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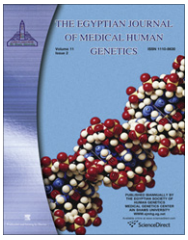

ORIGINAL ARTICLE

Prevalence and gene frequencies of phenylthiocarbamide (PTC) taste sensitivity, ABO and Rhesus factor (Rh) blood groups, and haemoglobin variants among a Nigerian population

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KEYWORDS

Phenylthiocarbamide;
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Nigerian population

Abstract *Background:* Blood groups and phenylthiocarbamide (PTC) are the most studied genetic traits among human populations around the world. In most of these studies, PTC taste sensitivity was described as a bimodal autosomal trait inherited in a simple Mendelian recessive pattern. ABO blood group is the most studied blood groups followed by Rhesus factors (Rh) and haemoglobin variants. Information from the study of these traits is useful to biologists, geneticists, anthropologists and clinicians. No information on the prevalence and gene frequencies of these traits among a population from Nigeria.

Aim: This study presents information on the prevalence and gene frequencies of PTC taste sensitivity, ABO blood group and Rhesus factor, and Haemoglobin variants from male and female Nigerians examined.

Subjects and methods: A total of 232 (51.33%) male and 220 (48.67%) female Nigerians participated in this study. Filter paper impregnated with 81.25 mg/L of saturated solution of PTC was

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used to determine PTC tasters, while blood group phenotypes, Rhesus factor and haemoglobin types were determined by classical method. Hardy–Weinberg method was used to determine allelic frequencies and graphpad 5 computer software was used for the data processing.

Results: The percentage frequency for non tasters of PTC was 29.42% with allele frequency $t = 0.5424$. There were more male (33.62%) non tasters than female (25.0%), but more female (75.0%) tasters than male (66.38%). This observation was statistically significant ($p = 0.0444$). Our findings support the bimodal inheritance of PTC taste sensitivity among Nigerians.

Overall trend of ABO blood group was O > B > A > AB. This same trend was observed for females but differed for males (O > B = A > AB). O blood group was the highest while AB group was the least among studied Nigerians in both genders. The distribution pattern did not differ significantly ($p = 0.1406$) from those expected under Hardy–Weinberg Law.

93.14% of the studied population was Rh+ (DD and Dd) and there were more Rh+ males than females but more Rh− females than males. The proportions and distributions of Rh factor among studied population did not show statistical significance ($X^2 = 0.6047$, df = 1, $P = 0.4624$). The overall allele frequency of the blood group as computed according to Hardy–Weinberg Law is $r = 0.8201$, $q = 0.0977$ and $p = 0.0822$. Similar trend in allele frequency was observed for both genders. The allele frequency for Rh+ (D) is 0.7381 and Rh− (d) = 0.2619. This trend is also similar in both sexes.

Among the six haemoglobin variants common to Nigerians CC was not detected in our study. The other five were observed in the order AA (76.55%) > AS (20.35%) > AC (1.99%) > SS (0.66%) > SC (0.44%). The overall allele frequency was $A = 0.8772$, $S = 0.1106$, $C = 0.0122$.

ConclusionThe findings from this study provide information on the studied traits. It will provide background information for further studies and will be useful to clinicians, geneticists and anthropologists with respect to blood transfusion, marriage counseling and population studies.

1. Introduction

Nigerians are a highly heterogeneous populated group with very few information on their genetic compositions. ABO blood group system is the most studied trait in human genetics followed by the ability to taste phenylthiocarbamide (PTC). These two traits have been extensively used in describing genetic variations among human populations around the world [1–4].

The divergence in taste responses to PTC was first described by Fox [5]. Since then many investigators had described PTC sensitivity as a bimodal autosomal trait inherited in a simple Mendelian recessive pattern, with tasters being dominant (T) and non-tasters recessive (t) [1,2,6,7]. Aside its importance in genetic and anthropological studies, PTC taste sensitivity has been shown to be important in food selection, which may affect individual metabolism and physiology [8]. It was previously used in paternity testing before the advent of DNA markers [9]. Ability to taste PTC or not has also been reported to show relationships with some diseases like diabetes [10], eye diseases [11], thyroid disorders, gastrointestinal ulcers and susceptibility to infectious disease [12,13].

ABO and Rh blood groups are the most studied blood systems among human populations due to their clinical, genetic and anthropological importance [14–16]. While the ABO blood group is expressed by three alleles on chromosome 9 controlling four phenotypes; A, B, AB and O, Rh system is genetically complex but is usually described as a single pair of allele, D and d, on chromosome 1, controlling two phenotypes, Rh positive (Rh+) and Rh negative (Rh−) [17,18]. The grouping of ABO and Rh factor into blood groups is based on the antigenic properties on the surface membrane of the red blood cells (RBCs) [19].

Haemoglobin (Hb) genotypes are also inherited blood traits, with about 400 different types and about two third containing the mutant β-type on their polypeptide chains. Among these mutant forms, HbS has been well studied due to its sickling disorder [20]. Blood grouping among human populations has shown relevance in genetic studies, blood transfusion and forensic pathology. It has also been associated with some diseases in the various populations studied. These include duodenal ulcer [14,21], urinary tract infections [22], Erythromatosis foetalis (haemolytic disease of the foetus and newborn) and sickle cell disease [16].

Sequel to the importance of PTC taste sensitivity and blood grouping to human population, it is, therefore, necessary to determine the prevalence and gene frequencies of PTC taste sensitivity, ABO blood group systems and haemoglobin variants from a studied human population. This information will be useful to clinicians in predicting the relationships between PTC taste sensitivity, hereditary blood factors and associated diseases. It will also find relevance in blood transfusion, genetic and anthropological studies.

This study examined the prevalence and gene frequencies of PTC taster and non taster alleles, ABO blood group, Rh factors and Haemoglobin variants among a given population in Nigeria.

2. Subjects and methods

Four hundred and fifty two (452) students (232 males and 220 females) with age range of 15–30 years were randomly selected from four Faculties (Science, Medical Science, Education and Social Science) of the University of Lagos, Nigeria. These students were from different ethnic groups in Nigeria and registered for Faculty of Science Introductory Biology course in 2008/2009 session.

Taste sensitivity to PTC was determined by the use of filter paper impregnated with a saturated solution of PTC

(81.25 mg/L). This value has been used to identify individuals as tasters and non tasters [23,24]. The subjects were asked to put the filter-paper on their tongues, allowed it to get soaked with their saliva and then fill out a questionnaire containing information on their taste perception, age, sex and state of origin.

The ABO and Rh blood group and the haemoglobin genotype tests were conducted in the Health Center, University of Lagos, in accordance with [25]. Briefly, for ABO and Rh blood group tests, a drop of anti-A, anti-B and anti-D human sera (Helena Laboratories, Beaumont, Texas) was added into 5% red blood cell suspension in normal saline in test tubes and the mixture stirred with glass rods. Blood groups were determined based on agglutination reaction.

Haemoglobin genotype was determined using cellulose acetate electrophoresis technique. Briefly, a small quantity of haemolysate from venous blood of the subjects was placed on the cellulose acetate membrane and carefully electrophoresed in Tris buffer solution for 15–20 min at an E.M.F. of 230 V. The results were read immediately to determine the different haemoglobin genotypes of the subjects.

Data were analysed using Hardy–Weinberg method [26] to determine allelic frequencies. The goodness-of-fit analysis was determined with Graphpad computer software at 95% confident interval.

Informed consent was obtained from parents of the children and this work was done after approval of the ethical committee.

3. Results

Table 1 presents the results of PTC taste sensitivity. Overall frequencies of tasters and non-tasters were 70.58% and 29.42%, respectively. 33.62% male was non-taster while 25.0% female was non-taster. Proportionately more males were observed to be non tasters than females. Overall allelic frequency for the non-tasters (t) is 0.5424. The allelic frequencies for non-taster males and females (t) were 0.5722 and 0.5100, respectively. Our observation that more females were PTC tasters than males is statistically significant (X^2 = 4.0410, df = 1, P = 0.0444).

Table 2 shows the results of the ABO blood groups of the subjects. O blood group has the highest overall percentage frequency (67.26%). AB blood group has the least overall percentage frequency (3.10%). There was a marginal difference between the overall percentage frequencies of blood groups B and A (15.49% and 14.16%, respectively). The overall p (A), q (B) and r (O) allele frequencies were 0.0822, 0.0977 and 0.8201, respectively. Similarly blood group O has the highest percentage frequency in males and females examined, but with males having higher frequency than females (male = 71.98% and females = 62.27%). Although AB group percentage frequency was least in male and female but male (2.16%) was lower than that of females (4.09%). A and B groups have equal frequencies in males but these frequencies were lower than those observed in females. Percentage frequency of B group was higher than that of A group in female. The allele frequencies observed for male and female showed similar pattern to overall values. The distribution of these blood groups did not differ from the expected population under Hardy–Weinberg equilibrium (goodness-of-fit X^2 = 7.6364, df = 3, $P > 0.05$).

Fig. 1 shows the Rh factor distribution in the tested population. Overall percentage frequency for Rh positive is 93.14%. Male has higher percentage frequency for Rh positive (93.75%) than female (92.54%). Overall allele frequency for D = 0.7381 was observed. The value of allele frequency for D was higher in females than in males (0.7569 and 0.7215, respectively). The value for percentage frequency of Rh positive was very high compared to that of Rh negative but was not statistically significant in its proportion and distribution (X^2 = 0.6047, df = 1, Fisher P value = 0. 4624).

Fig. 2 presents the results of the haemoglobin types and their allele frequencies. No HbCC phenotype was observed among the studied population. Overall highest percentage frequency was observed in HbAA group (76.55%), followed by HbAS (20.35%) and others in the order HbAC (1.99%), HbSS (0.66%) and HbSC (0.44%). There were more HbAA males than females but more HbAS females than males. No HbSC female was observed and the percentage frequencies for HbAC and HbSS were higher among males than among females. The overall haemoglobin allele frequencies for A, S and C were 0.8772, 0.1106 and 0.0122, respectively. The values for allele frequency A (male = 0.8815 and female = 0.8772) and C (male = 0.0172 and female = 0.0068) observed were higher for males than for females, but that observed for allele frequency S was higher in male than in female (0.1013 and 0.1205, respectively).

4. Discussion

The ability or inability to taste PTC has long been known to vary among human populations. PTC inheritance in a simple autosomal Mendelian recessive trait observed in our study is in agreement with available information in Nigeria and other countries where it has been previously studied. Although percentage frequency of 29.42% of non tasters and allele frequency t = 0.5424 observed in our study are not in total agreement with these studies [2,27]. While Scott-Emuakpor et al. [2] observed percentage and allelic frequencies of

Table 1 Distribution of phenotypic and allelic frequencies of PTC tasters and non tasters among Nigerians.

Population	No tested	Tasters	Non tasters	Allele frequency	
				T	t
Males	232	154 (66.38%)	78 (33.62%)	0.4202	0.5798
Females	220	165 (75.00%)	55 (25.00%)	0.5000	0.5000
Total	452	319 (70.58%)	133 (29.42%)	0.4576	0.5424

X^2 = 4.040, df = 1, P = 0.0444.
* Parentheses = percentages (%).

Table 2 Distribution of phenotypic and allelic frequencies of ABO blood groups among Nigerians.

Population	No tested	A	B	AB	O	Allele frequency		
						P	*q*	*r*
Males	232	30(12.93)	30(12.93)	5(2.16)	167(71.98)	0.0731	0.0785	0.8484
Females	220	34(15.45)	40(18.18)	9(4.09)	137(62.27)	0.0925	0.1184	0.7891
Total	452	64(14.16)	70(15.49)	14(3.10)	304(67.26)	0.0822	0.0977	0.8201

$X^2 = 7.6364$, df = 3, $P > 0.05$ (statistically insignificant).
* Parentheses = percentages (%).

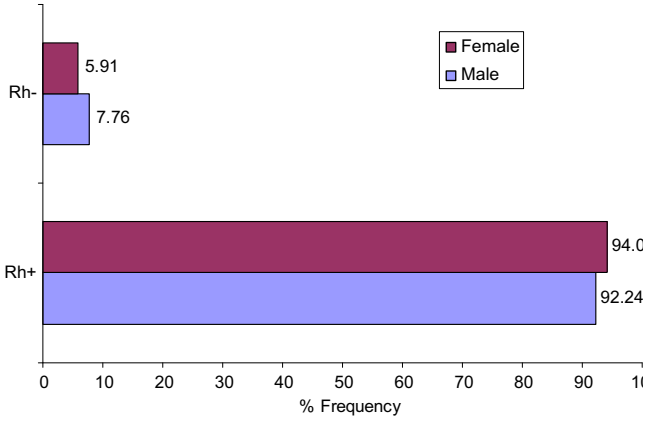

Figure 1 The percentage phenotypic distribution of Rhesus factor groups among Nigerians.

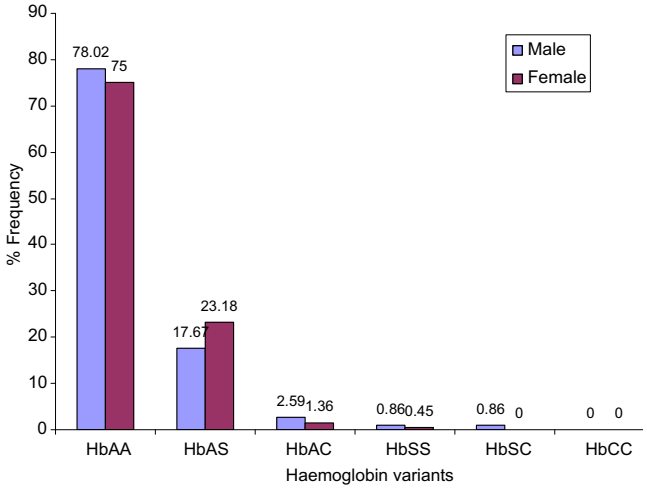

Figure 2 The percentage distribution of haemoglobin variants among Nigerians.

12.50% and $t = 0.354$, respectively, Odeigah [27] observed 12.60% percentage frequency and t allele of 0.354. A recent study [7] reported percentage frequency of 22.60% and allele frequency $t = 0.4754$ among Nigerians. Our data are almost similar to this study [7] than those of the other two [2,27]. Differences in these studies may be attributed to the methods of PTC administrations. While we utilized filtered paper impregnated with 81.25 mg/L PTC solution [23,24], Scott-Emuakpor et al. [2], and Odeigah [27] employed sorting method. Among Caucasians an overall estimated frequency for non tasters of 28% had been previously reported [6]. 24.5% frequency was also observed for non tasters in Angami Nagas of Nagaland [28] and 71.5% in Brahmins of Bilaspur [29]. The value of t allele also varies from 0.088 to 0.892 among various populations studied [7,27–30]. Differences in results from various studied populations suggest that frequency values for non taster of PTC may be unique to the specific populations studied. More so, our observation that there were more tasters than non tasters and that females have lower percentage frequency for non tasting ability than males is in agreement with most available data from Nigeria and other populations [2,7,23,27–29].

Percentage frequency distribution of blood group varies from race to race. Our results on blood group in the trend O > B ⩾ A > AB is not in total agreement with some previous studies from Nigeria [15,25], these studies observed frequencies are in the order O > A ⩾ B > AB. But our findings agreed with all available data that Nigerians are more with blood group O and least with AB group. Also frequency of blood group A may be similar or showed marginal difference from blood group B. That Nigerians are more of O blood group has its advantages which may include emergency blood transfusion as blood group O is a universal donor (lack both anti-A and anti-B antibodies) hence is readily available. Its disadvantages include higher risk of contacting cholera and plague by individuals, as well as developing duodenal and peptic ulcers than other blood groups [14,31]. They are also more susceptible to malaria infection since they are tasty to mosquitoes than other blood groups [19]. Cancer of the stomach has been significantly associated with blood group A individuals than other blood groups [31]. The frequency pattern of blood group observed among Nigerian is in agreement with those of Western European and American populations [32] although also showed variations from some other studies from other races. For instance, American Indians are exclusively blood group O [33] while the general trend in India is B ⩾ O > A > AB [34]. In Pakistan province different trends of the frequencies had been reported among the populations. Afzal et al. [35] reported B > O > A > AB in Punjab. This differs from B > A > O > AB reported in Bannu [36] and O > B > A > AB in Sindh [37]. ABO blood group allelic frequency of $r > q > p$ observed in our study shows slight difference from Bakare et al. [15], who reported $r > p = q$. Although information on ABO allelic frequency among Nigerians is scarce, but the trend observed in our study is common to most available data in other countries [34–36].

The proportion of Rh+ (93.14%) observed in our study is similar to most available data in Nigeria. Ukaejiofor et al. [37] reported 96.7% among the Ibos, Bakare et al. [15] reported 96.7% among Ogbomoso (Yorubas) and Jeremiah [16] reported 96.77% among the South south, all in Nigeria. Also the Rh factor allelic frequencies obtained in our study varied slightly from the above studies. The difference in the frequencies observed in our study and in others from Nigeria may be due to the heterogeneous nature of our subjects. Our subjects are representatives from the different ethnic groups in Nigeria unlike other studies which considered a particular ethnic group. The major importance of the Rh system to human is in the avoidance of the danger of Rh+ incompatibility between mother and foetus. This incompatibility called erythromatosis foetalis or Haemolytic Disease of the Newborn (HDN) is an antibody mediated cytotoxic disorder. Our findings suggest relatively safe Rh factor compatibility among Nigeria populations since over 92% of males and females are Rh+. This notwithstanding, with 5.91% females of the sampled population being Rh−, it is advisable for intended couples to seek the consent of genetic counsellors in order to avert the occurrence of antibody mediated cytotoxic disorder.

In Nigeria most available data showed that HbAA frequency is always the highest compared to others. Our findings that HbAA frequency of 76.55% is the highest compared to other Hb groups agrees with these studies. Although this value is slightly above the range of 55–75% earlier reported for Blacks [38] but agrees with the data from Kenya, East Africa, where HbAA value ranged from 74% to 97% [39]. Jeremiah [16] observed HbAA frequency of 80.32% among African descent in Port Harcourt, Nigeria while Bakare et al. [15] also reported 68.1% among Ogbomoso indigenes in Nigeria. HbSS is the most studied Haemoglobin in human population due to the sickling abnormality it causes on the individual with the genotype and is of medical importance. Lewin [40], and Richard [41] reported that the prevalence of this genotype among Africans ranged from 30% to 40% while Jeremiah [16] also reported that its prevalence among whites and blacks generally range from 1% to 10%. Our observation that 0.66% of the studied population is HbSS, none HbCC genotype and HbSC of 0.86% only in males showed that sampled population will rarely suffer from sickle cell anaemia and other related diseases. The allele frequencies of these traits observed in our findings had been similarly reported among Ogbomoso indigenes in Nigeria as *A* (0.81), *S* (0.14) and *C* (0.04) [15].

High frequency of HbAA individuals observed in our study compared to HbAS individuals suggests that some level of precautionary measures be taken against malaria infection since HbAA are prone to suffering from this infection and Nigeria is situated in the sub-tropical Sahara where malaria endemicity is very high. HbAS heterozygote is substantially more resistant to malignant tertian malaria (caused by *Plasmodium falciparum*) than homozygous HbAA.

In conclusion, this study presents the prevalence and gene frequencies of PTC taste sensitivity, ABO blood and Rh factors and haemoglobin variants among a Nigerian population. We are currently gathering data on the relationship between PTC taste sensitivity, blood groups and other related traits commonly expressed among Nigerian. These data will further provide information that will be useful for genetics, anthropological and clinical studies.

Conflict of interest

The authors declare that there is no conflict of interest.

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