

STUDY OF RED CELL ENZYME SYSTEMS IN TEHRAN AND ISFAHAN IRANIANS

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Summary Blood samples from Tehran and Isfahan were examined for seven red cell enzyme systems. Polymorphic variations were present for acid phosphatase, phosphoglucomutase locus I, adenylate kinase, 6-phosphogluconate dehydrogenase and phosphohexose isomerase loci controlling red cell enzyme systems. Statistical analysis demonstrated no significant variation between the two Iranian samples. Gene frequencies were compared with the distribution pattern known in other Iranian populations. The lactate dehydrogenase and Malate dehydrogenase systems were monomorphic.

INTRODUCTION

Few published observations are available on the red cell enzymes of the inhabitants of Iran. Bowman and Ronaghy (1967) first studied the distribution of some enzymes in the Moslems of Iran. Subsequently others looked at some other populations in Iran (Undevia *et al.*, 1972; Farhud *et al.*, 1973; Lehman *et al.*, 1973; Miyashita *et al.*, 1975; Kirk *et al.*, 1977). Still our knowledge about the distribution of polymorphic systems in Iran is limited. Thus the present survey has been conducted to enlarge our knowledge of the red cell enzyme groups in Iran.

MATERIALS AND METHODS

Blood samples were obtained from two cities of Iran, *i.e.* Tehran in the North and Isfahan in the Centre. All the individuals belonged to the cities and were healthy and unrelated. Blood samples from Tehran, mainly obtained from blood donors, were provided by the Helale Ahmar Blood Transfusion Service. From Isfahan, the samples were collected by authorities of the Clinical Biochemistry Department, Univ. of Isfahan. Haemolysates were prepared by the carbon tetrachloride method of

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Ager and Lehman (1961). Phosphoglucosmutase (PGM), acid phosphatase (AP) and adenylate kinase (AK) were typed by the methods of Spencer *et al.* (1963), Hopkinson *et al.* (1963) and Fildes and Harris (1966), respectively. For dehydrogenase enzymes, one half of the gel was stained for 6-PGD and G-6PD by the method of Fildes and Parr (1963) and the other half was stained for lactate dehydrogenase (LDH) and malate dehydrogenase (MDH) as described by Kirk *et al.* (1971). Phosphohexose isomerase (PHI) was performed by the method of Detter *et al.* (1968).

RESULTS AND DISCUSSION

The results on the red cell enzyme variants are given in Tables 1 and 2. Gene frequencies were calculated by the gene counting method. Appropriate χ^2 analysis, assuming Hardy Weinberg equilibrium, revealed no significant departure from expectation for any of the system. No major difference was found between the two samples.

a. Acid phosphatase (AP)

Table 3 shows that P^b is the most common of the three major alleles in each Iranian sample investigated. Its frequency ranges from 0.6429 in the Kurds of Marivan and Baneh (Lehman *et al.*, 1973) to 0.7500 in the Zoroastrian Iranis of Bombay (Undevia *et al.*, 1972). A lower range of values (0.2292 to 0.4043) characterizes the P^a allele. The present values of P^a (0.3193) and P^b (0.6618) are within the range of variation. The P^c gene is present in all the Iranian populations tested so far, the highest frequency being 0.030.

b. Phosphoglucosmutase locus I (PGM_1)

In general, the PGM_1 frequencies of the Iranians show marked similarities to Middle East and European values. The frequencies of PGM_1^2 in the Iranian populations lie between the limits of 0.2208 and 0.3480. The frequencies of PGM_1 alleles are consistent with the distribution pattern known in other Iranian populations (see Table 3). Besides the common three phenotypes, some variant type PGM 6-1, was present in the Isfahan Iranians. Similar type of variant was found in the Caspian littoral area (Kirk *et al.*, 1977).

c. Adenylate Kinase (AK)

As can be seen from the Table 3, very few observations for the AK system on Iranians have been reported so far. Bowman and Ronaghy (1967) found a frequency of 0.0497 for AK^2 allele in Iranian Moslems and Undevia *et al.* (1972) give a value of 0.0670 among the Parsis living in Bombay. These values are similar to those found in the present investigation for the Iranians (0.0498). In European populations, the frequencies of the AK^2 gene lie between the limits of 0.015 and 0.056 (Bhasin and Fuhrmann, 1972). Reported values in the Middle East range from

Table 1. The distribution of red cell enzyme groups in Tehran and Isfahan Iranians.

System	Tehran Iranians		Isfahan Iranians		Total		
	No.	%	No.	%	No.	%	
Acid phosphatase							
AP	A	21	13.04	6	7.79	27	11.34
	AB	68	42.24	30	38.96	98	41.18
	B	65	40.37	39	50.65	104	43.70
	BC	7	4.35	2	2.60	9	3.78
Total	161	100.00	77	100.00	238	100.00	
Phosphoglucomutase locus I							
PGM	1-1	101	61.21	50	58.14	151	60.16
	2-1	50	30.30	28	32.56	78	31.07
	2-2	14	8.48	7	8.14	31	8.37
	6-1	—	—	1	1.16	1	0.40
Total	165	99.99	86	100.00	251	100.00	
Adenylate kinase							
AK	1-1	150	89.29	76	91.57	226	90.29
	2-1	18	10.71	7	8.43	25	9.46
	2-2	—	—	—	—	—	0.25
Total	168	100.00	83	100.00	251	100.00	
6-Phosphogluconate dehydrogenase							
6-PGD	A	157	95.15	84	94.38	241	94.88
	Ca	8	4.85	5	5.62	13	5.12
	C	—	—	—	—	—	—
Total	165	100.00	89	100.00	254	100.00	
Phosphohexose isomerase							
PHI	1-1	163	98.79	89 ^a	100.00	—	—
	3-1	2	1.21	—	—	—	—
	3-3	—	—	—	—	—	—
Total	165	100.00	89	100.00	—	—	
Lactate dehydrogenase ^b							
LDH		165		89			
Malate dehydrogenase ^c							
MDH		165		89			

^a All 89 Isfahan Iranians tested for PHI showed the type 1-1. ^b All LDH samples were normal.

^c All MDH samples exhibited type 1-1.

Table 2. Gene frequencies for red cell enzyme groups in Tehran and Isfahan Iranians.

System		Tehran Iranians	Isfahan Iranians	Total
Acid phosphatase				
AP	p^a	0.3416	0.2727	0.3193
	p^b	0.6367	0.7143	0.6618
	p^c	0.0217	0.0130	0.0189
Phosphoglucomutase				
PGM	PGM_1^1	0.7636	0.7500	0.7590
	PGM_1^2	0.2364	0.2442	0.2390
	PGM_1^6	—	0.0058	0.0020
Adenylate kinase				
AK	AK^1	0.9464	0.9578	0.9502
	AK^2	0.0536	0.0422	0.0498
6-Phosphogluconate dehydrogenase				
6-PGD	$PGDA$	0.9758	0.9719	0.9744
	$PGDC$	0.0242	0.0281	0.0256
Phosphohexose isomerase				
PHI	PHI^1	0.9939	—	—
	PHI^3	0.0061	—	—

0.0252 to 0.0687 (Tills *et al.*, 1971a). The present value of 0.0498 falls within this range and demonstrates a similarity between different populations of the Middle East and Europe.

d. 6-Phosphogluconate dehydrogenase (6-PGD)

As for the AK system, observations for 6-PGD in Iranians are very limited. Farhud *et al.* (1973) gave a value of 0.0153 for the $PGDC$ allele in Iranians and Bowman and Ronaghy (1967) found a value of 0.0280 in Iranian Moslems. The $PGDC$ frequency of 0.0256 in this survey is comparable with the earlier samples. Further comparison with the Kurdish series of Lehman *et al.* (1973) shows that the Kurds of Marivan and Baneh have the highest frequency of $PGDC$ (0.0714) in Iran. The value of $PGDC$ shown for the Iranians in Tables 3 are within the range for Europeans. However, it is lower than for some Middle Eastern populations (Tills *et al.*, 1971b).

e. Phosphohexose isomerase (PHI)

Variants of PHI have been reported to be absent in Iranians (Farhud *et al.*, 1973). In this survey, however, two Iranians from Tehran exhibited the 3-1 phenotype. Detter *et al.* (1968) found that the Asiatic populations exhibit an appreciable frequency of the allele PHI_1^3 and the present survey confirms this tendency.

Table 3. Gene frequencies in selected populations of Iran.

Sample	No. Tested		AP		No. Tested		PGM		No. Tested		AK		No. Tested		6-PGD		Author(s)
	p^a	p^b	p^c		PGM_{11}	PGM_{12}	PGM_{16}		AK_1	AK_2	$PGDA$	$PGDc$					
Tehran & Isfahan Iranians	238	.3183	.6618	.0189	251	.7590	.2390	.0020	251	.9502	.0498	254	.9744	.0256	Present study		
Moslems	—	—	—	—	—	—	—	—	322	.9503	.0497	322	.9720	.0280	Bowman and Ronaghy (1967)		
Iranians	449	.304	.668	.030	—	—	—	—	—	—	—	—	—	—	Walter and Bajatzadeh (1968)		
Iranians (Bombay)	48	.2292	.7000	.0208	46	.7065	.2935	—	48	.9792	.0208	48	.9847	.0153	Undevia <i>et al.</i> (1972)		
Parsis (Bombay)	418	.4043	.5959	—	401	.7369	.2631	—	418	.9330	.0670	418	.9847	.0153	Undevia <i>et al.</i> (1972)		
Iranians	—	—	—	—	127	.6850	.3150	—	—	—	—	132	.9847	.0153	Farhud <i>et al.</i> (1973)		
Kurds	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
a. Marivan & Baneh	77	.3441	.6429	.0130	77	.7792	.2208	—	77	.9416	.0584	77	.9286	.0714	Lehman <i>et al.</i> (1973)		
b. Sanandaj & Bija	105	.3190	.6667	.0143	105	.6857	.3143	—	105	.9238	.0762	105	.9715	.0285	Lehman <i>et al.</i> (1973)		
Iranians (Caspian area)	—	—	—	—	1,016	.6235	.3765	—	—	—	—	—	—	—	Miyashita <i>et al.</i> (1975)		
Iranians (Caspian area)	470	.353	.636	.011	463	.649	.350	.003	463	.945	.055	470	.976	.026	Kirk <i>et al.</i> (1977)		

f. *Lactate dehydrogenase (LDH)*

Genetic variants of LDH are rare, only one case of LDH Cal-1 has been reported in the Iranians of Caspian area (Kirk *et al.*, 1977). In the present series a total of 254 samples examined yielded only normal pattern.

g. *Malate dehydrogenase (MDH)*

A single case of s-MDH 5-1 have been found in the Caspian (Kirk *et al.*, 1977). However, all of the samples in the present series showed the normal type.

REFERENCES

- Ager, J.A.M., and Lehman, H. 1961. Laboratory detection of abnormal haemoglobins. *Ass. Clin. Path. Broadsheet*. 33.
- Bhasin, M.K., and Fuhrmann, W. 1972. Geographic and ethnic distribution of some red cell enzymes. *Humangenetik* **14**: 204-223.
- Bowman, J., and E. Ronaghy, H. 1967. Haemoglobin, glucose-6-phosphate dehydrogenase and adenylate kinase polymorphism in Moslems in Iron. *Am. J. Phys. Anthropol.* **27**: 119-123.
- Detter, J.C., Ways, P.O., Giblett, E.R., Baugham, M.A., Hopkinson, D.A., Poey, S., and Harris, H. 1968. Inherited variations in human phosphohexose isomerase. *Ann. Hum. Genet.* **31**: 329-338.
- Farhud, D.D., Ananthkrishnan, R., Walter, H., and Loser, J. 1973. Electrophoretic investigations of some red cell enzymes in Iran. *Hum. Hered.* **23**: 263-266.
- Fildes, R., and Parr, C.W. 1963. Human red cell phosphogluconate dehydrogenase. *Nature* **200**: 890-891.
- Fildes, R.A., and Harris, H. 1966. Genetically determined variation of adenylate kinase in man. *Nature* **209**: 261-263.
- Hopkinson, D.A., Spencer, N., and Harris, H. 1963. Red cell acid phosphatase variants: a new human polymorphism. *Nature* **199**: 969-971.
- Kirk, R.L., Blake, N.M., Moodie, P.M., and Tibbs, G.J. 1971. Population genetic studies in Australian aborigines of the Northern Territory. *Hum. Biol. Oceania*. **1**: 54-76.
- Kirk, R.L., Keats, Bronya, Blake, N.M., McDermid, E.M., Ala, F., Karimi, M., Nickbin, B., Shabazi, H., and Kmet, J. 1977. Genes and people in the Caspian littoral: A population genetic study in Northern Iran. *Am. J. Phys. Anthropol.* **46**: 377-390.
- Lehman, H., Ala, F., Hedeyat, S., Montazemi, K., Nejad, H.K., Lightman, S., Kopec, A.C., Mourant, A.E., Teasdale, P., and Tills, D. 1973. The hereditary blood factors of the Kurds of Iran. *Phil. Trans. R. Soc. Lond.* **266**: 195-205.
- Miyashita, T., Ohkura, K., Matsumoto, H., and Matsumoto, K. 1975. Distribution of polymorphic traits in Iran. *Jpn. J. Hum. Genet.* **20**: 55.
- Tills, D., Vanden Braden, J.L., Clements, V.R., and Mourant, A.E. 1971a. The world distribution of electrophoretic variants of red cell adenylate kinase. *Hum. Hered.* **21**: 302-304.
- Tills, D., Vanden Braden, J.L., Clements, V.R., and Mourant, A.E. 1971b. The distribution in man of genetic variants of 6-phosphogluconate dehydrogenase. *Hum. Hered.* **21**: 305-308.
- Undevia, J.V., Blake, N.M., Kirk, R.L., and McDermid, E.M. 1972. The distribution of some enzyme group systems among Parsis and Iranis in Bombay. *Hum. Hered.* **22**: 274-282.
- Walter, H., and Bajatzadeh, M. 1968. Studies on the distribution of the human red cell acid phosphatase in Iranians and other populations. *Acta Genet.* **18**: 421-428.