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RESEARCH ARTICLE

ARE BLOOD GROUPS LINKED TO OBESITY AND MENTAL HEALTH? : A CROSS SECTIONAL STUDY

***,[1]Dr. Megha Agrawal and [2]Sumana, H. M.**

[1]Post graduate, Bangalore Medical College and Research Institute
[2]MSc, Tutor, Bangalore Medical College and Research Institute

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ABSTRACT

Background: Mental health (stress, anxiety, depression etc.) and obesity have become global concerns in recent years leading to many health concerns like metabolic syndrome. Sedentary lifestyle, over-nutrition (high caloric/fatty diet), substance abuse etc. can contribute to the above as "modifiable factors". The purpose of the present study is to determine if "non modifiable factors" like blood group can be an attributing factor for causation of these disorders and whether any particular blood group is more predisposed to them. This study was taken up to explore the differences in psychological heath and physical health among various blood groups in a group of normal healthy young individuals and to assess if blood group can be considered as a predictor of obesity and poor psychological health.

Objectives: To explore the differences in BMI, perceived stress and psychological morbidity among different blood groups in young healthy adolescents.

Materials and Methods: Two hundred healthy adolescents were included in the study after applying exclusion criteria and taking informed consent. Cohen's Perceived Stress Scale (PSS) and General Health Questionaire-12 were used to assess stress and psychological morbidity respectively. The height and weight of the subjects were measured and blood groups were assessed using agglutination reaction.

Statistical Analysis: Data was entered in Microsoft excel (2011) and was analyzed using SPSS 16. The values have been represented as Mean± SD. The mean values have been compared among different blood groups using ANOVA and unpaired "t" test. Association has been found using Chi square test. $p<0.05$(two tailed) has been taken as statistically significant.

Results: Out of 200 students (143 males, 57 females), 72 had O blood group (36%), followed by 68 having B (34%), 46 having A (23%) and 14 having AB blood group (7%). 189 were Rh positive (94.5%) whereas only 11 were Rh negative (5.5%). The results showed no significant differences between different blood groups with regards to BMI or psychological health (PSS and GHQ-12). However, PSS scores were significantly worse in females as compared to males ($p<0.01$).

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INTRODUCTION

Health has become a crucial issue of global concern in the current context as a result of drastic changes in the lifestyle of individuals. Poor mental health in the form of stress, anxiety and depression along with poor physical health like obesity (due to improper diet and lack of exercise) are the major risk factors implicated in innumerable health problems including metabolic syndrome. Metabolic syndrome, a worldwide growing epidemic (Haffner and Taegtmeyer, 2003) is associated with early aging as well (Nunn *et al*., 2009; Yao *et al*., 2014). Abdominal adiposity promotes inflammation and oxidative stress, which are precursors of various complications involving Metabolic Syndrome components, namely insulin resistance, hypertension and hyperlipidemia (Yao *et al*., 2014; Francisqueti *et al*., 2015). A bidirectional association has been found between depression and Metabolic Syndrome (An Pan *et al*., 2012). While depression is related to stress, nonetheless, it is a distinctly different construct (Gutman and Nemeroff, 2011). Stress has been strongly implicated in the pathogenesis of cardiovascular conditions for e.g. coronary heart disease (Rozanski *et al*., 1999) and acute myocardial infarctions (Rosengren *et al*., 2004). Stress causes alterations in the immune system (Segerstrom and Miller, 2004) and increased susceptibility to infection (Cohen *et al*., 1991). The nervous system is also compromised during times of undue stress (Sapolsky, 1999; Woolley *et al*., 1990). Stress is related to declining physical function over time (Cheng *et al*., 2000) and obesity (Siervo *et al*., 2009; Holmes *et al*., 2010; Ogden *et al*., 2012), which contributes to further cardiovascular risk.

Corresponding author:* **Dr. Megha Agrawal,
Post graduate, Bangalore Medical College and Research Institute

Several other mechanisms that affect heath have been established. These factors are either "non-modifiable" such as genetic endowment, race, age and sex or "modifiable" such as over-nutrition (high caloric/fatty diet), sedentary lifestyle, physical inactivity, substance abuse or environmental factors (High Blood Pressure in African-Americans, 2015; U.S. Department of health and human services, 2014; Diabetes in the UK 2012; Wang *et al*., 2015; Nemesure *et al*., 2006; Nwafor *et al*., 2015). With the global rise of health concerns, it has become imperative to find out the role of other factors (such as blood group) in its pathophysiology as well, so that preventive measures could be applied well in time. Blood group is known to be associated with cancers, peptic ulcer, coagulation disorders, bleeding disorders, clotting disorders, infections, and renal diseases. Past research has associated ABO blood type and mental stress with cardiovascular risk (Arunima Chaudhuri *et al*., 2016). There are also reports that specific personality traits, such as depression and anxiety, may also be associated with cardiovascular diseases (The Interplay of Biological, 2001; Hansen *et al*., 2005; Steptoe and Molloy, 2007). Since different blood groups are linked with different behavioral responses and personality traits, they may be of significance in causation of these diseases. Previous studies have shown variable results, with very few studies done in this field. Thus, this study was taken up to explore the differences in psychological heath and physical health among various blood groups in a group of normal healthy young individuals and to assess if blood group can be a predictor of obesity and poor psychological health, thus contributing as a "non modifiable" risk factor for metabolic syndrome later in life.

Objectives

To explore the differences in BMI, perceived stress and psychological morbidity among different blood groups in young healthy adolescents.

MATERIALS AND METHODS

Subjects

200 Young healthy adolescents (first year MBBS students of Bangalore Medical College & Research Institute) aged 17-19 years (Mean age = 18.23±0.5 years) were included in the study. The exclusion criteria were H/O psychological disorders (e.g. anxiety/ depression etc.), H/O stress (e.g. period of exams), H/O endocrine disorders (e.g. thyroid disorders), H/O sleep disturbances (e.g. insomnia), H/O eating disorders (e.g. anorexia, morbid obesity etc.), drug history and substance abuse.

Instruments

Two questionnaires were used

- Cohen's Perceived Stress Scale (PSS-10)- The perceived stress scale (PSS) by Cohen *et al*. is the most widely used psychological instrument for measuring the perception of stress. It is a measure of the degree to which situations in one's life are appraised to be stressful. The questions in the PSS ask about feelings and thoughts during the last month in a Likert scale (0 to 4). It comprises of 10 items, four of which are reverse-scored and then summed across all scale items. Total score ranges from 0 to 40. Scores less than 13 are considered average, whereas scores more than 20 are considered to indicate severe stress (Cohen *et al*., 1983).
- General Health Questionnaire-12- The General Health Questionnaire-12 (GHQ-12) is an instrument useful in detecting psychological distress with high sensitivity and specificity. Developed in the 70s, it detects non-psychotic psychiatric problems such as depression, anxiety, and related psychiatric morbidity. Studies of GHQ-12 have yielded high validity coefficients when administered in several languages and in countries including India. It consists of 12 questions in a Likert scale with best to worst scores (0-3) (Goldberg, 1972; Goldberg *et al*., 1997).

Methodology

A questionnaire was given to students consisting of PSS and GHQ12 to assess perceived stress and psychological morbidity like anxiety/depression respectively. Blood groups were assessed by agglutination reaction in the Haematology laboratory. Body mass Index was calculated by measuring height and weight of individuals. Informed consent was taken from all the participants and ethical clearance was obtained from Institutional Ethical Committee.

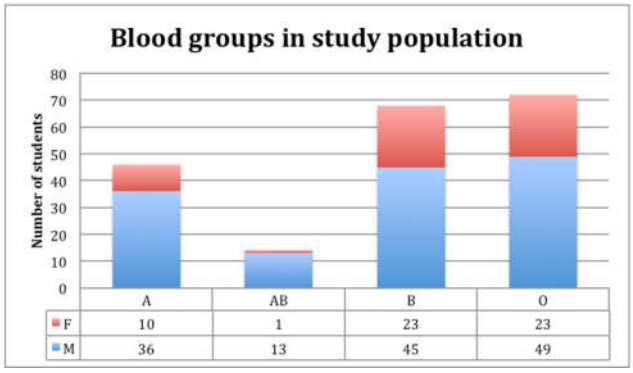
Statistical Analysis

Data was entered in Microsoft excel (2011) and was analyzed using SPSS 16. The values have been represented as Mean ± SD. The mean values have been compared among different blood groups using ANOVA and unpaired "t" test. Association has been found using Chi square test. $p < 0.05$ (two tailed) is taken as statistically significant.

RESULTS

i)Distribution of blood groups in the study population

Out of 200 students (143 males, 57 females), 72 had O blood group (36%), followed by 68 having B (34%), 46 having A (23%) and 14 having AB blood group (7%). 189 were Rh positive (94.5%) whereas only 11 were Rh negative (5.5%). (Graph 1)

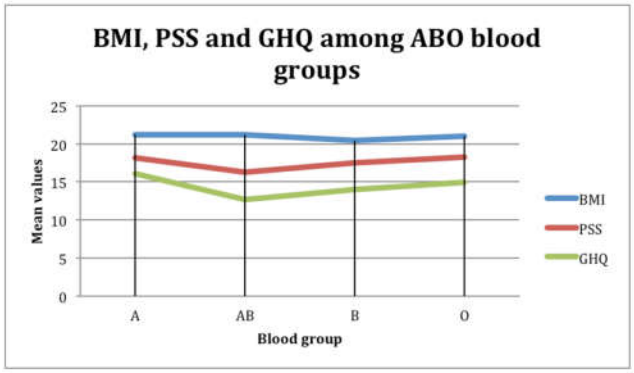


Graph 1. Distribution of blood groups in the study population

ii)Differences in BMI, PSS and GHQ scores among ABO blood groups

All the blood groups had comparable BMI. Though there were no significant differences in General health questionnaire and

Perceived stress scale among various blood groups, blood group A showed relatively worse scores of GHQ-12, blood group O had maximum stress and AB had better psychological health (both GHQ and PSS). (Graph 2, Table 1)



Graph 2. Differences in BMI, PSS and GHQ scores among ABO blood groups

Table 1. Differences in BMI, PSS and GHQ scores among ABO blood groups

Blood groups	A	AB	B	O	p
BMI (kg/m^2)	21.24±3.46	21.25±3.39	20.46±3.47	21.06±3.72	0.63
PSS	18.22±5.69	16.28±4.76	17.56±5.30	18.28±5.45	0.57
GHQ-12	16.06±6.78	12.64±3.97	13.98±5.08	14.90±5.73	0.13
n	46	14	68	72	

iii)Comparison of BMI, PSS and GHQ-12 among Rh blood groups

There were no significant differences between BMI, PSS and GHQ-12 between Rh positive and negative individuals.

Table 2. Comparison of BMI, PSS and GHQ-12 among Rh blood groups

Blood group	Rh+	Rh-	t	p
BMI	20.87±3.51	21.60±4.31	-0.66	0.51
PSS	17.89±5.4	17.63±5.59	0.15	0.88
GHQ-12	14.65±5.70	15.54±6.33	-0.5	0.62
n	189	11		

iv)Association of PSS with ABO blood groups

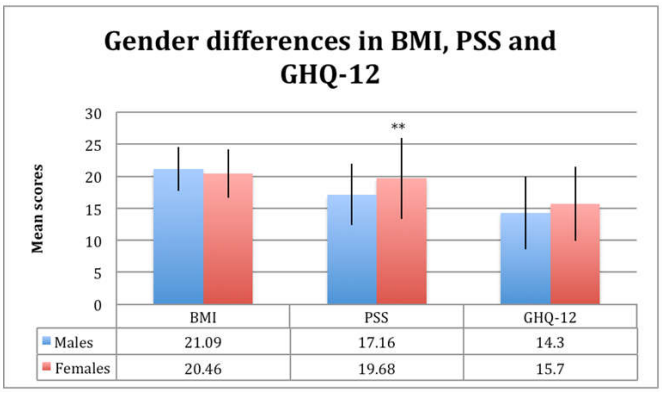
Based on the PSS scores, 40 had average stress (20%), 93 had moderate stress (46.5%) and 67 had severe stress (33.5%) in our study population of 200 students. However, no association was found among the different blood groups with stress using the Chi square test. (p= 0.85)

Table 3. Association of PSS with ABO blood groups

PSS	A	AB	B	O	Total
≤13	9	4	14	13	40
14-19	21	7	34	31	93
≥20	16	3	20	28	67
	46	14	68	72	200

v)Comparison of BMI, PSS and GHQ-12 between the two genders

The BMI was comparable between the two groups. PSS and GHQ-12 showed higher /worse scores in females with highly significant values for PSS (p=0.008). (Graph 3)



** p<0.01

Graph 3. Gender differences in BMI, PSS and GHQ-12

DISCUSSION

In our study we found out that the distribution of different blood groups was as follows: O (36%), A (23%), B (34%), and AB (7%). 189 were Rh positive (94.5%) whereas only 11 were Rh negative (5.5%). Significant differences were not found among different blood groups in BMI, PSS and GHQ-12 scores, though blood group A had highest scores of GHQ-12, O has highest scores of PSS and AB had better psychological health (both GHQ and PSS) as compared to other blood groups. The PSS scores were significantly worse in females as compared to males (p<0.01). The distribution of blood groups in our study population was similar to a previous study done on 1,000 adolescent subjects where the distribution of blood type O, A, B and AB was 43.9%, 31.4%, 19.0% and 5.7%; with ratio: 8:6:3:1 respectively (Arthur Nwafor Chuemere *et al*., 2015). There were no significant differences among different blood groups with regards to BMI or psychological health. This is in accordance with a previous study that showed that no particular blood type was more predisposed to overweight and obesity, hypertension or diabetes (Arthur Nwafor Chuemere *et al*., 2015).

Interestingly, other studies show variable results in this regard. A recent study done in 2016 indicates that subjects with blood group O perceived more stress as compared to subjects of blood group A (Arunima Chaudhuri *et al*., 2016). People with blood group O are more prone to duodenal ulcers and perceived stress is thought to be a significant contributor in developing the disease (Song *et al*., 2015; Franchini *et al*., 2014; Paré *et al*., 2008; Karakas *et al*., 2012). O-type blood has been found to occur more frequently in manic-depressive patients as well (Karakas *et al*., 2012). On the other hand, the blood type A group had higher initial levels of very low-density lipoprotein (LDL) toxicity-preventing activity (TxPA) and cortisol, as well as quicker stress recovery rates than the type O group in a study done by Neumann *et al*. (1992) Non-O blood groups were also found to be associated with increased risk of gastric cancer (Franchini and Lippi, 2015). Previous studies have found that the non-O phenotypes were more frequent in ischemic stroke patients than controls and were associated with an increased risk of MI and CAD (Clark *et al*., 2005; Carpeggiani *et al*., 2010; Tanis *et al*., 2006) contributing to nearly 6% of total deaths and as many as 9% of cardiovascular deaths (Franchini and Lippi, 2015). Blood types B and AB lie between these extremes when it comes to dealing with stress. In general type B's respond to stress closer to the A end of the continuum, while AB's slide more towards the type O response end of the

spectrum. The response of B blood group to stress was much more individualistic and showed a wide spectrum (Peter J. D'Adamo, 2008-2010). Another study conducted by Anandarajan *et al*. revealed a considerable difference in academic scores between the blood groups O and A when scholastic performance of medical students in south India were compared (Anandarajan *et al*., 2015). Blood groups can also predict personalities and some personalities are more prone to stress. Cattell *et al* showed significant association of Premsia versus Harria personality trait ("tender-minded vs. tough-minded"). A blood type was more premsic, and O, B, and AB were more harric, in that order (Cattell *et al*., 1964).

In our study, height, weight and BMI were not associated with ABO blood groups. In several studies, there was no association between anthropometric measures and ABO blood groups (Slipko *et al*., 1994; Mascie-Taylor and Lasker, 1990; Elham Jafari *et al*., 2012). However a few studies have shown an association between anthropometric measures and ABO blood groups. In one study conducted among 898 young men, blood group B (B, AB) subjects were taller than non-B (A, O) subjects (Borecki *et al*., 1985). In another study on Brazilian infants, weights of females with blood group A were significantly more than other blood types. However, this difference was not found among male infants (Kelso *et al*., 1992). A cross-sectional study conducted in Turkey evaluated the association between ABO phenotypes and risk of obesity among 3290 men with airborne occupational exposure and found a relationship with phenotype O (Suadicani *et al*., 2005). Apart from obesity, blood group has also been linked to Diabetes and Cardiovascular risk. In yet another meta-analysis, blood group "O" has minimum association with type 2 diabetes whereas, blood group "B" is associated with high incidence of type 2 diabetes (Meo *et al*., 2016; Cornelis *et al*., 2010) as group B individuals were found to have lower levels of E-selectin (Paterson *et al*., 2009). It was also found that perceived stress significantly worsened LDL-C levels (Arunima Chaudhuri *et al*., 2016). In another study done in Iran, high stress was found in individuals with high levels of TC, LDL-C and low levels of HDL-C compared to normal individuals after adjustment for age and sex (Shahnam *et al*., 2010). Blood groups seem to have link to diet as well that may serve as a predisposing factor to obesity. Based on the 'Blood-Type' diet theory, group O is considered the ancestral blood group in humans followed by the advent of A and B. Thus, the optimal diet for O blood group should resemble the high animal protein diets typical of the hunter-gatherer era, vegetarian diet of agrarian societies for blood group A and dairy products for B blood group as it was believed to originate in nomadic tribes. Also, individuals with an AB blood group are believed to benefit from a diet that is intermediate to those proposed for group A and group B (Adamo and Whitney, 1996). Though not many studies agree with this theory (Cusack *et al*., 2013).

Different blood groups respond to exercise differently. All other factors being equal, the envelope for exercise is smallest for type A's, but with proper "conditioning" a blood type A individual can excel in more strenuous activities. Unlike blood type A, blood type O individuals generally respond well to intense exercise (lifting weights, running, biking, swimming, aerobics) as a safety valve. However, a well-conditioned type A to stress has a bigger envelope for exercise than a poorly conditioned type O. While many blood type As respond very well to lifting weights or aerobic activities, blood type Os are advised to do yoga as they are already in the exhaustion stage because of accumulated stress and should not consider intense exercise as being in their best interest (Peter J. D'Adamo, 2008-2010).

Several mechanisms have been proposed to explain the association of blood groups to the pathophysiology of disease. The ABO blood group system consists of three main alleles (two co-dominant (A and B) and one recessive (O)) (Yamamoto *et al*., 1990; Storry and Olsson, 2009). The A and B alleles of the ABO locus encode A and B glycosyltransferase activities, which convert precursor H antigen into either A or B determinants, the A and B antigens having an extra saccharide unit to the O unit (N-acetylgalactosamine and galactose, respectively). Group O individuals lack such transferase enzymes and express basic, unchanged H-antigen (Lowe,1993). Not only are the ABO antigens expressed on the surface of red blood cells but also on a variety of human cells and tissues, including epithelia, platelets, vascular endothelia and neurons (Franchini and Liumbruno, 2013). Therefore, it can be proposed that such carbohydrate moieties are of importance for the pathogenesis of various systemic diseases (Liumbruno and Franchini, 2013; Franchini and Mannucci, 2014; Franchini and Lippi, 2016; Anstee, 2010; Franchini *et al*., 2012).

A scientific hypothesis concerning ABO blood groups and personality traits was recently proposed by Hobgood (Hobgood, 2011). Dopamine beta-hydroxylase (DBH) is known to catalyze the conversion of dopamine to norepinephrine, and the DBH gene is in tight linkage with the ABO gene on chromosome 9q34 (Wilson *et al*., 1988; Goldin *et al*., 1982). The ABO group B marker rs8176746 and the low-activity DBH allele rs1611115T exhibit similar frequency distributions among HapMap populations. For these reasons, and considering the known effects of catecholamine on behavior, Hobgood (Hobgood, 2011) suggested that linkage between DBH and ABO may explain the associations between personality traits and ABO blood type. Personality trait research has found that low-activity DBH is associated with the impulsiveness trait, whereas high-activity DBH is associated with sensation seeking (La Grange et al., 1995; Hess et al., 2009). Also, ABO group B subjects with low DBH activity show low Persistence, whereas ABO group A and O subjects with high DBH activity show high Persistence (Hobgood, 2011). It is well known, that individuals with non-O blood group have circulating levels of both VWF and FVIII that are approximately 25% higher than O blood group subjects. The underlying mechanism resides in the positive influence on VWF levels and activity of the addition of A and B antigens, by the specific glycosyltransferase enzymes, on the existing VWF H oligosaccharides (Franchini *et al*., 2014). The non-O related increased levels of VWF and FVIII, in addition to those of several inflammatory cytokines (i.e., tumor necrosis factor-alpha, soluble intercellular adhesion molecule 1, E-selectin, P-selectin and interleukin-6) and cholesterol levels, have been suggested as the most likely mechanisms for explaining the association between ABO blood group and cardiovascular diseases (Paré *et al*., 2008; Karakas *et al*., 2012; Paterson *et al*., 2009; Chen *et al*., 2014) due to its profound influence on hemostasis (Arthur Nwafor Chuemere *et al*., 2015; Song *et al*., 2015; Enrico Capuzzo *et al*., 2016).

Another study emphasized that patients with blood group A, B and AB are more susceptible to oxidative stress compared to that of O blood group due to presence of specific carbohydrate molecules on the red cell antigens of blood group A and B

which may impair the metabolism of lipids in blood (Kapoor Shalini *et al*., 2012). Even in banked blood, it was seen that blood group O endured oxidative insult more efficiently than A and B blood groups (Carl *et al*., 2016).

Sherrington *et al*. reported that although blood group A individuals respond to stress by releasing profuse adrenaline but elimination is also very fast. However O blood group appears to have more difficulty with catecholamines. Once it is produced it is difficult to eliminate them and their effects (Sherington *et al*., 1994). An enzyme called monoamine oxidase (or MAO for short) is responsible for the breakdown or inactivation of adrenaline and noradrenaline. When measuring the activity of MAO in platelets, research has shown that type O individuals have the lowest activity of this enzyme. The lower activity of this enzyme found in Type O's makes it harder for them to break down an excess of catecholamines. Again with respect to MAO, it has been found that A's and O's are on the opposite ends of the spectrum. Type A's tend to have the highest activity (Peter J. D'Adamo, 2008-2010). This difference in stress management may also be attributable to individual coping mechanisms exhibited by different blood groups. A study by Gsellhofer *et al*. (1992) explored the relationship between individual strategies of coping and blood pressure responses during and after mental stress. Individuals who used coping strategies characterized by controlling the situation directly and constructively, in contrast to probands not using these strategies, exhibited lower blood pressure during the stress situation and a faster return to baseline levels after cessation of stress. Subjects using a coping behavior characterized by the use of defense mechanisms such as suppression and denial also showed lower blood pressure during stress, but a significantly delayed return to baseline levels of blood pressure after stress was concluded. Based on the above studies, it can be inferred that O blood group which has a deficient carbohydrate moiety can endure oxidative stress more effectively than non O blood groups. However, O blood group has poorer recovery from stress as compared to A blood group, thus leading to stress related duodenal ulcers. A blood group releases more cortisol and catecholamines in response to stress but has faster elimination and thus, faster stress recovery rates. Non O blood groups are also related to increased levels of VWF, factor VIII and inflammatory cytokines in circulating blood thereby contributing to thromboembolic phenomenon and cardiovascular risk. However, we did not find any significant differences among different blood groups in our study population.

The limitations of our study were a small sample size and inclusion of limited parameters for assessment of obesity. Additional parameters like waist circumference, waist hip ratio as well as lipid profile can give more insight into the existing information. The future directions would be to extend this study to a bigger population that is at risk of developing/has metabolic syndrome with more parameters. Also, Rh blood group can be included along with ABO cluster as very few studies have focused on it. To conclude, there were no significant differences in the levels of perceived stress, psychological morbidity or body mass index among different blood groups (ABO and Rh) in our study population.

Conflicts of interest

None

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REFERENCES

Adamo P. and Whitney C 1996. Eat Right 4 Your Type: The individualized diet solution to staying healthy, living longer & achieving your ideal weight. New York: Putnam.

An Pan, NaNa Keum, Olivia I. Okereke, Qi Sun, Mika Kivimaki, Richard R. Rubin, Frank B. Hu. 2012. Bidirectional Association Between Depression and Metabolic Syndrome: A systematic review and meta-analysis of epidemiological studies. *Diabetes Care*, May; 35(5): 1171–1180.

Anandarajan B, Prathiba A, Dorairaj VS, Banu KK, Muthukumar S. 2015. Correlation of academic scores with blood group among first MBBS medical students. *Int J Biomed Adv Res*., 6: 328-30.

Anstee DJ. 2010. The relationship between blood groups and disease. *Blood,* 115: 4635-43.

Arthur Nwafor Chuemere, Oluwadare Joyce Olorunfemi, Jonah Uzoma Nwogu, Owate Faith Mmom, Emmanuel Onuka Agbai and Vitalis Voh Vurey. 2015. Correlation between Blood group, Hypertension, Obesity, Diabetes, and combination of Prehypertension and Pre-Diabetes in School Aged Children and Adolescents in Port Harcourt. *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*. Dec. 14(12): 83-89

Arunima Chaudhuri, Manjushree Ray, Samir Kumar Hazra, Ayan Goswami, Shyamal Bera. 2016. Correlation of perceived stress with blood group A and O among medical students and its effect on lipid profile in a medical college of Eastern India. *Saudi Journal of Sports Medicine*, January - April 16 (1)

Borecki IB, Elston RC, Rosenbaum PA, Srinivasan SR, Berenson GS. 1985. ABO associations with blood pressure, serum lipids and lipoproteins, and anthropometric measures. *Hum Hered*., 35:161-70.

Carl H, Soumya R, Srinivas P, Vani R. 2016. Oxidative stress in erythrocytes of banked ABO blood. *Hematology*, Dec; 21(10):630-634. Epub 2016 May 28.

Carpeggiani C, Coceani M, Landi P, Michelassi C, L'abbate A. 2010. ABO blood group alleles: A risk factor for coronary artery disease. An angiographic study. *Atherosclerosis*, 211(2): 461–6.

Cattell RB, Young HB, Hundleby JD. 1964. Blood groups and personality traits. *Am J Hum Genet*, 16: 397-402.

Chen Y, Chen C, Ke X, *et al*. 2014. Analysis of circulating cholesterol levels as a mediator of an association between ABO blood group and coronary heart disease. *Circ Cardiovasc Genet*, 7:43-8.

Cheng YW, Kawachi I, Coakley EH, *et al*. 2000. Association between psychosocial work characteristics and health functioning in American women: prospective study. *BMJ*, 320(7247): 1432–6. (PubMed: 10827043)

Clark P, Meiklejohn DJ, O'Sullivan A, Vickers MA, Greaves M. 2005. The relationships of ABO, Lewis and Secretor blood groups with cerebral ischaemia of arterial origin. *J Thromb Haemost*., 3(9):2105–8.

Cohen S, Kamarck T, Mermelstein R. 1983. A global measure of perceived stress. *J Health Soc Behav*., 24:385-96.

Cohen S, Tyrrell DAJ, Smith AP. 1991. Psychological stress and susceptibility to the common cold. *N Engl J Med*., 325:606–12. (PubMed: 1713648)

Cornelis MC, Kraft P, Jensen M, van Dam RM, *et al*. 2010. Genetic variants in ABO blood group region, plasma soluble E-selectin levels and risk of type 2 diabetes. *Hum Mol Genet*, 19: 1856–1862.

Cusack L, De Buck E, Compernolle V, Vandekerckhove P. 2013. Blood type diets lack supporting evidence: a systematic review. *Am J Clin Nutr*., Jul;98(1):99-104. doi: 10.3945/ajcn.113.058693. Epub 2013 May 22.

Diabetes in the UK 2012: Key statistics on diabetes . Available from: https://www.diabetes.org.uk/diabetes-in-the-uk-2012. Accessed on: 22/3/17

Elham Jafari, Vahid Sebghatollahi, Shadi Kolahdoozan, Elham Elahi, Akram Pourshams, 2012. Body Mass Index and ABO Blood Groups among Different Ethnicities of the Golestan Cohort Study Subjects. Govaresh. 17(1): 50-54.

Enrico Capuzzo, Carlo Bonfanti, Francesco Frattini, Paolo Montorsi, Rosalia Turdo, Maria Grazia Previdi, Elisa Turrini, Massimo Franchini. 2016. The relationship between ABO blood group and cardiovascular disease: results from the Cardiorisk program. *Ann Transl Med*., 4(10):189

Franchini M, Crestani S, Frattini F, *et al*. 2014. ABO blood group and von Willebrand factor: biological implications. *Clin Chem Lab Med*., 52:1273-6.

Franchini M, Favaloro EJ, Targher G, *et al*. 2012. ABO blood group, hypercoagulability, and cardiovascular and cancer risk. *Crit Rev Clin Lab Sci*., 49: 137-49.

Franchini M, Lippi G. 2015. The intriguing relationship between the ABO blood group, cardiovascular disease, and cancer. *BMC Med*., 13:7.

Franchini M, Lippi G. 2016. Relative Risks of Thrombosis and Bleeding in Different ABO Blood Groups. *Semin Thromb Hemost*., 42: 112-7.

Franchini M, Liumbruno GM. 2013. ABO blood group: old dogma, new perspectives. *Clin Chem Lab Med*., 51: 1545-53.

Franchini M, Mannucci PM. 2014. ABO blood group and thrombotic vascular disease. *Thromb Haemost*, 112: 1103-9.

Francisqueti FV, Nascimento AF, Corrêa CR. 2015. Obesidade, in amação e complicações metabólicas. *Nutrire*, 40(1): 81-9.

Goldberg DP, Gater R, Sartorius N, Ustun TB, Piccinelli M, Gureje O *et al*. 1997. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. *Psychol Med*., 27:191-7.

Goldberg DP. 1972. The Detection of Psychiatric Illness by Questionnaire. Michigan: Oxford University Press.

Goldin LR, Gershon ES, Lake CR, Murphy DL, McGinniss M, Sparkes RS. 1982. Segregation and linkage studies of plasma dopamine-beta-hydroxylase (DBH), erythrocyte catechol-O-methyltransferase (COMT), and platelet monoamine oxidase (MAO): possible linkage between the ABO locus and a gene controlling DBH activity. *Am J Hum Genet*, 34:250–62. pmid:6951409View Article PubMed/NCBI Google Scholar

Gsellhofer B, Montoya P, Müller A, Piesbergen C, Schandry R. 1992. The correlation between coping with stress and blood pressure reaction. *Z Exp Angew Psychol*., 39:419-33

Gutman, DA, Nemeroff, CB. 2011. Stress and depression. In: Baum, A.; Contrada, R., editors. The handbook of stress science. Springer; New York: p. 345-58.

Haffner S, Taegtmeyer H. 2003. Epidemic obesity and the metabolic syndrome. *Circulation*, 108: 1541–1545.

Hansen PE, Floderus B, Frederiksen K, Johansen C. 2005. Personality traits, health behavior, and risk for cancer: a prospective study of Swedish twin court. *Cancer*, 103:1082–91.

Hess C, Reif A, Strobel A, Boreatti-Hümmer A, Heine M, Lesch KP, *et al*. 2009. A functional dopamine-beta-hydroxylase gene promoter polymorphism is associated with impulsive personality styles, but not with affective disorders. *J Neural Transm*., 116:121–30 doi: 10.1007/s00702-008-0138-0.pmid:18982239 View Article PubMed/NCBI Google Scholar

High Blood Pressure in African-Americans. American Heart Association, Inc 2015.

Hobgood DK. 2011. ABO group B is associated with personality traits through linkage disequilibrium with low activity dopamine beta hydroxylase. Hypothesis in the Life Sciences, 1:1–8View Article PubMed/NCBI Google Scholar.

Hobgood DK. 2011. Personality traits of aggression-submissiveness and perfectionism associate with ABO blood groups through catecholamine activities. *Medical Hypotheses*, 77: 294–300. doi: 10.1016/j.mehy.2011.04.039. pmid:21601990View Article PubMed/NCBI Google Scholar

Holmes ME, Ekkekakis P, Eisenmann JC. 2010. The physical activity, stress and metabolic syndrome triangle: a guide to unfamiliar territory for the obesity researcher. *Obes Rev*., 11(7): 492–507. (PubMed: 19895413)

Kapoor Shalini, Kumar Rajesh, Arora Neeraj, 2012. Association of ABO Blood Groups with Lipid Profile and the Level of Oxidative Stress in Hypertensive Patients. *Trends in Biosciences*, 5(3) :191-195

Karakas M, Baumert J, Kleber ME, *et al*. 2012. A variant in the ABO gene explains the variation in soluble E-selectin levels-results from dense genotyping in two independent populations. Plos one. December 7 (12) | e51441

Kelso A J, Siffert T, Maggi W. 1992. Association of ABO pheno- types and body weight in a sample of Brazilian infants. *Am J Human Biology*, 4:607–11

La Grange L, Jones TD, Erb L, Reyes E. 1995. Alcohol consumption: biochemical and personality correlates in a college student population. *Addict Behav*., 20:93–103. pmid: 7785486View Article PubMed/NCBI Google Scholar

Liumbruno GM, Franchini M. 2013. Beyond immunohaematology: the role of the ABO blood group in human diseases. *Blood Transfus*., 11: 491-9.

Lowe JB. 1993. The blood group-specific human glycosyltransferases. *Baillieres Clin Haematol*., 6: 465-92.

Mascie-Taylor CG, Lasker GW. 1990. Lack of an association be- tween ABO and Rh blood group polymorphisms and stature, body weight, and BMI in a cohort of British women. *Hum Biol*., 62:573-6.

Meo, S.A., F.A. Rouq, F. Suraya, S.Z. Zaidi, 2016. Association of ABO and Rh blood groups with type 2 diabetes mellitus. *European Review for Medical and Pharmacological Sciences*, 20:237-242

Nemesure B, Wu S, Hennis A, Leske C. 2006. Hypertension, type 2 diabetes, and blood groups in a population of African ancestry. *Ethnicity and Disease*, 16:822-829

Neumann JK, Arbogast BW, Chi DS, Arbogast LY. 1992. Effects of stress and blood type on cortisol and VLDL toxicity preventing activity. *Psychosom Med*., 54:612-9.

Nunn AV, Bell JD, Guy GW. 2009. Lifestyle-induced metabolic inflexibility and accelerated ageing syndrome: insulin resistance, friend or foe? *Nutr Metab (Lond.)*, 6: 16.

Nwafor A, Mmom FC, Obia O, Obiandu C, Hart VO, Chinko BC. 2015. Relationship between blood pressure, blood glucose and body mass index and coexisting prehypertension and prediabetes among rural adults in Niger Delta Region, Nigeria. *British Journal of Medicine & Medical Research*, 9(7): 1-12.

Ogden LG, Stroebele N, Wyatt HR, *et al*. 2012. Cluster analysis of the national weight control registry to identify distinct subgroups maintaining successful weight loss. *Obesity*, 20(10): 2039–47. (PubMed: 22469954)

Paré G, Chasman DI, Kellogg M, *et al*. 2008. Novel association of ABO histo-blood group antigen with soluble ICAM- 1: results of a genome-wide association study of 6,578 women. *PLoS Genet*, 4: e1000118.

Paterson AD, Lopes-Virella MF, Waggott D, Boright AP, Hosseini SM, *et al*. 2009. Genome-wide association identifies the ABO blood group as a major locus associated with serum levels of soluble E-selectin. *Arterioscler Thromb Vasc Biol*., 29: 1958–1967.

Peter J. D'Adamo. 2008-2010. Blood group genetics, exercise and stress Copyright 2008-2010. Available from: http://www.dadamo.com/txt/index.pl?1002 . Accessed on: 22/3/17

Rosengren A, Hawken S, Ounpuu S, *et al*. 2004. Association of psychosocial risk factors with risk of acute myocardial infarction in 11,119 cases and 13,648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet*, 364(9438): 953–62. (PubMed: 15364186)

Rozanski A, Blumenthal JA, Kaplan J. 1999. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation, 99(16): 2192–217. (PubMed: 10217662)

Sapolsky RM. 1999. Glucocorticoids, stress, and their adverse neurological effects: relevance to aging. *Exp Gerontol*., 34(6): 721–32. (PubMed: 10579633)

Segerstrom SC, Miller GE. 2004. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. *Psychol Bull*., 130(4):601–30. (PubMed: 15250815)

Shahnam M, Roohafza H, Sadeghi M, Bahonar A, Sarrafzadegan N. 2010. The correlation between lipid profile and stress levels in central Iran: Isfahan healthy heart program. *ARYA Atheroscler*., 6:102-6.

Sherington R, Curtis D, Brynjolfsson J, Moloney E, Rifkin L, Petursson H *et al*. 1994. A linkage study of affective disorder with DNA markers for the ABO-AK1-ORM linkage group near the dopamine beta hydroxylase gene. *Biol Psychiatry*, 36(7): 434-2.

Siervo M, Wells JCK, Cizza G. 2009. The contribution of psychosocial stress to the obesity epidemic: an evolutionary approach. *Horm Metab Res*., 41(4): 261–70. (PubMed: 19156597)

Slipko Z, Latuchowska B, Wojtkowska E. 1994. Body structure and ABO and Rh blood groups in patients with advanced coronary heart disease after aorto-coronary by-pass surgery. *Pol Arch Med Wewn*, 91:55-60.

Song J, Chen F, Campos M, *et al*. 2015. Quantitative Influence of ABO Blood Groups on Factor VIII and Its Ratio to von Willebrand Factor, Novel Observations from an ARIC Study of 11,673 Subjects. *PLoS One*, 10: e0132626.

Steptoe A. and Molloy GJ. 2007. Personality and heart disease. Heart, 93:783–4. pmid:17569802 View Article PubMed/ NCBI Google Scholar

Storry JR. and Olsson ML. 2009. The ABO blood group system revisited: a review and update. *Immunohematology*, 25: 48-59.

Suadicani P, Hein HO, Gyntelberg F. 2005. Airborne occupational exposure, ABO phenotype, and risk of obesity. *Int J Obes*., 29: 689-96.

Tanis B, Algra A, van der Graaf Y, Helmerhorst F, Rosendaal F. 2006. Procoagulant factors and the risk of myocardial infarction in young women. *Eur J Haematol*., 77(1):67–73.

The Interplay of Biological, Behavioral, and Societal Influences. Health and Behavior: Biobehavioral Factors in Health and Disease Washington (DC): National Academies Press (US). 63 p. 2001.

U.S. Department of health and human services, National Institute of Diabetes and Digestive and Kidney Diseases (2014): What African Americans with Diabetes or High Blood Pressure Need to Know.

Wang J, Zhu Y, Jing J, Chen Y, Mai J, Wong SHS, O'Reilly J, Ma L Relationship of BMI to the incidence of hypertension: a 4 year's cohort study among children in Guangzhou, 2007–2011. BMC Public Health 2015; 15:782

Wilson AF, Elston RC, Siervogel RM, Tran LD. 1988. Linkage of a gene regulating dopamine-beta-hydroxylase activity and the ABO blood group locus. *Am J Hum Genet*, 42:160–6. pmid:3422127 View Article PubMed/NCBI Google Scholar.

Woolley CS, Gould E, McEwen BS. 1990. Exposure to excess glucocorticoids alters dendritic morphology of adult hippocampal pyramidal neurons. *Brain Res*., 531(1–2): 225–31. (PubMed: 1705153)

Yamamoto F, Clausen H, White T, *et al*. 1990. Molecular genetic basis of the histo-blood group ABO system. *Nature*, 345: 229-33.

Yao L, Herlea-Pana O, Heuser-Baker J, Chen Y, Barlic-Dicen J. 2014. Roles of the chemokine system in development of obesity, insulin resistance, and cardiovascular disease. *J Immunol Res*., 181450.

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