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Association of ABO Blood Group Antigens and Body Mass Index in Sudanese Students in Faculty Medicine of International University of Africa

A thesis Submitted for Partial Requirement of M.Sc. Degree in Human Physiology

By:

Mohamed Abdullah Elsiddig

B.Sc. in Basic Medical Sciences

Faculty of Basic Medical Sciences

Omdurman Islamic University

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Supervisor:

Dr. Mohamed Elshiekh Saeed

Assistant Professor of Physiology

December, 201

DECLARATION

This thesis is a presentation of my original research work.

Wherever contributions of others are involved, every effort is made indicate this clearly with due reference to literature, and acknowledgement of collaborative research and discussion.

The work was done under the guidance of Dr. Mohamed .El.shiekh Saeed at the

International University of Africa, Khartoum, Sudan. In my capacity as supervisor of the candidates thesis.

I certify that the above statements are true to the best of my knowledge

Mohamed A.Siddig

Mohamed alawy

Dec.2019

Dedication

To my parents..mother and father ..their words, advises,

infinite supporting ,patience all over years ..

My teachers. And every researcher asking about the truth…

To my home…Sudan presented it as is stepping forward..

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All praise and thanks to Allah who pleased to me by putting all those wonderful people on my way for preparation and completion this study

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Abstract

Background: Many studies have supported a number of associations between ABO blood type and certain diseases, including pancreatic cancer, venous thromboembolism, and myocardial infarction in the presence of coronary atherosclerosis, sexual maturity, breast cancer, cancer, infections, Diabetes mellitus, cardiovascular diseases ,hypertension, peptic ulcers, intelligence and socioeconomic class ,personality, suicide ,BMI and obesity . The ABO blood group is one such pivotal genetic determinant that can give valuable information for early detection of risk population.

The present study aims to investigate and to reveal the relationship between ABO blood groups and body mass index (BMI) among Sudanese medical students

Method: by using the cross –sectional study involve 105 medical students ,53 male ,52 female ,in a group of age 16 and 32 International Africa University (IUA),faculty of medicine. Weight, height for BMI and blood groups were determined in order to find any association between ABO blood group and BMI.

Result: Blood group O+ was most prevalent 28.6 % followed by A+ 25.7 %, B+ 23.8 %, O- 8.6 %, AB+ 4.8, A- 4.8 %, B- 1.9 % and AB- 1. Obesity was insignificantly (p= 652) as in our study we did not observe any significant difference regarding the ABO blood group in relation to , BMI, and Rhesus blood group. The prevalence of overweight observed in this study is similar to that of a cross-sectional study conducted among sampled students in other studies.

Conclusion: This study provides a ground for future research to confirm or refute the hypothesis of ABO type association with BMI

Abstract (Arabic)

الخلفية :دعمت العديد من الدراسات عددًا من الارتباطات بين فصيلة الدم ABO وبعض الأمراض ، بما فيذلكسرطانا لبنكرياس ، الجلطات الدموية الوريدية ، واحتشاء عضلة القلب في وجود تصلب الشرايين التاجية ، والنضج الجنسي ، وسرطان الثدي ، والسرطان ، والتهابات ، ومرض السكري ، وأمراض القلب والأوعيةالدموية ، ارتفاع ضغط الدم ، القرحة الهضمية ، الطبقة الاجتماعية والاقتصادية ، الشخصية ، الانتحار ، مؤشر كتلة الجسم والسمنة .تعد فصيلةالدم ABO أحد المحدد ات الوراثية المحورية التي يمكن أن تعطي معلومات قيمة للكشفا لمبكر عن السكان المعرضين للخطر.

الطريقة :تهدف هذه الدراسة إلى التحقيق والكشف عن العلاقة بين فصائلالدم ABO ومؤشر كتلةالجسم (BMI)بين طلاب الطب السودانيين باستخدام دراسة مقطعية تشمل 105 طلاب الطب ، 53 من الذكور ، 52أنثى ، في مجموعة من سن 16 و 32 جامعة إفريقيا العالمية (IUA) ، كلية الطب .تم تحديد الوزن والطول لمؤشر كتلة الجسم وفصائل الدم من أجل إيجاد أيارتباط بين فصيلةالدم ABO ومؤشر كتلة الجسم.

النتيجة :كانت مجموعة الدم + O أكثر انتشارًا بنسبة28.6 ٪ ، تليها25.7 + A ٪ ،23.8 + B ٪ ، O- 8.6٪ ، AB + 4.8 ، A- 4.8٪ ، B- 1.9٪ و AB- 1. كانت السمنة غيرملحوظة) ع (652 = كماهو الحال في دراستنا ، لمنلاحظأ يفرق مهم فيما يتعلق بفصيلة الدم ABO فيما يتعلق بفصيلة الدم Rhesus. وBMI يشبهان تشار زيادة الوزن التي لوحظت في هذه الدراسة انتشار دراسة مقطعية أجريت بين طلاب العينة في دراسات أخرى.

خاتمة :توفر هذه الدراسة أساسًا للبحث المستقبلي لتأكيد أودحض فرضيةا رتباط نوع ABO مع مؤشر كتلة الجسم

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Abbreviation

Abbreviations	Page	meaning
AB		Before date of birth
ABH		antigens
ABO		Blood antigen system
A1&A2		Alleles of Major blood group
BGMUT		Blood Group antigen gene Mutation database
BMI		Body mass index
C		C terminal of protein
CH/RG		Chido/Rodgers
C>T		Cytosine and thiamine
Co		Colton
cDNA		Cyclic dineuclic acid
Di		Diego
DM		Diabetes mellitus
Do		Dombrock
Fuc		fructose
Fy		Duffy
Gal		galactose
GE		Gerbich
GalNAc		galactosamine

Glc		glucose
GlcNAc		glucosamine
GTA		acetylgalatosaminyltransferase
GTB		galactosyltransferase
H		histidine
Jk		Kidd
K		Kell
Lea&leb		Blood cells phenotype
Mn2+		Manganese
MNSs		Other blood antigen system
N		N terminal of protein
OH-3		Hydroxyl terminal of peptide
OK		Other blood group
RBCs		Red blood cells
RE		Endoplasmic reticulum
Rh		Rhesus antigen in blood
UDP		Uridinediphosphate -
Yt		Cartwright
WHO		World health organization

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Introduction

1.1 Background:

The distribution pattern of the ABO blood antigen varies by the prevalence type among different populations in the world. The association between ABO blood group and several elements of the human population such as intelligence (1), socioeconomic status (2), diet (3), diseases (4), and others has long been suggested. Some of these reports such as from Gibson et al. (1) and Beardmore and Karimi Booshehri (2) linking ABO blood type to intelligence and socioeconomic class, respectively, have been decades old, and the potential mechanism by which ABO antigens determine these consequences was not underscored. Furthermore, D'Amato's (3) popular blood type diet, without proven scientific evidence, was theoretically based on the belief that each ABO blood group carries the genetic.

According to World health organization, body mass index (BMI) is defined as a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It provides a measure to determine the distribution of fat in children and adults. The precision of measurements of height and weight suggests that a variant for height for weight provides a more reliable measure of adiposity within populations (5, 6). Obesity and overweight both are harmful for health (7). Obesity that is defined by World Health Organization (WHO) as abnormal and excessive fat accumulation (8) has become an epidemic

due to changing eating habits and inactive life style (9). According to WHO Fact Sheet, there were more than 1.9 billion adults (18 years and older) and 41 million children (5 years and younger) who were overweight in 2014 (3). This shows that obesity and overweight has become a serious problem in the world.

ABO blood group and BMI have individually been appraised as risk factors for certain illnesses, few studies (11 – 13) have been conducted to examine whether carrying a particular ABO blood antigen potentially predisposes one to higher body mass index. These studies, have arrived at different conclusions on whether ABO status associates or does not associate with BMI .Due to the racial and ethnic disparities existing among different people globally, population-based studies are relevant. To our knowledge, no study has been done to test the association of BMI and ABO blood group in a Sudanese people.

1.2 Justification:

This study was undertaken to investigate the distribution and association of ABO blood group and BMI categories in a Sudanese population.

1.3 Objectives:

1.3.1 General objective:

To investigate the distribution and association of ABO blood group and BMI categories in a Sudanese population.

1.3.2 Specific objectives:

To measure the ABO antigens among study groups

To measure rhesus antigen among study groups

To correlate ABO and Rhesus factor to BMI

2. Literature Review

2.1 History of blood antigen:

An ancient ABO-like gene is believed to have existed as early as 40 million years ago with the evolution of the ABO gene starting at least 13 million years ago (14). Several phylogenic studies suggest that A, B and O lineages developed between 1 to 4 million years ago (15). In 1901 Karl Landsteiner reported testing red blood cells and sera from six healthy men and discovery of the ABO blood group system, for which he earned the Nobel Prize in 1930. In 1911 von Dungern and Hirschfeld reported the distribution of blood group A (47 %), B (11%), AB (6%) and O (36%) in Europeans, and separation of blood group A into A1 and A2. In 1926 and 1930 Yamakai, Lehres and Putkonen found soluble ABO blood group substances in secretions and could divide them into two groups, secretor and non-secretor (16). In 1924 Bernstein proposed the theory of inheritance (17) that still holds true today. Several researchers isolated ABO blood group determinants from glycoproteins (reviewed by Morgan & Watkins 2000)(16) and the study of ABO glycolipids became popular, with most of the basic ABO structures being resolved during this period (18, 19). On the back of the new genetics revolution Yamamoto identified cDNA of the α1→3N-acetylgalactosaminyl transferase (A-transferase) (20) in 1990, and by doing so opened the door for genomic studies of ABO blood group system. For the next 20 years a wave of ABO gene discovery continued and

by 2009 a total of 215 ABO alleles had been reported (21), and new alleles still continue to be identified and reported (22).

2.2 The ABO System:

The ABO blood group system is defined by the presence or absence of two antigens (A and B) and is recognized as four major blood group phenotypes A, B, AB and O. The antigens are inherited according to Mendel's law, where one haplotype from each parent is inherited. The frequency in the European population is reported as blood group A 41.7%, B 8.5%, AB 3.0% and O 46.7% (23), but the frequency varies significantly in different ethnic groups.

ABO antigens exist on glycoproteins and glycolipids in red cell membranes and also on most cells and tissues in humans, and in animal tissues. The antigens are also present in the secretory fluids in the majority of humans. Thus the term "histoblood group system" is a more accurate description than "blood group system". The antigens are unequally expressed among and within the different cells and tissues and in different species (24, 25). Except for humans, only anthropoid apes, the orangutan and the gorilla have ABO antigens on their red cells, which suggest that the red cells are the last cells during evolution to obtain the ABO antigens (23). A, B and H antigens are carbohydrate molecules built stepwise from saccharides such as galactosamine (GalNAc), glucosamine

(GlcNAc), fucose (Fuc), galactose (Gal), and glucose (Glc). The synthesis is catalyzed by glycosyltransferases encoded by the ABO genes, and thus A and B antigens are secondary gene products. The major alleles at the ABO locus are A, B and O and to-date a number of ABO blood groups variants have been reported, with approximately 250 different alleles registered in the Blood Group antigen gene Mutation database (BGMUT) (26).

2.2.1 ABO Genetics:

The ABO gene is located at the long arm of chromosome 9q34 [27] and consists of seven exons and introns, covering approximately 20 kilo base pairs from the initiation to the stop codons. The nucleotide sequence of the A allele cDNA consists of 1062 base pairs, and encodes the enzyme protein (28). The cDNA (the A1 allele, [A101]) encoding the N-acetylgalactosamine transferase was cloned and sequenced by Yamamoto et al (20) and is considered as the consensus (index) gene against which all other variant of ABO genes are compared. The ABO genes are very polymorphic both between and within the blood groups; however several main mutations in the genes are characteristic for some ABO blood groups. The A2 allele [A201] has a substitution at nucleotide 467 (C>T) and a deletion (C) involving nucleotides 1059 to 1061, which extend the transferase with 21 amino acids, causing a less effective enzyme (29).

2.2.2 ABO glycosyltransferases:

ABO antigens are secondary products of ABO gene defined specific enzymes, so called glycosyltransferases. N-acetylgalatosaminyltransferase (GTA) and galactosyltransferase (GTB) are the enzymes encoded by the ABO genes. GTA and GTB catalyze the transfer of GalNAc (using UDP-GalNAc) or Gal (using UDPGal) to the OH-3 position of the terminal Gal of the H structure (Fucα2Gal) to create A and B antigens, respectively (33). Manganese ions (Mn2+) are required as a co-factors and the disaccharide Fucα1-2Gal residue is the minimal required acceptor. These glycosyltransferases, and others that construct the requisite precursors, reside mostly in the endoplasmatic reticulum (RE) and Golgi apparatus. The glycosyltransferases are type II transmembrane proteins, and exist both membrane-bound and as soluble proteins in plasma and other body fluids. The membrane-bound enzyme has a short cytoplasmic N-terminal tail, a hydrophobic transmembrane domain, a stem region, plus a large C-terminal which constitutes the catalytic domain. The soluble transferases lack the N-terminal and the hydrophobic transmembrane domain (33).

2.2.3 ABO biochemistry:

The majority of ABO antigens on red cells are linked to glycoproteins (approximately 70%), thus they very much influence the blood group activity on

the red cells. However this thesis only describes glycolipids and very little will be mentioned about the unknown contribution of glycoproteins to the phenotype. Glycolipids are chosen because they are relatively structurally less complex than glycoproteins, easier to isolate to homogeneity, are usually representative of a single biosynthetic process, and can be relatively easily structurally resolved. The ceramide part in the glycolipid is formed by a fatty acid in amide linkage to a sphingosine, which is anchored in the cell membrane (36). The configuration of the carbohydrate chain of the four core structures (table 1) differs and can cause the ABO glycotopes to be presented differently on the surface membrane. Type 1 is nearly vertical to the cell membrane while type 2, 3 and 4 are bent more or less parallel in their minimum energizing state. Furthermore, rotations of the carbohydrate chains may cause the A determinant to point in different directions. This presentation of the antigen on the cell surface may affect the susceptibility for antibody and microbial binding (37).

Other than the A1 and A2 phenotypes the contribution of the various ABO antigen bearing structures to the serological phenotypes observed is largely unknown.

2.2.4 Relation of ABO system with other Groups

The ABO Blood group system is discovered by the Austrian scientist Karl Landsteiner, who found three different blood types in 1900. He was awarded

Nobel Prize in 1930. Alfred Von Decastello and Adriano Sturli discovered the fourth type 'AB' in 1902 (38**).**

The epitopes of ABO antigens are determined by carbohydrates (sugars), which are linked either to polypeptides (forming glycoproteins) or to lipids (glycolipids). Antigenic differences between different species were recognized before differences within a species. Landois discovered that when the red blood cells of an animal, e.g. a lamb, when mixed with the serum of another animal (a dog) and incubated at 370C they will be lysed within 2 min (39).Landsteiner was prompted by the work of Landois to see whether it was possible to demonstrate differences, although presumably slighter ones, between individuals of the same species. As he later explained, he chose the simplest plan of investigation and simply allowed serum and red cells from different human individuals to interact (40). He discovered that the red cells agglutinate if blood is incompatible and lead to discovery of ABO blood group system.

2.2.5 MNS systems:

After the discovery of the ABO Blood group system no new blood group systems were found for 25 years. Landsteiner and Witt examined human sera for antibodies other than anti-A and anti-B but could find only weak agglutinins active at low temperatures (41). It occurred to Landsteiner and Levine that they might be able to

reveal other antigens by injecting different samples of human red cells into rabbits. Antibodies identifying three new human antigens were obtained (42); to the first of these the letter M was given to indicate that the antigen had been identified with immune serum ('I' was avoided because of confusion with the numeral (43).

2.2.6 The Rhesus System:

Antibodies demonstrating Rh polymorphism in humans were found in two different ways. Landsteiner and Wiener injected the red cells of rhesus monkeys into rabbits and guinea pigs and tested the resulting serum against human red cells (44). Meanwhile, Levine and Stetson in 1939 found an antibody (which subsequently proved to be anti-Rh) in the serum of a recently delivered woman whose fetus had died in utero (45).

2.2.7 Bombay Blood Group H-antigen:

H-antigen is the precursor to the ABO blood group antigens. It is present in all RBCs irrespective of the ABO system. Persons with the rare Bombay phenotype are homozygous for the H gene (HH), do not express H-antigen on their RBCs. As H-antigen acts as precursor, its absence means the absence of antigen A and B. However, the individuals produce iso-antibodies to H-antigen as well as to antigens A and B (46).

Individuals belonging to Bombay blood group (oh) (46) are homozygous for the absence of H gene i.e., they are of the genotype 'hh', so that they are unable to bring about the initial part of conversion of the precursor blood group substance (47). This means that even if 'A' and 'B' genes are present, they have no substrate for their normal function of producing 'A' and 'B' blood group substances (48). The ABO genes cannot therefore be expressed and such individuals appear to belong to 'O' but their true state can be detected because of the presence in their serum of anti-H .Thus the 'Bombay phenotype' , lack 'A', 'B' and 'H' antigens on their erythrocytes and in secretions. Nevertheless they appear to have normal 'A' and 'B' genes that can be expressed in the next generation if their children acquire an 'H' gene from the other parent (49). It follows that there is no 'O' antigen; group 'O' erythrocytes and the saliva of group 'O' secretors contain 'H' antigen, but the designation group 'O' erythrocytes has been retained for historical reasons (50).

2.2.8 Lewis Blood Group System:

The Work of Mourant (1946) and subsequent work of Grubb (1951) and Ceppellini (1955)(51) showed that Lewis antigen is also found on red blood cells and is related to ABO system and secretion of ABH antigens. There are two types of Lewis antigen and designated as Lea and Leb respectively, and give rise to three red blood cell phenotypes which are designated as Le(a - b+), Le(a + b -), Le(a - b -). The synthesis of Le antigen is regulated by the independent gene Le. The

Lewis antigen appears on the same glycoproteins as the ABH determinants (51). These antigens are synthesized from the same precursor substance as ABH antigen (52).

2.2.9 Other blood group systems:

The structure and functions of the membrane proteins and glycoprotein carrying blood group antigens have been reviewed by carton (53)and Daniels(54) .The H antigen content of red cells depends on the ABO group and when assessed by agglutination reactions with anti-H, the strength of reaction tends to be graded O> A2 > A2B > B > A1 > A1B. Other subgroups are occasionally found. The A, B, and H antigens are detectable early in fetal life but are not fully developed on the red cells at birth. The number of antigen sites reaches adult level at around 1 year of age and remains constant until old age, when a slight reduction may occur. The ability to secrete A, B and H substances in water soluble form is controlled by FUT2 (dominant allele Se).

Between 1946 and 1971 the Kell (K), Duffy (Fy), Kidd (Jk), Diego (Di), Cartwright (Yt), Xg, Sc, Dombrock (Do) and Colton (Co), Lewis and Lutheran blood group systems were discovered. As shown in table 1.0, twenty-five blood group systems have been given numbers so far (41). In numerical order, systems

001-025 are: ABO, MNSs, P1, Rh, Lu, Kell, Lewis, Fy, Jk, Di, Yt, Xg, Sc, Do, Co, LW, Chido/Rodgers, Hh, Kx, Ge (Gerbich), Cromer, knops, Indian, Ok.MER2

2.3 Important of ABO system:

Epstein and Ottenberg in 1908 suggested that ABO blood groups were inherited, and this was confirmed by Von Dungern and Hirsfeld in 1910. The exact manner was published by Bernstein in 1924(55). Attempts were made earlier to 1900, to replace blood, for example, in cases of hemorrhage, by transfusion of a donor's blood. In some instances, the therapy met with success and in some severe as well as fatal hemolytic reaction occurred. In other words, blood of some people was compatible and that of others incompatible. One could not understand the cause of this phenomenon at that time and they attributed it to some unknown immunological differences between the recipient and the donor.

Table 1. Blood group systems recognized by the ISBT working party

System number	System name conventional	System symbol ISBT	chromosomal location	Gene (s)
1	ABO	ABO	9q34.1-q34.2	ABO
2	MNS	MNS	4q28-q31	GYPA, GYPB
3	P	PI	22q11.2-qter	P
4	Rh	RH	1p36.2-p34	RHD, RHCE
5	Lutheran	LU	19q12-q13	LU
6	Kell	KEL	7q33	KEL
7	Lewis	LE	19p13.3	FUT3
8	Duffy	FY	1q22-q23	FY
9	Kidd	JK	18q11-q12	HUT11
10	Diego	DI	17q12-q21	SLC4A1
11	Yt	YT	7q22	ACHE
12	Xg	XG	Xp22.32	XG
13	Scianna	SC	1p36.2-p22.1	SC
14	Dombrock	DO	12p13.2-p12.1	DO
15	Colton	CO	7p14	AQP1
16	LW	LW	19p13.2-cen	LW
17	chido/Rogers	CH/RG	6p21.3	C4A,C4B
18	H	H	19q13	FUT1
19	Kx	XK	Xp21.1	XK
20	Gerbich	GE	2q14-q21	GYPC
21	Cromer	CROM	1q32	DAF
22	Knops	KN	1q32	CR1
23	Indian	IN	11p13	CD44
24	Ok	OK	19pter-p13.2	OK
25	MER2	RAPH	11p15	MER2

In 1875, Landois noticed that if red blood cells of an animal of one species were mixed with serum from an animal of another species, clumping or agglutination of red blood cells usually occurred (55).The phenomenon was recognized as being similar to that which followed the mixing of bacteria with appropriate immune sera.

Landsteiner from his observations stated “if an agglutinogen is present on the red blood cells of a blood, the corresponding agglutinin is absent from the plasma; if the agglutinogen is absent the corresponding agglutinin must be present (56). This statement is popularly known as Land Steiner's law. The Landsteiner law, however, is not always true, for example, 'Rh' negative persons need not and normally do not contain anti-Rh agglutinin but may develop the agglutinin as a result of immunological response (Sensitization). When 'Rh' positive red blood cells enter the subject's circulation during blood transfusion or maternal circulation from the 'Rh' positive foetus.

Landsteiner (1901) and later workers, namely, Jansky (1907) and moss (1907) showed that the red blood cells of all the individuals can be grouped according to the presence of two blood group substances or agglutinogens called 'A' and 'B', into four main blood groups 'A', 'B', 'AB' and 'O' (57). Table 2.0 shows blood group phenotype, antigen present on red blood cells and agglutinins present in Plasma (serum):

Group 'A' is further subdivided into 'A1' and 'A2'. Anti-A serum contains two antibodies anti-A and anti-A1; it is generally believed that 'A1' has two antigens, 'A' and 'A1', while 'A2' has only one 'A'. 'A2' cells react weakly with anti-A serum; hence a high titre serum is necessary while grouping; 'A2B' cell react even less readily with anti-A serum. The subgroups of An increase the number of groups from four to six; 'A1' ,'A2' ,'B', 'A1B' , 'A2B' and 'O.'

The main four groups of ABO system are inherited as Mendelian characters by three allelic genes, A, B, and O

(Thompson, R.B. et al.,). The dominant 'A' and 'B' determine the presence or absence of the corresponding blood group substance so that an individual who inherits an A gene from each parent will be of genotype 'AA', and similarly with 'B'. The inheritance of 'A' from one parent and 'B' from the other will result in the genotype 'AB'. The 'O' gene may be paired with either 'A' or 'B' but has no suppressive effect so that an individual of genotype 'AO' or 'BO' reacts as group 'A' or 'B' respectively. When 'O' gene inherited from each parent the genotype is 'OO' and the

Table 2. Genotyping of ABO system

Genotype	Group
AB	**AB**
AA or AO	**A**
BB or BO	**B**
OO	**O**

2.4 Rhesus group:

The Rh blood group system was first described 60 years ago. A woman had a severe transfusion reaction when she was transfused with blood from her husband following delivery of a stillborn child with erythroblastosis fetalis. Her serum agglutinated red blood cells (RBCs) from her husband and from 80% of Caucasian ABO compatible donors (58).

The following year, Landsteiner and Wienr (59) found that sera from rabbits (and later guinea pigs) immunized with RBCs from Macaca mulatta (Macacus rhesus in the original paper) agglutinated 85% of human RBC samples. Initially, it was thought that the animal and human antibodies identified a common factor, Rh, on the surface of rhesus and human RBCs. It was soon realized that this was not the case (60). Therefore, the original terms (Rh factor and anti-Rh) coined by Landsteiner and Wiener, although being misnomers, have continued in common

usage. The heteroantibody was renamed anti-LW (after Landsteiner and Wiener), and the human alloantibody was renamed anti-D (61).

Even after Karl Landsteiner's discovery in 1900, transfusion reactions were still prevalent (62). It was not until 1940 when Landsteiner and Weiner discovered the Rh factor that transfusion medicine involved less risk. Immunogenicity of the Rh factor along with A, B antigens made it mandatory for pre-transfusion testing (63). Currently there are more than 50 antigens in the Rh blood group system but the principal Rh antigens of medical interest are D, C, E, c and e (16). A person with Rhesus antigen is referred to as Rhesus positive while individuals lacking the antigen are Rhesus negative. When a Rhesus negative person is exposed to Rhesus positive blood, antibodies will be produced, which cause potentially fatal haemolytic reactions

2.5 Body Mass Index (BMI):

Body mass index (BMI) is a mathematical calculation that estimates a person's health status based on his height and weight (65). BMI is used generally to assess a person's risk for various chronic diseases such as diabetes, cardiovascular disease, stroke, cancer and numerous more (65). BMI functions by categorizing people into four different weight categories that are used to classify a person's health and allows physicians and researchers to easily communicate with the public about

potential health issues encountered in that category (66). Much of the initial research was performed over a decade ago; however, there is some still being performed today. Researchers have and continue to look at the link between BMI and chronic diseases such as diabetes, hypercholesteremia, and hypertension, as well as its association with waist circumference. Along with this, researchers have expanded their research to new areas involving BMI like looking at childhood BMI as a potential predictor of health later in life.

BMI and waist circumference Body mass index and waist circumference are two measurement tools commonly used to evaluate obesity. Chinedu et al. (67) examined the two tools to see if there was a correlation between them. They examined 489 Nigerian participants aged 18-75 years for waist circumference, height, and weight. The results showed a significant, positive relationship between BMI and waist circumference ($r=0.75$) indicating that as BMI increased so did waist circumference. Additionally, Gierach et al. (68) found similar results in a study of 839 participants aged 32-80 years diagnosed with metabolic syndrome. Researchers found that waist circumference was significantly associated with BMI ($r=0.78$) again indicating that with a higher BMI, participants tended to have a larger waist circumference. This correlation was stronger in women compared to men. However, no potential explanation was given for this. Abdominal obesity has frequently been studied and is determined to be a major factor in metabolic

syndrome. Nahuelcuera and Barria also found these results in a group of 188 Chilean adolescents and young adults aged 3-25 years (69) which suggests that this relationship may be present throughout the lifespan. Romero-Corral et al. (70) examined body mass index compared to bioelectric impedance analysis to determine body fat percentage. The cross-sectional study included 13,601 U.S. citizens excluding individuals that were unable to receive bioelectric impedance. . They found that BMI has a high specificity for detecting obesity but has a poor sensitivity meaning it often misses

2.5.1 Obesity:

Obesity that is defined by World Health Organization (WHO) as abnormal and excessive fat accumulation (82) has become an epidemic due to changing eating habits and inactive life style (83). According to WHO Fact Sheet, there were more than 1.9 billion adults (18 years and older) and 41 million children (5 years and younger) who were overweight in 2014 (84). This shows that obesity and overweight has become a serious problem in the world. It has been reported that obesity is an important risk factor for some types of diseases, such as metabolic syndrome, type 2 diabetes, cardiovascular diseases and cancer (85). Especially, metabolic syndrome is widespread and complicated disorder directly related to obesity (86).

2.5.2 Body mass index and ABO System:

There were attempts to disclose a possible relationship between ABO blood groups and various diseases in related literature. The potential relationship between ABO blood groups and various diseases, such as ischemic heart disease, coronary artery disease (87, 88), cancer (89), cardiovascular diseases (90), etc., have been investigated by many researchers for a last two decades. These studies have shown the strong relationship between blood groups and such diseases. This relationship contributes to diagnosis of the disease and supports the possible preventive measures to decrease the incidence (91). Additionally, several studies on relationship between ABO blood group and obesity has been also performed on different communities and subjects. Behera et al. (83) found that the blood group aB and rh (–) was associated with the highest number of obese subjects. Sukalingam and ganesan (92) and Qunq and abdel Hamid (93) revealed that the patients with blood group B were more susceptible to be obese compared to those with the other blood groups. Ainee et al. (94) and Krishnakanth et al. (95) found higher incidence of obesity among the children with blood group O as compared to children with the other blood groups. On the other hand, Jafari et al. (96) and Mascie-Taylor and lasker (97) revealed that there was no relationship between blood groups and BMI. Although ABO blood group and BMI have individually been appraised as risk factors for certain illnesses, few studies (98) have been

conducted to examine whether carrying a particular ABO blood antigen potentially predisposes one to higher body mass index. There are studies claiming relation of ABO blood groups to overweight and obesity (99). Some studies concluded that there was no association between development of obesity and a particular blood group. (100). Even though the blood group is a non-modifiable risk, having knowledge of association between obesity and blood group can help to make healthy life styles. These healthy life styles can be implemented in early life of at risk individuals as a preventive measure before the development of obesity and its complications.

3. Methodology

3.1 Study design:

Cross-sectional descriptive study.

3.2 Study area:

This study was conducted in Faculty of Medicine, Africa International University.

3.3 Study population:

Study population was included all Sudanese student in the Faculty of Medicine, Africa International University.

3.4 Sample size:

This is convenience study; sample size will be included one hundred thirty participants.

3.5 Data collection:

ABO and Rhesus antigens measurement:

All the blood samples were collected between 8am and 12 noon's each day. Blood samples (5mls) were obtained from each subject by veno-puncture into EDTA (ethylenediaminetetacetic salt) bottle and used for determination of blood groups and Rhesus factors. For ABO blood grouping, a drop of antiserum A, antiserum B

and anti AB was placed in clean tile and labelled 1, 2, and 3. To each anti sera was added a drop of 5% red blood cells, mixed thoroughly and observed for agglutination.

Similarly, for Rhesus D typing a drop of anti D serum was placed in a clean labelled tile, mixed with a drop of blood and watch for agglutination.

3.6 Anthropometric measurements:

Weight and height:

Calibrated weight measure scale was used weight measurement. Firstly, the person was asked to remove any heavy clothes or items; then person's feet were set onto the centre of the scale platform with feet slightly a part for better balance, and ask person to look straight and then record the weight.

For height measurement; the person was asked to remove his/her shoes prior to taking measurement; person was stand with his/her feet slightly a part and back as straight as possible with the heels, shoulder touch the surface of height board. Person will be asked to look straight ahead with head erect, the headpiece was placed flat against the wall at a right angle to the head, the headpiece was lowered until it firmly touches the crown of the head and the measurement was recorded.

3.7Anthropometric measurements of Body mass index (BMI):

BMI was calculated as weight kg/height squared (kg/m^2) and subjects were considered as underweight if their BMI were less than 18, normal weight if their BMI between 18 and 25, overweight if their BMI between 26 and 30 and obese if their BMI more than 30.

3.8 Statistical analysis:

Statistical Package for Social Science was used to analysis data. Data were presented as mean ± Std. Descriptive statistics of the mean standard deviation and standard error was used to examine the data. Student's t test for nonparametric data was used to compare the difference between the means of the two investigated parameters. The Pearson chi-square correlation analysis was used to determine the association between BMI and ABO blood group. Percentages for independent variables were calculated, and $p<0.05$ will be considered statistically significant.

Ethical consideration:

Ethical approval was obtained from Faculty of Medicine, Africa International University committee. Written informal consent was obtained from each participant in this study.

4. Results:

Descriptive statistics of study group:

As shown in table (3) the mean age of study participants was 19.89 ± 3.99 year and mean of height and weight were 168.97 ± 8.44 cm and 64.68 ± 15.14 kg respectively. The mean of systolic blood pressure of study participants were 118.79 ± 16.37 mmgH and the mean of diastolic blood pressure of study participants were 74,93 ± 8.02.

Table (3) Descriptive statistics of study participants

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	102	16	36	19.89	3.992
Height	104	153	197	168.97	8.447
Weight	105	35	112	64.68	15.146
Systolic	57	80	177	118.79	16.378
Diastolic	57	60	90	74.93	8.022
Valid N (listwise)	55				

Gender distribution of study participants:

In our study 50.5 % of study participants were male and 49.5 % of the study participants were female table (4).

Table (4**)** Gender distribution of study participants

Sex					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	53	50.5	50.5	50.5
	Female	52	49.5	49.5	100.0
	Total	105	100.0	100.0	

Blood group of participant's distribution:

Blood group O+ was most prevalent 28.6 % followed by A+ 25.7 %, B+ 23.8 %, O- 8.6 %, AB+ 4.8, A- 4.8 %, B- 1.9 % and AB- 1 %. Table (5).

Table (5) blood group of participant's distribution

Blood Group					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A+	27	25.7	26.0	26.0
	B+	25	23.8	24.0	50.0
	O+	30	28.6	28.8	78.8
	A-	5	4.8	4.8	83.7
	B-	2	1.9	1.9	85.6
	O-	9	8.6	8.7	94.2
	AB+	5	4.8	4.8	99.0
	AB-	1	1.0	1.0	100.0
	Total	104	99.0	100.0	
Missing	System	1	1.0		
Total		105	100.0		

Table (6) association of ABO blood group and BMI

Blood Group * BMI							
			BMI				Total
			(Lowest thru 18.00= Underweight)	(18.01 thru 25.00=Normal)	(25.01 thru 30.00= over weight)	(30.01 thru Highest= obese)	
Blood Group	A+	Count	24	2	0	1	27
		% within Blood_Group	88.9%	7.4%	0.0%	3.7%	100.0%
	B+	Count	20	3	1	0	24
		% within Blood_Group	83.3%	12.5%	4.2%	0.0%	100.0%
	O+	Count	23	1	4	2	30
		% within Blood_Group	76.7%	3.3%	13.3%	6.7%	100.0%
	A-	Count	4	0	1	0	5
		% within Blood_Group	80.0%	0.0%	20.0%	0.0%	100.0%
	B-	Count	1	1	0	0	2
		% within Blood_Group	50.0%	50.0%	0.0%	0.0%	100.0%
	O-	Count	8	1	0	0	9
		% within Blood_Group	88.9%	11.1%	0.0%	0.0%	100.0%
	AB+	Count	5	0	0	0	5
		% within Blood_Group	100.0%	0.0%	0.0%	0.0%	100.0%
	AB-	Count	1	0	0	0	1
		% within Blood_Group	100.0%	0.0%	0.0%	0.0%	100.0%
Total		Count	86	8	6	3	103
		% within Blood_Group	83.5%	7.8%	5.8%	2.9%	100.0%

Table (7) Chi-Square Tests degrees

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.951[a]	21	.652
Likelihood Ratio	18.429	21	.622
Linear-by-Linear Association	.063	1	.802
N of Valid Cases	103		

P value = .652 is more than 0.05 so it's considered insignificant

To investigate the distribution and association of ABO blood group and BMI categories in a Sudanese population.

5.1 Discussion:

The aim of our present study is investigated the distribution and association between blood group antigens, BMI categories and blood pressure. Our results demonstrated that Blood group O+ was most prevalent 28.6 % followed by A+ 25.7 %, B+ 23.8 %, O- 8.6 %, AB+ 4.8, A- 4.8 %, B- 1.9 % and AB- 1 %. In addition, our study did not observe any significant difference regarding the association between blood group antigens (ABO and Rhesus factor), BMI and blood pressure.

Previous study had reported the great importance of ABO blood group system in determining disease and health states. Not only ABO blood group system is important for determining hypertension, erythroblastosis fetalis, and blood transfusion and exchange reactions (101) but has also been shown to be relevant to conditions such as osteodysplasia and as genetic marker of obesity (101). More recent developments are exploring the relationship between ABO blood grouping and obesity (102), which was also one of the main objectives of current study. Relationship between Lewis blood grouping and obesity was extensively studied by Hein HO and his colleagues (102) and many other researchers; however the association between ABO blood group system and obesity is still to be hypothesized due to conflicting results documented by various researchers. With regards to susceptibility of various blood groups with obesity, in contrast our study

did not show any significant association between blood group antigens, BMI and blood pressure.

Our study showed that the most common blood group in our study population was O, followed by A, B and AB. These results were disagree to those reported by studies conducted in Swat, District Nowshera, Lahore, Gujranwala, Multan, Faisalabad and many other cities of Punjab (103). Incompatible to our results, studies from northern area reported blood group A to be the commonest blood group (104). Considering the least common blood group, all aforementioned studies were inconsistent with our study demonstrated blood group AB to be the least commonest blood group (`105). It was also consistently shown that like in our results, all ethnicities demonstrated greater population of Rhesus Positive individuals as compared to Rhesus negative. Confirmatory studies are required to elucidate the relationship between obesity and blood groups and to delineate the mechanistic basis of this association. Blood type O was the prevalent ABO blood group in the present study. This trend of result is similar to the report from studies by Acquaye (106) in Ghana and Eruetal. (107) in Nigeria. Also, studies by Bhatti et al. (108) in India and as well as Bhattacharyya et al. (109) in Pakistan have reported similar ABO blood group pattern. Worldwide distribution pattern has shown blood type O to be the most prevalent blood group followed by group B,

group A, and group AB (110), which is consistent with the findings in this present study.

Blood group O is hypothesized to offer the maximum protection to people who live in areas endemic for infectious diseases. Hence, the incidence of this blood group is very high in tropical regions of the world where infectious diseases are common and the clinical importance of this distribution is illuminate by the low malaria parasitemia seen in individuals with the blood group O who live in West Africa (111).

Reports in literature on the relationship between ABO blood group and BMI are inconsistent (112), with various authors associating increased BMI with the presence of particular ABO antigens, while others have shown no association between these two factors. Significant association was seen between ABO blood group and BMI among sampled populations from Pakistan (113), India (114), Malaysia (115), Nigeria (116), and Denmark.

5.2 Conclusion:

In the last we concluded that Blood group O+ was most prevalent followed by A+, B+, O-, AB+, A-, B- and AB-. Furthermore, prevalence of Rhesus positive factor was observed in this study. In addition, our study did not observe any significant difference regarding the association between blood group antigens (ABO and Rhesus factor), BMI and blood pressure.

5.3 Recommendation:

* Further studies need to be carried out to investigate relation between BMI and blood group O more thoroughly by investigating the mechanism behind it, to come up with more definitive conclusion.

* There is also need to identify the young peoples at risk of obesity in various regions.

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