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Full Length Research Paper

Gene frequencies of ABO and rhesus blood groups and haemoglobin variants in Ogbomoso, South–West Nigeria

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The distribution and gene frequencies of ABO and rhesus (Rh) blood groups and haemoglobin variants for samples of the Nigerian population at Ogbomoso was determined. Data consisting of records of blood groups and haemoglobin types of different ages ranging from infants to adults for a period of 4 to 6 years (1995 – 2000) was collected from Baptist Medical Centre (BMC), Ladoke Akintola University of Technology Health Centre (LAUTHC) and Oyo State General Hospital (OSGH), all in Ogbomoso, Oyo State, Nigeria. Overall, a total number of 7653, 7053 and 14,845 individuals were typed for ABO and Rh blood groups, and haemoglobin genotypes, respectively. 3824 (50%) were blood group O, 1750 (22.9%) were blood group A, 1629 (21.3%) were blood group B and 450 (5.9%) were blood group AB. This distribution differs significantly (P<0.05) from those expected under the Hardy Weinberg law. The proportion of the individuals belonging to the various ABO blood groups also varied significantly (P<0.05) over the period of the study. Overall gene frequencies for the A, B and O alleles were 0.15, 0.15 and 0.70, respectively. For the Rh blood group 6823 (96.7%) were Rh-positive (DD and Dd) while 230 (3.3%) were Rh – negative (dd). The distribution and proportion of individuals belonging to each group did not differ significantly from those expected under the Hardy Weinberg law (P>0.05). The gene frequencies of D and d alleles were 0.82 and 0.18, respectively. Six haemoglobin genotypes were recorded in the order of AA (68.1%) > AS (21.0%) > AC (5.7%) >SS (3.0%) >SC (2.0%) >CC (0.3%). The gene frequencies were 0.81, 0.14 and 0.04 for A, S and C alleles, respectively. Our results are representative of the distribution of these genetic variants in Nigeria.

Key words: Gene frequency, blood groups, haemoglobin, Nigeria.

INTRODUCTION

The most famous blood groups are those of ABO and Rhesus (Rh) series. Both are routinely typed for in any blood bank or blood transfusion service. The Rh blood groups rank with ABO groups in clinical importance because of their relation to haemolytic disease of the newborn (HDN) and their importance in blood transfusion. The Rh is genetically complex but it is simply described in terms of a single pair of alleles, D and d. Rhesus positive (Rh+ve) persons are DD and Dd, and Rhesus negative (Rh-ve) are dd. The first discovery that the frequencies of the blood groups differed from one population to another was made in the early 20th century. Subsequent results from practically all countries of the world have corroborated this, and have also shown that frequency figures are valid only for the specific population from which they are derived (Mourant et al., 1976).

The haemoglobin variants on the other hand, constitute the most thoroughly studied and most completely

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Table 1. Phenotypic distribution of ABO and Rh blood group systems for the years 1995 – 2000 in Ogbomoso, Nigeria.

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Study sites/yr	ABO system					Rh system			
	O	A	B	AB	Total	Sex	Rh+ve	Rh-ve	Total
Baptist Medical Centre (1995-2000)	1604 (46.3)	818 (23.6)	857 (24.7)	187 (5.4)	3466	Male	463 (17)	40 (28)	503 (17.5)
						Female	2265 (83.0)	103 (72.0)	2368 (82.5)
						Total	2728 (95)	143 (5.0)	2871
Ladoke Akintol Univ. of Tech. Health centre (1997-2000)	1815 (53.3)	742 (21.8)	612 (18.0)	235 (6.9)	3404	Male	2449 (72.9)	31 (70.5)	2480 (72.9)
						Female	911 (27.1)	13 (29.5)	924 (27.1)
						Total	3360 (98.7)	44 (1.3)	3404
Oyo State General Hospital (1995-2000)	405 (51.8)	190 (24.3)	160 (20.4)	28 (3.6)	783	Male	352 (47.9)	21 (48.8)	373 (47.9)
						Female	383 (52.1)	22 (51.2)	405 (52.1)
						Total	735 (94.5)	43 (5.5)	778
Gross Total	3824 (50.0)	1750 (22.9)	1629 (21.3)	450 (5.9)	7653		6823 (96.7)	230 (3.3)	7053

Values in parentheses represent percentages of occurrence

Heterogeneity tests

ABO groups: $X^2 = 66.47$, df = 2, $P<0.05$

understood of all human genetic polymorphisms. The great majority of people everywhere have one major type of haemoglobin; the normal adult haemoglobin or HbA. About 400 different abnormal types are known, two thirds of which have an abnormal B (beta)- chain type. Most of the abnormal types are extremely rare. In West Africa, only four of them (HbS, C, K, Woolwich, and D (Queled O–Rabah) are sufficiently frequent to be of clinical or anthropological interest. The first two haemoglobin and the thalassemia are relatively common. Only HbS however, has a clinical importance due to the sickling phenomenon (Winter, 1987).

In West Africa, reports have been provided to show the distribution pattern of ABO and Rh blood groups and haemoglobin variants in a few countries including Nigeria. However, most of these studies only reported the observed phenotypes; but not the genotypic and allelic frequencies, and their occurrences among certain age range persons (Muller, 1927; Chalmers et al., 1952; Garlick and Barnicot, 1957; Yankah, 1965; Coker, 1976; Ahmed et al., 1993). However, gene frequencies among random population of people will give more accurate distribution pattern among the persons.

There has been no known data of the distribution pattern and frequency of ABO and Rh blood group and haemoglobin variants from Ogbomoso. This study aims at providing information on the distribution pattern of the phenotypes and genotypes, and the gene frequencies of these genetic variants in Ogbomoso; with a view to contributing to existing knowledge on the subject matter.

MATERIALS AND METHODS

Data were collected from 3 different hospitals in Ogbomoso (8°N and 4° 3′E). These are Ladoke Akintola University of Technology Health Centre (LAUTHC), Oyo State General Hospital (OSGH) and Baptist Medical Center (BMC). Records for different ages ranging from infants to adults for 6 consecutive years, 1995 – 2000, were collected. At LAUTHC, we were deeply involved (with the assistance of the Chief Technologist) in blood typing of a few number of patients in 1999/2000. For each test, a drop of blood from a sterilized finger was used.

ABO and Rh blood group tests were carried out on a white porcelain tile and or microslide using blood grouping sera (Lome Laboratories Ltd., UK.; BIOTEC Laboratories Ltd., UK.). The haemoglobin type was determined using Hb – electrophoresis. The genotypic and allelic frequencies were computed based on Hardy-Weinberg formulations. Heterogeneity tests between years were calculated using the chi-square test (The Open University, 1983). Goodness-of-fit statistics were calculated for the figures observed compared to values expected using the Hardy-Weinberg equilibrum (Russell, 1998).

RESULTS

The different types and distribution of ABO and Rh blood group system recorded in the 3 hospitals in Ogbomoso, from 1995 to 2000 are shown in Table 1. Overall, a total number of 7653 and 7053 individuals were typed for ABO and Rh blood groups, respectively.

The data from the 3 hospitals combined shows that 22.9% were blood group A, 21.3% were blood group B,

Table 2. Gene frequencies of ABO and Rh blood group alleles for the years 1995 – 2000 in Ogbomoso, Nigeria.

Study sites/yr	Gene (allele)	Frequency	Genotype	Frequency	Phenotype	Frequency (%)
	O	0.68	OO	0.4624	O	46.3
	A	0.16	AA	0.0256	A	
			AO	0.2176	A	23.6
Baptist	B	0.16	BB	0.0256	B	
Medical			BO	0.2176	B	24.7
Centre (1995-2000)	-	-	AB	0.0512	AB	5.4
	D	0.78	DD	0.61	Rh(D)+ve	
			Dd	0.34	Rh(D)+ve	95
	D	0.22	dd	0.05	Rh(d)-ve	5.0
	O	0.73	OO	0.5329	O	53.3
Ladoke	A	0.14	AA	0.0196	A	
Akintola Univ.			AO	0.2044	A	21.8
of Tech.	B	0.13	BB	0.0169	B	
Health centre			BO	0.1898	B	18.0
(1997-2000)	-	-	AB	0.0364	AB	6.9
	D	0.89	DD	0.79	Rh(D)+ve	
			Dd	0.20	Rh(D)+ve	98.7
	D	0.11	dd	0.12	Rh(d)-ve	1.3
	O	0.72	OO	0.5184	O	51.8
	A	0.15	AA	0.0225	A	
Oyo State			AO	0.216	A	24.3
General	B	0.13	BB	0.0169	B	
Hospital			BO	0.1872	B	20.4
(1995-2000)	-		AB	0.039	AB	3.6
	D	0.77	DD	0.59	Rh(D)+ve	
			Dd	0.35	Rh(D)+ve	94.5
	D	0.23	dd	0.05	Rh(d)-ve	5.5
	O	0.70	OO	0.49	O	50.0
	A	0.15	AA	0.0225	A	
			AO	0.21	A	22.9
	B	0.15	BB	0.0225	B	
Gross Total of			BO	0.21	B	21.3
the 3 sites	-	-	AB	0.045	AB	5.9
	D	0.82	DD	0.67	Rh(D)+ve	
			Dd	0.30	Rh(D)+ve	96.7
	D	0.18	dd	0.03	Rh(d)-ve	3.3

5.9% were blood group AB and 50.0% were blood group O (Table 1). The overall allelic frequencies were 0.70, 0.15 and 0.15 for O, A and B alleles, respectively. On the rehesus status, 96.7% were Rh +ve while 3.3% were Rh -ve. This gave the allelic frequencies as 0.82 and 0.18 for D and d alleles, respectively (Tables 1 and 2). The proportion of individuals belonging to the various ABO blood groups varied significantly over the period of the study (X^2=66.47, df=2, P<0.05); and the distribution also differed significantly from those expected under the Hardy Weinberg equilibrium {(Goodness-of-fit X^2= 47.25, df=3, P<0.05) Table 3}. However, the proportion (X^2= 0.91, df=1, P>0.05) and the distribution {(Goodness-of-fit X^2= 1.58, df=1, P>0.05) Table 3} of Rh blood group individuals is on the contrary.

Table 2 also presents the frequencies of the various genotypes in the ABO and Rh systems. In all, for example, the frequency of BB genotype was 0.0225 while that of BO genotype was 0.21. Thus, among those who are blood group B, 9.6% were homozygous BB

Table 3. Observed versus expected frequency of ABO and Rh blood groups among individuals sampled in Ogbomoso, Nigeria.

ABO System					Rh system				
Blood group	Obs. Number	Obs. Frequency (%)	Expect. Frequency (%)	Expect. Number	Blood group	Obs. Number	Obs. Frequency (%)	Expect. Frequency (%)	Expect. Number
O	3824	50.0	49.0	3750	Rh(D) +ve	6823	96.7	97.0	6841
A	1750	22.9	23.3	1779					
B	1629	21.3	23.3	1779	Rh(D) -ve	230	3.3	3.3	212
AB	450	5.9	4.50	344					
Total	7653	100.0	100.0	7652		7053	100.0	100.0	7053
Goodness-of-fit X^2 = 47.25, df = 3, P<0.05					Goodness-of-fit X^2 = 1.58, df = 1, P>0.05				

Obs.=Observed
Expect.=Expected
X^2=Chi - square

while about 90% were heterozygous BO. Similar deductions can be made for blood group A, and for Rh +ve among DD and Dd individuals. The frequencies of the genotypes for Rh blood group were 0.67 for DD, 0.30 for Dd and 0.03 for dd.

Table 4 presents the phenotypic distribution and gene frequencies of the haemoglobin types in the study sites from 1995 to 2000. Three different haemoglobin types were recorded. They are Hb A, C and S and they occurred in 6 genotypic combinations as AA, AS, AC, SC, SS and CC. The overall order of occurrence is AA (68.1%) > AS (21.0%) > AC (5.7%) > SS (3.0%) > SC (2.0%) > CC (0.3%). The gene frequencies were 0.81, 0.14 and 0.04 for A, S and C alleles, respectively.

DISCUSSION

In this study, the gene frequencies of ABO and Rh blood groups and haemoglobin variants of individuals typed in Ogbomoso were considered. Though the allelic frequencies of each blood group per year are similar, there was significant variation in the proportion of individuals belonging to the various ABO blood groups. This was due to distinct variation in the number of observed and expected individuals at LAUTHC (Table 3). And also due to fewer records obtained for all the blood groups at OSGH, which might be a function of poor record keeping in the hospital. Data from the 3 hospitals showed that there were more O blood group in this survey. The allelic frequency of O (0.70) was also higher than those of A (0.15) and B (0.15). This is due to the fact that many of the individuals who are of blood groups A and B may have been heterozygous, carrying one O gene together with an A or B gene. Bernstein (1924) reported that the genetics of the ABO blood group system were dependent on a set of three allelic genes I^A, I^B and I^O. I^A and I^B are co-dominant in blood group AB and both are dominant to I^O.

The observed values and frequency figures are similar to those previously reported by other workers in Nigeria (Odaibo et al., 1974; Onwukeme, 1990; Njoku et al., 1996; Omotade et al., 1999; Falusi et al., 2000). They independently reported ABO blood group frequencies in the order O > A ≥ B > AB. This is in concert with the fact that Nigerian populations are characterised by high frequencies of the O allele and an average of about 14% each of the A and B genes (Odeigah, 1990).

On the rhesus factor, the proportion of Rh -ve (3.3%) is far lower than for Rh +ve (96.7%) within the period of study. Overall, 97% (consisting of 67% of DD individuals and 30% of Dd individuals) were phenotypically Rh +ve while 3% were Rh -ve. This is in agreement with what is expected from the Hardy Weinberg equilibrum. Our results are in contrast to that of Salmon et al. (1988) and Njoku et al. (1996) who reported rhesus positive values of 100% for Eastern Highlands of Papua Guinea and Nigeria, respectively. It is also disimilar to that in Indians with a preponderance of the Rh(d) of 89.7% over the Rh(D) gene of 10.3% (Thangaraj et al., 1992). Our data are however, similar to findings among Africans, West Indians and Blacks living in Britain (Arneaud and Young, 1955; Yankah, 1965; Worlledge et al., 1968; Leck, 1969; Coker, 1976; Omotade et al., 1999; Falusi et al., 2000). It is also in concert with the fact that the frequency of Rh(d) is often low in parts of the world where malaria is endemic (Emery, 1979; Falusi et al., 2000).

Table 4. Phenotypic distribution and gene frequencies of haemoglobin variants for the years 1995 – 2000 in Ogbomoso, Nigeria.

Study sites/yr	Sex	Haemoglobin type						Total
		AA	AS	AC	SC	SS	CC	
Baptist Medical Centre (1995-2000)	Male	2600 (63.7)	538 (51.5)	263 (54.7)	124 (51.5)	290 (78.2)	14 (53.9) 12 (46.2)	3829 (61.3)
	Female	1479 (36.3)	507 (48.5)	218 (45.3)	117 (48.5)	81 (21.8)	(0.4)	2414 (38.7)
	Total	4079 (65.0)	1045 (16.7)	481 (7.7) 0.08	241 (3.9) 0.04	371 (5.9)	0.004	6243
	Genotypic frequency	0.65	0.17			0.06		
Allelic frequencies: f(A) = 0.78, f(S) = 0.16, f(C) = 0.062								
Ladoke Akintola Univ. of Tech. Health centre (1997-2000)	Male	3831 (72.1)	1413 (76.6)	265 (77.7)	31 (75.6) 10 (24.4)	12 (54.5)	05 (55.6) 04 (44.4)	5557 (73.4)
	Female	1485 (28.0)	432 (23.4)	76 (22.3) 341 (4.5)	41 (0.5)	10 (45.5)	09 (0.1)	2017 (26.6)
	Total	5316 (70.2)	1845 (24.4)	0.05	0.005	22 (0.3)	0.001	7574
	Genotypic frequency	0.70	0.24			0.003		
Allelic frequencies : f(A) = 0.85, f(S) = 0.13, f(C) = 0.03								
Oyo State General Hospital (1995-2000)	Male	294 (41.2)	120 (55.1)	12 (44.4) 15 (55.6)	07 (53.9) 06 (46.2)	24 (47.1)	03 (60.0) 02 (40.0)	460 (44.8)
	Female	420 (58.8)	98 (45.0) 218 (21.2)	27 (2.6)	13 (1.3)		05 (0.5)	568 (55.3)
	Total	714 (69.5)		0.03	0.01	51 (5.0)	0.005	1028
	Genotypic frequency	0.70	0.21			0.05		
Allelic frequencies : f(A) = 0.81, f(S) = 0.16, f(C) = 0.02								
Gross total of the 3 sites		10109 (68.1)	3108 (21.0)	849 (5.7) 0.06	295 (2.0) 0.02	444 (3.0)	40 (0.3)	14845
	Genotypic frequency	0.68	0.21			0.03	0.003	
Allelic frequencies : f(A) = 0.81, f(S) = 0.14, f(C) = 0.04								

Values in parentheses represent percentages of occurrence.

The data for haemoglobin types is lowest at OSGH probably due to poor record keeping in the hospital. Of the 6 haemoglobin genotypes recorded in the 3 hospitals, HbAA has the highest proportion (68.1%) while HbCC has the lowest (0.3%) (Table 4). The alleles A, S and C control these genotypes and they occurred at a frequency of 0.81, 0.14 and 0.04, respectively. These frequencies are similar to those previously reported for Ivorian, Ghanaian and Nigerian populations of West Africa (Cabannes et al., 1987).

Of clinical interest are alleles S and C because they are abnormal, and in particular S due to the sickling phenomenon associated with it. Overall, both occurred, apart from in the heterozygous state with Hb A (i.e. AC and AS), at a relatively low proportion of 2.0% in their heterozygous state (SC) and 3.0% and 0.3% in their homozygous state; SS and CC, respectively (Table 4). Considering the data of each hospital separately, there were more HbSS at BMC and OSGH than at LAUTHC; and also more HbCC at BMC than at OSGH and LAUTHC. This might be due to records of several numbers of infants taken at BMC and OSGH. It is possible that in an institution of higher learning (such as where LAUTHC is situated) very few of individuals with HbSS would qualify for admission, their primary and secondary education having probably been disturbed by frequent illness. Also a high proportion of all HbS homozygotes in Africa die in infancy of sicke cell anaemia (SCA) (Cabannes et al., 1987). The appreciable value of HbSS obtained in this study might be due to the fact that many now reside in urban communities with improved medical services.

The proportion and genotypic frequencies of the haemoglobin variants in our survey is in good agreement with Walters and Lehmann (1956) and Garlick and Barnicot's (1957) figures for a large sample of Yorubas of all ages and with Allison's (1956) for Yorubas resident in Accra.

This report clearly present the distribution and more importantly, the gene frequencies of the alleles controlling the ABO and Rh blood group system and haemoglobin variants for samples of the Nigerian population at Ogbomoso. Data obtained may serve as reference for other studies in this field. It may also be useful in the planning of blood transfusion programmes, since they are an integral part of the genetic profile of the Nigerian population.

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