gene frequency. Of the notable red cell enzymes, probably the one that most interests physical anthropologists is glucose-6- phosphate dehydrogenase; the deficiency of which causes complications in fava beans-eating individuals and in those taking certain kinds of antimalarial drugs. Presently, polymorphism of glucose 6-phosphate dehydrogenase deficiency is studied among the Kolams. High percentage of consanguinity practised in this population, might have its own telling effect on this genetic locus, and may even lead to drastic changes in gene frequencies from one generation to the other. Thus the present genetic study deals with:

1. Incidence of G6PD deficiency among the Kolams of Adilabad, district of Andhra Pradesh.
2. Generational variation, among the Kolams with respect to incidence G6PD deficiency if any.
3. Effect of consanguinity on the distribution of G6PD deficiency.

MATERIALS AND METHODS

Collection of Blood Samples: One day before going to the field the sterile sample collecting tubes were rinsed with the anticoagulant, EDTA solution of 0.5% concentration. In the field 2 to 3 drops of blood were collected in the sample collecting tubes by pricking the middle finger of the individual using a disposable sterilized needle. All the details regarding the name, sex, and age of that particular individual were noted down in a register. The properly labeled blood samples were placed in the icebox and transported to the field laboratory at Utnoor and analysed for G6PD deficiency using Buetler's fluorescent technique (Beutler and Mitchel, 1968).

Samples for Screening: A total of 620 blood samples were collected from both related and the unrelated individuals. These samples were randomized systematically avoiding the closely blood related individuals to get a random sample (454) which could be used as the representative sample of the Kolam population.

Sample for Generational Variation: Later the blood samples were categorized into parental and the offspring generations. For this 135 families were selected and 3 samples from each family were chosen, which included that of wife, husband and their first child; thus the total sample size of parental generation came to be 270 and that of the offspring generation was 135. These 270 blood samples of parental generation

included 135 males (husbands), 135 females (wives) of the ages between 15 to 45 years. 135 blood samples of the offspring generation consisted of children of both sexes below the age of 15 years.

Samples to Study the Effect of Consanguinity on the Distribution of G6PD Deficiency: For this 154 blood samples of offspring below the age of 15 years were selected .As the mating pattern of parents of these children was definitely known, they were categorized in to two groups i.e. consanguineous and no consanguineous, with the respective sample sizes of 89 and 65.

RESULTS AND DISCUSSION

Table 1 shows the gene frequency of Gd^- allele in both males and females of Kolam tribe. The frequency of Gd^+ (normal or p) gene in Kolam males is found to be 0 .8849 and the frequency of Gd^- (deficient or q) gene is found to be 0.1151. In the females frequencies of normal (p) and deficient (q) genes are found to be 0.9627 and 0 .0373, respectively. These frequencies in females were calculated by the gene counting method (Bhasin et al., 1994). From the table it is evident that the gene frequency of Gd^- allele in males is quite high compared to that of the females.

Table 2 shows the distribution of G6PD deficiency among the different tribes of Andhra Pradesh. Though Andhra Pradesh has a number of different tribal populations, including 12 primitive tribal groups, only the above-mentioned tribes have been screened for this trait. In all the cases only males were included in the study except for the tribe Thoti and the present study (Elizabeth et al., 1999). Bhasin and Walter (1998) in a comprehensive zone wise evaluation of G6PD deficiency in India, have thus summarized the position, "the frequency is comparatively higher in North and West India zones, which indicates a considerable stability of this allele in these areas, where as in South India except in Andhra Pradesh and Tamil Nadu and from East India the studies are too few to evaluate." The Andhra tribals show a range of zero percent in Pradhans of Adilabad to 5.9 per cent in Thoti of Adilabad (Elizabeth et al., 1999). The percentage of G6PD deficiency among the Kolams of the present study is the highest among all the tribes studied so far. This may be attributed to high consanguinity reported in this population (Chakravorty, 1968; Pingle, 1975 and Saraswathy et al., 1999) due to which the non lethal genes like G6PD would tend to increase, as they are not lost from the population in neither homozygous nor heterozygous condition.

Table 1: Distribution of Gd- allele frequency among the Kolams

Sex	*No*	*Phenotypic Frequencies*						*Allele Frequencies*	
		Gd (N)		*Gd (I)*		*Gd (D)*		Gd^+	Gd^-
		N	*%*	*N*	*%*	*N*	*%*	-	-
Male	226	200	88.5	-	-	26	11.5	0.8849	.1151
Female	228	214	93.86	11	4.82	03	1.32	0.9627	.0373

N - Normal, I-Partially deficient, D-Deficient

Table 2: Distribution of G6PD deficient gene among the tribes of Andhra Pradesh

S.No	*Population*	*Area*	*No*	*Phenotypic Frequencies*		*Genotypic Frequencies*		*Reference*
				Gd (N)	*Gd (D)*	*Gd (N)*	*Gd (D)*	
			M			*[p]*	*[q]*	
1	Koya Dora	Thailavaram	131	130	1	99.2	8	Meera Khan, 1964.
2	Koya Dora	Adilabad	365	352	13	96.44	3.56	Rao and Goud, 1979
3	Raj Gond	,,	197	192	5	97.46	2.54	Rao and Goud, 1979
4	Naikpod	,,	86	85	1	98.84	1.16	Rao and Goud, 1979
5	Pradhans	,,	101	101	—	100	000	Rao and Goud, 1979
6	Lambadi	Warangal	154	152	2	98.71	1.29	Rao and Goud, 1979
7	Thoti	Adilabad	188	177	11	94.15	5.85	Elizabeth et al., 1999
8	Kolams	,,	226	200	26	88.49		Present study

Out of the 73 primitive tribal groups identified in India, other than the present one, only 6 have been screened for G6PD deficiency (Table 3). It is interesting to note that all the primitive tribal populations studied so for, except the Todas in whom the enzyme deficiency is absent, the deficiency is present with very high frequency. One of the reasons for this high frequency among the primitive tribal groups could be their small size and isolation leading to high consanguinity. Thus the Kolams of the present study, being a primitive tribe with high consanguinity are expected to have a high frequency of G6PD deficiency in males and females, which indeed is the case (11.51% in males and 73% in females).

Generational Variation

In the parental generation, a total of 270 individuals were screened for G6PD deficiency, of which 135 were males and 135 were females. In the offspring generation 135 children of the same couples were screened. In the parental generation, 14.81% of males and .74% of females were found to be completely deficient and 6.7% of females were partially deficient for G6PD. Where as in the offspring generation all the 80 male children tested were normals (100%), and among the female children, 3.64% were completely deficient, 9.09% were partially deficient and .87.27% were normal. As the sons get the *Gd* allele from the mothers, and since the phenotypic frequency of Gd^- allele in the mothers is very low, the absence of the same is expected or justified in the males of the offspring generation. In the female population of the offspring generation the G6PD deficiency in both homozygous and heterozygous conditions seemed to be higher than that of their mothers in the parental generation. Since the percentage of Gd^- allele in the fathers of parental generation was observed to be higher, and as the daughter of every affected father is expected to have a Gd^- allele, this observed higher frequency of Gd^- phenotype in females of offspring generation is expected.

The χ^2 values of 14.69 and 5.57, respectively for 1 degree of freedom at 5% probability reveal a significant difference between the males and the females with respect to the distribution

Table 3: Distribution of G6PD deficiency among the different Primitive Tribes of India

S. No.	*Sate*	*Population*	*Sex*	*Total No.*	*Allele Frequencies*		*Reference*
					p	*q*	
1	Andhra Pradesh	Thoti	Male	188	94.1	05.90	Elizabeth, 1999
			Female	209	99.0	01.00	
2		Kolam	Male	226	88.49	11.51	Present study
			Female	228	98.69	01.31	
3	Maharashtra	Katkari	Male	296	89.5	10.5	Kate et al., 1978
		Ketkari	Female	77	92.2	7.8	
4	Rajasthan	Saharia	Male	50	78.0	22.0	Jain et al., 1984
5	Tamil Nadu	Irula	Male	89	91.0	9.0	Saha et al., 1976
			Female	81	95.1	4.9	
6		Kurumba	Male	16	87.5	12.5	Saha et al., 1976
			Female	23	92.3	7.7	Saha et al., 1976
7		Toda	Male	48	100.00	0.0	Saha et al., 1976
			Female	50	100.00	0.0	Saha et al., 1976

Table 4: Distribution of G6PD deficient gene among the parental and offspring generations among the Kolams

Pop	*Sex*	*No.*	*Phenotypic Frequencies*						χ^2	*Df*	*P*	*Frequencies*	
			Gd –(D)		*Gd +(N)*		*Gd – (I)*					Gd^+	Gd^-
			N	*%*	*N*	*%*	*N*	*%*				*p*	*q*
P	M	135	20	14.81	115	85.19	-	-	14.69	1	P>.001	.8519	.1481
	F	135	1	0.74	125	92.59	9	6.67	-	-	-	.9593	.0407
O	M	80	-	00	80	1	-		5.57	1	p>.02	1.00	0.00
	F	55	2	3.64	48	87.27	5	9.09	-	-	-	.9182	.0818

P- Parental, O- Offspring, D- Deficient, N – Normal, I – Intermediate.

of Gd phenotypes in both the parental and the offspring generations, respectively. The percentile frequency or the gene frequency of Gd^- allele among the males of parental generation is found to be 0.1481, where as in the males of offspring generation, it is found to be 0.0. On the contrary in the females of offspring generation a higher frequency of Gd^- allele (0.0818) is found, compared to that of the parental generation (0.0407). Gd^- allele frequency in males of parental generation is higher and so is the case with their daughters [females of offspring generation], which is quite as expected since the *Gd* allele is a sex linked one.

As already mentioned G6PD allele is an X linked one, its frequency varies in males and females from one generation to the other. This is because; the genes from males of the parental generation do not pass on to the males in the offspring generation. On the contrary, every daughter of the affected father inherits this gene. Regarding the female population, every son and daughter of the affected female carries this gene, while there is a 50% chance for females and males in the offspring generation to get this gene from their carrier mothers. Thus to see the difference between the two generations with respect to G6PD deficiency χ^2 was applied between the parents (Father and mother of the parental generation) and their daughters, as the daughter gets the gene from both the parents and also between the mothers (females of parental generation) and their sons, as the sons have 100% chance to get the gene from their deficient mothers and 50% chance to get it from their carrier mothers. Low χ^2 values in both the cases reveal a non-significant difference between the two generations with respect to G6PD deficiency.

Effect of Consanguinity on the Distribution of G6PD Deficiency: 58 and 35 male children of consanguineous and non-consanguineous matings respectively were screened for G6PD deficiency, of which all were found to be normal with respect to G6PD deficiency. In the case of female children of consanguineous matings, 6.45% were found to be completely deficient (homozygous condition) and 6.45% were partially deficient (heterozygous condition).Among the children of nonconsanguineous matings, only 3.33% female children were found to be partially deficient (heterozygous condition).Gd^- allele in homozygous condition is found to be absent even among the females of nonconsanguineous matings As the Gd^- allele is not lethal under normal conditions, in both heterozygous and homozygous conditions its frequency seems to increase in the children of consanguineous matings. Thus a higher frequency of Gd^- allele (.0967) is observed in the children of consanguineous matings than those of the non-consanguineous matings (.0166). The gene frequencies mentioned in the table 6 were calculated for the total samples in each group instead of treating the two sexes separately, as the sample size in

Table 5: Generational variation among the Kolams with respect to the distribution of G6PD deficiency

Population	*Sex*	*Total No.*	*GD(D)*	*GD(N)*	*GD(I)*	χ^2	*Probability*	*Df*
Parental [Mother+ Father]	Male+Female	270	21	240	9	0.035	.90> p>.80	
Offspring [Daughter]	Female	55	2	48	5			
Parental [Mothers]	Female	135	1	125	9	2.314	.20>p>.10	1
Offspring (sons)	Male	80	0	80	-			

Table 6: The distribution of phenotypic and genotype frequencies of G6PD deficiencies among the children of consanguineous and non-consanguineous marriages in the Kolams

TM	*Sex*	*No.*	*Phenotypic frequencies*						*Gene frequencies*	
			Gd-(D)		*Gd+(N)*		*Gd-(I)*		Gd^+	Gd^-
			N	%	*N*	%	*N*	%	*p*	*q*
C	Male	58	0	0	58	100			0.9033	0.0967
	Female	31	2	6.45	27	87.10	2	6.45		
NC	Male	35	0	0	35	100	—	—	0.9834	0.0166
	Female	30	0	0	29	96.67	1	3.33		

C – Consanguineous, NC- Non consanguineous, D - Deficient, N - Normal, I- Intermediate, TM – Type of Marriage

Table 7: χ^2 comparison between the male and the female children respectively of consanguineous and non-consanguineous matings with respect to G6PD deficiency

TM	*Sex*	*No*	*Gd- (D)*	*Gd+(N)*	*Gd-(I)*	χ^2	*Df*	*p*
C	Male	58	0	58	—	0.059	1	.8>p>.7
NC	Male	35	0	35	—			
C	Female	31	2	27	2	5.911	2	.1>p>.05
NC	Female	30	0	29	1			

C – Consanguineous, NC – Non consanguineous, D- Deficient, N - Normal, I – Partially deficient, TM - Type of Marriage

each group was very small.

Statistically no significant difference was observed between the males of consanguineous and non consanguineous matings. Same was the case with the females of consanguineous and non consanguineous matings.

CONCLUSION

Relatively a higher percentage of G6PD deficiency is observed among the Kolams. Though the difference between the parental and offspring generations was statistically non-significant, there definitely was an increase in the incidence of G6PD deficiency in the offspring generation, which needs attention. Regarding the effect of consanguinity on the incidence of this genetic trait, it is difficult to comment, as the sample size is too small in both groups.

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