

Original Article

Association of ABO/Rh Blood Group with Hypertension in Pre- and Postmenopausal Libyan women

Mahmoud M. Ashawesh*, Olla A. Bashimam¹, Falak F. Jebali¹

Department of Medical Laboratories Sciences, Faculty of Medical Technology, the University of Tripoli, Libya

*Corresponding author Dr Mahmoud M. Ashawesh Msc, PhD

<https://orcid.org/0000-0003-4581-043X>

Corresponding Email: M.ashawesh@uot.edu.ly

ABSTRACT

BACKGROUND AND AIM: Hypertension is a prevalent and significant public health issue worldwide, affecting a substantial portion of the population. While various risk factors have been implicated in the development of hypertension, including genetics, lifestyle, and hormonal changes, the role of ABO/Rh blood groups in hypertension remains underexplored, particularly in different stages of Libyan women's life. This research study aimed to investigate the potential association between ABO/Rh blood groups and hypertension in both pre- and post-menopausal Libyan women.

METHODOLOGY: This study was conducted over a four-month period on a diverse cohort of women aged 35 to 75 years. It involved a total of 200 hypertensive women divided into pre- (n=100) and post-menopausal (n=100) groups. It took place at Tripoli University Hospital, Tajoura Heart Centre and Total Care Clinic. Data were collected through structured interviews, clinical examinations, and blood sample analyses. Blood pressure (BP) measurements and blood group typing were performed using standard medical procedures. A statistical analysis was done using SPSS program version 26.

RESULTS: The distribution of ABO blood groups shows that blood group O is the most prevalent blood group among samples (58% in the pre- and 41% in post-menopausal hypertensives), whereas blood group AB is the least prevalent (only 9% in the pre-menopausal and 7% in post-menopausal hypertensives). One hundred and eighty-one (90.5%) were Rh +ve. Analysis of data revealed significant differences in age distribution as well as in the percentages of Rh +ve and Rh -ve blood groups among pre- and post-menopausal women ($p < 0.05$). However, there was no statistically significant difference in the mean values of BP indices between ABO/Rh blood groups ($p > 0.05$).

CONCLUSION: This study showed that ABO/Rh blood group system does not significantly affect BP indices among the pre- and post-menopausal women. Findings of present study also illustrated that age could potentially influence the connection between blood groups and hypertension. Additionally, among ABO/Rh blood groups, the most observed type was 'O.' However, further investigation is necessary to validate these initial results and better understand the underlying mechanisms behind this relationship.

Keywords: ABO blood group, Rh blood group, hypertension, pre-menopausal, post-menopausal.

Citation: Ashawesh* Mahmoud, Bashimam Olla, Jebali Falak . Association of ABO/Rh Blood Group with Hypertension in Pre and Postmenopausal Libyan women. <https://doi.org/Ljmr18-1.09>. **Received:** 12/02/2024; **accepted:** 27/02/2024; **published:** 05/03/2024 Copyright ©Libyan Journal of Medical Research (LJMR) 2024. Open Access. Some rights reserved. This work is available under the CC BY license <https://creativecommons.org/licenses/by-nc-sa/3.0/igo>

INTRODUCTION

Hypertension is a significant comorbidity that profoundly affects the onset of various severe conditions such as stroke, myocardial infarction, and renal failure. It has been the subject of extensive research throughout the previous century [1]. The disorder is typically referred to as high BP and can generally be defined as a medical condition characterized by consistently elevated pressure within the arteries (≥ 130 and/or ≥ 80 mm Hg) [2]. Reports from the World Health Organization (WHO) have illustrated that around 1.28 billion adults globally between the ages of 30 and 79 are affected by hypertension, with 46% of them being unaware of their condition. In fact, this prevalence was higher, particularly in countries with low and moderate incomes [3]. Some of the regional heterogeneity in the prevalence of hypertension may be explained by variations in the levels of risk factors for hypertension, such as high salt intake, low potassium intake, obesity, alcohol consumption, physical inactivity, as well as poor diet [4]. Based on the results of a recent study conducted in Libya by Beaney, T *et al.*, in 2020 involving 7279 participants, it was found that 2567 (35.3%) individuals had hypertension, and among them, 63.4% were conscious of their hypertensive condition [5].

It has also been postulated that hypertension is by far the most important risk factor affecting women in their early post-menopausal years. At around 60 years of age, approximately 30 to 50% of women acquire hypertension, and its onset can produce a

variety of signs and symptoms which are commonly linked to menopause [6]. Moreover, women who suffered hypertension during pregnancy and those with familial history of high BP are more prone to develop hypertension within this period [7]. Several studies suggest that the gradual rise in BP with age is more noticeable in women than in men, possibly due to hormonal changes during the menopausal period [8]. In a study conducted by Zhou, Y *et al.*, 2015 which aimed to examine the incidence and factors contributing to hypertension in pre-menopausal and post-menopausal women, demonstrated the presence of a considerably higher prevalence of hypertension in post-menopausal women compared to pre-menopausal women. Specifically, the percentages of hypertension were found to be 62.4% and 29.7% in post-menopausal and pre-menopausal women, respectively [9].

One of the interesting observations obtained from the literature was the presence of a possible linkage of hypertension to different susceptibility levels based on ABO blood groups. This link between disease and blood groups has been extensively investigated since the early 21st century, when scientists discovered that antigens and antibodies are hereditary [10]. For instance, a study conducted by Chandra & Gupta in 2012 demonstrated that individuals with the B blood group had a higher vulnerability to hypertension and obesity in comparison to individuals with other blood groups. They achieved this finding after assessing the relationship and distribution of ABO blood

types, obesity, and hypertension in various blood donor categories [11]. Moreover, a recent study by Hiteshkumar *et al.*, 2021 showed that blood group B is most likely to develop prehypertension and hypertension, as well as obesity. [12].

In a different study focusing on investigating potential links between ABO blood group and the likelihood of hypertension in post-menopausal women from northern India, the results indicated a higher occurrence of hypertension in individuals with blood group O. Specifically, 10.4% of the total 250 post-menopausal women surveyed were found to have hypertension in this blood group [13].

Although several comprehensive studies have described a possible relationship between hypertension and ABO blood groups in post-menopausal women worldwide, very limited studies have been established so far in Libya. Indeed, to the best of our understanding, there have been no previous studies conducted in our country that have investigated the potential connection between hypertension and ABO/Rh blood group specifically in post-menopausal women. The only research study carried out in Libya was by Taher, Y. *et al.*, 2009 who showed that hypertension was a prevalent health condition linked to the frequency of menopausal symptoms. Specifically, the study found that 37.2% of the population being studied consisted of post-menopausal women with hypertension [14].

Improved comprehension regarding the potential link between hypertension risk and ABO blood type in post-menopausal would offer significant insights for identifying at-risk individuals at an early stage, and assist health planners creating preventative strategies in a particular area to address future health concerns. This is crucial due to the alarming rise in mortality and disability rates associated with cardiovascular diseases, which are expanding rapidly especially in developing nations and are projected to become the leading global burden [13]. Therefore, the aim of this study is to explore the potential relationship between the ABO blood types and hypertension in post-menopausal Libyan women and compare them with pre-menopausal subjects.

MATERIAL AND METHODS

STUDY DESIGN AND POPULATION

This cross-sectional study was carried out in a period of four months between the 1st of May and the 29th of August. It involved a total of 200 randomly selected hypertensive female participants attending multiple healthcare facilities and clinics within the local community, including Tripoli University Hospital, Tajoura Heart centre and Total Care Clinic. The subjects were namely categorized into two groups based on menopausal status, pre-menopausal (n=100) and post-menopausal (n=100). The menopausal status of each participant was determined based of self-reporting and verified through medical records when available. To ensure the

homogeneity of the post-menopausal group, participants were required to be at least 45 years old and have experienced 12 consecutive months of amenorrhea.

On the other hand, the pre-menopausal group has compromised females aged between 35 and 45 years, with regular menstrual cycles. Inclusion criteria included a confirmed diagnosis of hypertension, with subjects having taken medication for at least two years. Participants' age and hypertensive status were obtained using structured questionnaires administered during face-to-face interviews, which included questions related to medical history, age at menopause (for post-menopausal group), and medication usage. Moreover, participants meeting any of the following criteria, including pregnancy, malignancies, being over the age of 75, and those unwilling to provide informed consent were excluded from this study.

SAMPLE COLLECTION, BLOOD TEST AND MEASUREMENTS

Determination of ABO/Rh Blood Group

After receiving informed consent from participants, approximately 5 mL of venous blood was collected for each sample using vacutainer tubes containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant, to maintain the integrity of the blood sample upon transportation to the blood bank. The blood group was determined using the tube agglutination method, where blood samples were collected and mixed with

anti-A and anti-B serums in separate microcentrifuge tubes. If the agglutination reactions were observed in the "Anti-A" tube, this indicates blood type A. Blood group type B refers to agglutination in the "Anti-B" tube, and agglutination in both tubes represents blood type AB. No agglutination in either tube indicates blood type O, and lastly agglutination in the "Anti-D" tube indicates an Rh +ve blood type. Quality control measures were employed, and ethical guidelines were followed.

Determination of BP

BP measurements were taken using a standardized protocol. Subjects were asked to rest while seated for at least 5 minutes before measurements were recorded. Subsequently, the correctly sized cuff was placed on the right upper arm, and the BP was measured while the individual remained in a seated position. Systolic (SBP) and diastolic blood pressure (DBP) readings were measured using a digital BP monitor (Omron, Kyoto, Japan) and a calibrated sphygmomanometer. The average of two readings was used for analysis.

STATISTICAL DATA ANALYSIS

The data was entered in Microsoft Excel spreadsheets and IBM SPSS version 26.0 software was used for the statistical analysis. Continuous variables were reported as mean values with corresponding standard deviations, whilst categorical variables were provided as numerical counts and percentages. An independent (unpaired) t-

test was used to compare the means between the two groups, while a chi-square analysis was used to assess the distribution of ABO blood groups among pre- and postmenopausal women. Analysis of variance (ANOVA) test was used to analyse BP parameters across ABO blood groups. For all tests, the significance level was set at $p < 0.05$.

RESULTS

The percentage distribution of ABO blood groups is summarised in Figure 1 for the pre-menopausal group and Figure 2 for the post-menopausal group. In the present study blood group O is the most prevalent blood group among samples (58% in the pre-menopausal and 41% in post-menopausal), whereas blood group AB is the least prevalent (only 9% in the pre-menopausal and 7% in post-menopausal) (Figures 1 and 2).

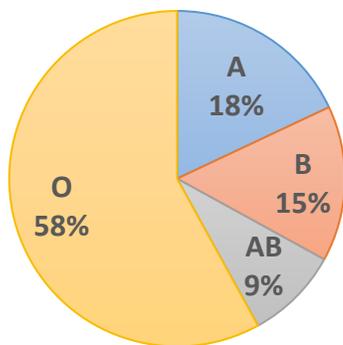


Figure 1. The distribution of the ABO blood groups in the pre-menopausal group.

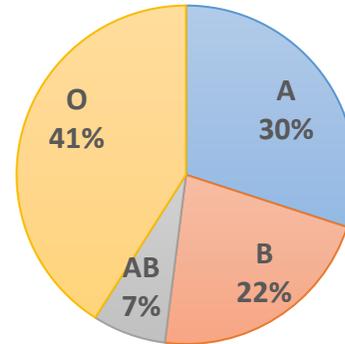


Figure 2. The distribution of the ABO blood groups in the post-menopausal group.

Table 1 shows the average and the standard deviation of certain variables, including age, SBP and DBP in the sampled group of hypertensive women, both pre- and post-menopausal. A statistically significant difference in the mean ages was observed between the two groups (p -value= 0.000). Although post-menopausal women had slightly higher SBP and DBP values compared to the pre-menopausal group, these differences were not statistically significant (p -value= 0.704 and 0.179, respectively).

Table 1. The mean age and BP indices of the sampled hypertensive, pre- and post-menopausal women.

Variable	Pre-menopausal (n=100)	Post-menopausal (n=100)	t-test	P-value
	Mean \pm SD	Mean \pm SD		
Age	42.2 \pm 4.166	61.0 \pm 7.47	21.976	0.000*
SBP	136.2 \pm 11.84	137.0 \pm 18.60	0.381	0.704
DBP	80.1 \pm 7.57	81.8 \pm 10.16	1.349	0.179

Table 2 represents the distribution of Rh +ve blood groups (N=181) among hypertensive pre- and post-menopausal women. Interestingly, the most prevalent Rh +ve blood group among pre-menopausal women was O+, comprising 60% of the sampled individuals in this group. Similarly, 38.5% of post-menopausal women had the blood type O+. Conversely, the least common Rh +ve blood group in both study groups was AB+, making up only 7.7% of the total (Figures 3 and 4). In order to compare these percentages more precisely, a Chi-square test was applied. As shown in Table 2, a statistically significant difference was noted in percentages of the Rh +ve blood groups among pre- and post-menopausal subjects (p-value= 0.006).

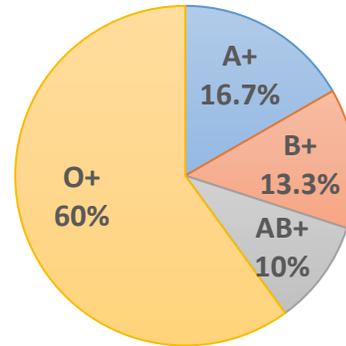


Figure 3. The distribution of the Rh +ve blood types in the pre-menopausal group

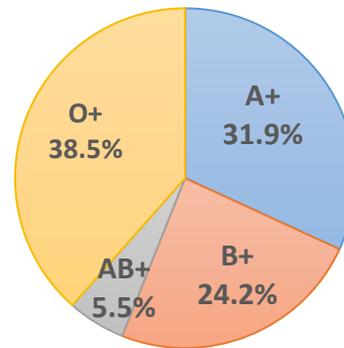


Figure 4. The distribution of the Rh +ve blood types in the post-menopausal group

Table 2. The ABO Rh +ve blood group distribution between pre- and post-menopausal hypertensive women.

Blood Group	Pre-menopausal	Post-menopausal	Total	X ²	P-value
A+	15 (16.7%)	29 (31.9%)	44 (24.3%)	12.590	0.006*
B+	12 (13.3%)	22 (24.2%)	34 (18.8%)		
AB+	9 (10%)	5 (5.5%)	14 (7.7%)		
O+	54 (60%)	35 (38.5%)	89 (49.2%)		
Total	90 (49.7%)	91 (50.3%)	181 (100%)		

In terms of the distribution of Rh -ve blood groups (N=19) between the two research groups, the most prevalent blood group was O-, accounting for 52.6% of the total, with 40% found in hypertensive pre-menopausal women and 66.7% in post-menopausal women (Figures 5 and 6). However, none of the pre-menopausal women had blood group AB-. Furthermore, none of the post-menopausal women had blood group B-. Similarly, a statistically significant difference

was noted in percentages of the Rh -ve blood groups among pre- and post-menopausal subjects (p-value= 0.040), as illustrated in Table 3.

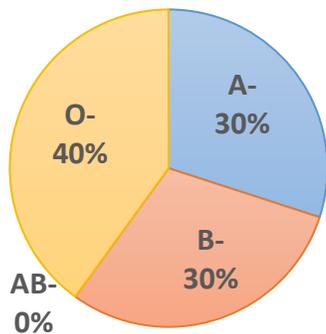


Figure 5. The distribution of the Rh -ve blood types in the pre-menopausal group

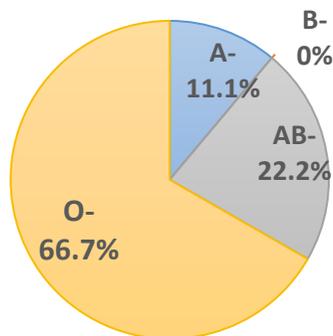


Figure 6. The distribution of the Rh -ve blood types in the post-menopausal group

Table 3. The ABO Rh -ve blood group distribution between pre- and post-menopausal hypertensive women.

Blood Group	Pre-menopausal	Post-menopausal	Total	χ^2	P-value
A-	3 (30%)	1 (11.1%)	4 (21.1%)	6.365	0.040*
B-	3 (30%)	0 (0%)	3 (15.8%)		
AB-	0 (0%)	2 (22.2%)	2 (10.5%)		
O-	4 (40%)	6 (66.7%)	10 (52.6%)		
Total	10 (52.6%)	9 (47.7%)	19 (100%)		

To examine the relationship between the BP indices and ABO/Rh blood groups in pre and post-menopausal women more precisely, a comparison of the mean values of BP indices in Rh +ve ABO blood group pre-menopausal hypertensive women was first performed using ANAOA test (Table 4).

Table 4. A comparison of BP indices in pre-menopausal women with their Rh +ve ABO blood group

BP indices	Rh +ve blood groups				ANOVA (f-statistic)	P-value
	A+ (n=15)	B+ (n=12)	AB+ (n=9)	O+ (n=54)		
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
SBP	140.6±14.35	136.7±12.18	135.3±9.12	134.8±11.74	0.919	0.435
DBP	82.3±10.04	79.8±6.79	80±9.06	78.9±6.74	0.763	0.518

The results indicate that the highest mean SBP and DBP readings were found in pre-menopausal women with blood group A+ (140.6 and 82.3 mm/Hg, respectively), whereas the lowest values of SBP and DBP were observed in those with blood group O+ (134.8 and 78.9 mm/Hg, respectively) (Figure 7).

Nevertheless, ANOVA revealed no significant difference was observed in the mean SBP and DBP between the Rh +ve ABO blood groups in pre-menopausal women (p-value= 0.435 and 0.518, respectively) Table 4.

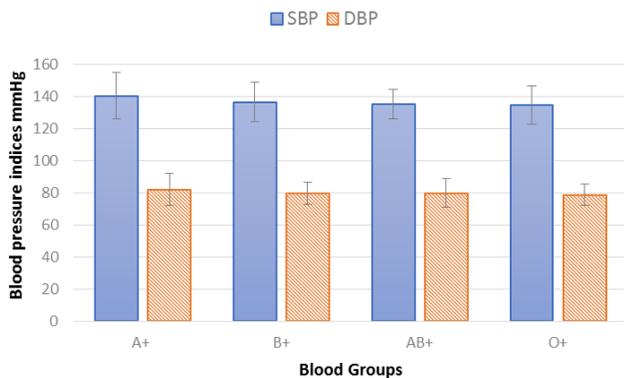


Figure 7. BP indices in pre-menopausal women with respect to their Rh +ve blood group.

Subsequently, the following comparison was for the mean values of BP indices in Rh -ve ABO blood group pre-menopausal hypertensive women (Table 5). Similarly, the highest mean levels of SBP and DBP were observed in individuals with blood group A- while the lowest BP indices were found in those with the blood group B-. Once again, no statistically significant difference was observed between the mean SBP and DBP values across the different blood types (p> 0.05) (Figure 8).

Table 5. A comparison of BP indices in pre-menopausal women with their Rh -ve ABO blood group.

BP indices	Rh -ve blood groups				ANOVA (f-statistic)	P-value
	A- (n=3)	B- (n=3)	AB- (n=0)	O- (n=4)		
Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD			
SBP	143.3±15.27	131.3±10.59	-	137.2±4.85	0.992	0.418
DBP	86.6±5.77	79.3±7.024	-	84±8.00	0.814	0.481

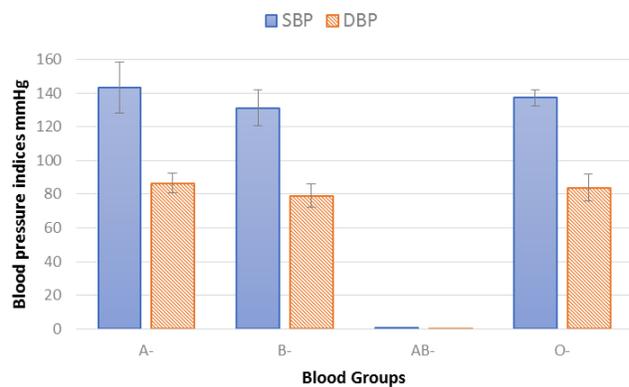


Figure 8. BP indices in pre-menopausal women with respect to their Rh -ve blood group

In regard to the hypertensive post-menopausal ABO/Rh blood group participants, our findings primarily revealed that post-menopausal women with blood group A+ exhibited the highest average SBP, whereas those with blood group B+ had the highest average DBP (Figure 9). The discrepancy in mean SBP values between Rh +ve blood groups in post-menopausal women showed a slight significance (p= 0.057), while there was no statistically significant difference in DBP values between the blood groups (p= 0.788) Table 6.

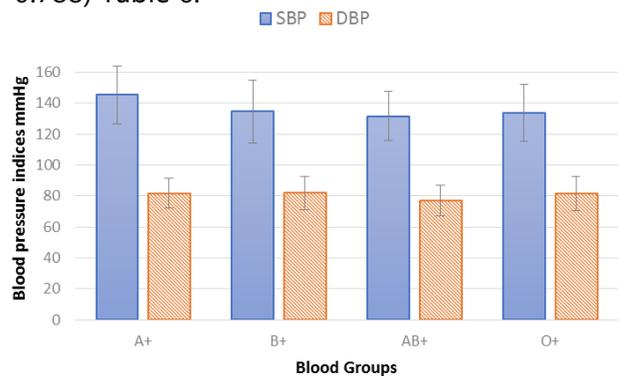


Figure 9. BP indices in post-menopausal women with respect to their Rh +ve blood group.

Table 6. A comparison of BP indices in post-menopausal women with Rh +ve ABO blood group

BP indices	Rh +ve blood groups				ANOVA (f-statistic)	P-value
	A+ (n=29) Mean ± SD	B+ (n=22) Mean ± SD	AB+ (n=5) Mean ± SD	O+ (n=35) Mean ± SD		
SBP	145.2±18.49	134.5±20.30	131.6±15.66	133.5±18.46	2.61	0.057
DBP	81.9±9.78	82.1±10.75	77.0±9.74	81.6±11.10	0.351	0.788

Finally, according to their Rh -ve ABO blood types, Table 7 lists the mean and standard deviation of BP measurements taken from hypertensive post-menopausal women. The post-menopausal women with blood type AB- had the greatest mean SBP and DBP (139 and 91 mm/Hg, respectively) Figure 10. The mean SBP and DBP values among post-menopausal women in the Rh -ve blood groups did not differ statistically (p values = 0.484 and 0.271, respectively).

Table 7. A comparison of BP indices in post-menopausal women with Rh -ve ABO blood group.

BP indices	Rh -ve blood groups				ANOVA (f-statistic)	P-value
	A- (n=1) Mean ± SD	B- (n=0) Mean ± SD	AB- (n=2) Mean ± SD	O- (n=6) Mean ± SD		
SBP	130	-	139±8.48	130.8±8.01	0.820	0.484
DBP	80	-	91±1.41	82±7.07	1.638	0.271

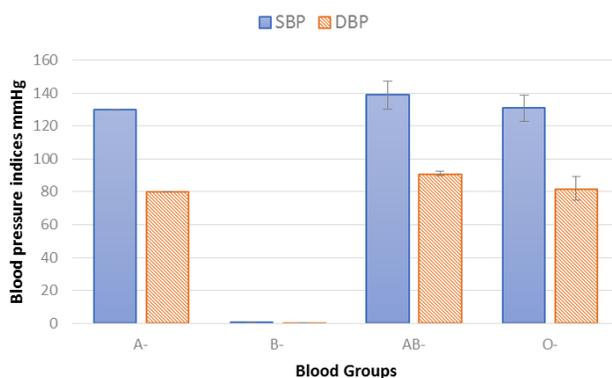


Figure 9. BP indices in post-menopausal women with respect to their Rh +ve blood group.

DISCUSSION

The relationship between blood groups and various health conditions has gathered considerable interest in medical research. One interesting area of study involves investigating the potential association between ABO/Rh blood groups and hypertension. Understanding whether certain blood groups are more predisposed to hypertension in specific demographic groups such as pre- and post-menopausal women, could offer valuable insights into the underlying mechanisms of this condition [10]. To ensure a comprehensive analysis of potential associations and account for clinical relevance, we included both Rh +ve and Rh -ve blood groups in our study. By considering both groups, our research captures a more complete understanding of the role of blood groups in hypertension, potentially uncovering nuanced relationships that might not be apparent when studying only one blood group type. Hence, the primary objective of this research was to investigate the potential link between ABO/Rh blood group types and hypertension among post-menopausal Libyan women, and to contrast these findings with those from pre-menopausal participants.

The first significant observation was the difference in factor of age between the pre- and post-menopausal women (Table 1). This discrepancy is expected since menopause is a natural transition that typically occurs

between the ages of 45 and 55. The age difference is important to consider as age is a well-established risk factor for hypertension [6]. In our study, this difference highlights the need to account for age when interpreting the results, as it can confound the relationship between blood groups and hypertension, because as individuals age, various physiological changes occur that can independently influence BP [6].

Unexpectedly, we found no statistically significant differences in SBP and DBP readings between pre- and post-menopausal women. This suggests that, in our sample, menopausal status alone does not play a significant role in determining BP levels (Table 1). In fact, this finding was inconsistent with a very recent study conducted by Shah, H. *et al.*, in 2023, in which they noted a significant elevation in BP readings among post-menopausal women [15].

For the distribution of subjects according to Rh phenotypes, our research showed that the Rh +ve was detected in 181 (90.5%) subjects while the Rh -ve was found in 19 (9.5%) subjects in the total sample size of 200 studied (Tables 2 & 3). This result agrees with that of other researchers [16, 17, 18, 19], who reported Rh +ve to be the highest while Rh -ve was the lowest. Furthermore, the distribution of ABO blood group types among the study participants revealed a pattern consistent with global prevalence rates, with blood type O being the most common,

followed by types A, B, and AB (Figures 1 and 2). Our findings can be compared to that of Shekhar Gogoi, H., & Bora, B, 2016 [20]. Their study corresponds with ours in demonstrating that the O+ blood group exhibits the highest prevalence among both pre- and post-menopausal hypertensive women. Likewise, our study and that of Shekhar Gogoi, H., & Bora, B, 2016 reached the same conclusion that AB+ was the blood type with the lowest prevalence. Previous research suggests that individuals with blood group 'O' may have an increased susceptibility to hypertension due to reduced Von-Willebrand factor levels. This is significant because lower levels of these proteins, which regulate blood clotting, can elevate the likelihood of developing cardiovascular issues [21, 22].

Similarly, the most common Rh -ve blood group in both pre- and post-menopausal women was O-. Comparable findings were reported by both Kaur, Maninder, 2014 and Ojeka, S, *et al.*, 2021, suggesting that individuals possessing blood type O might have a heightened vulnerability to developing hypertension [13, 23]. However, some observations have contradicted this notion and indicated that blood type B was predominant among individuals with hypertension [12, 25]. Indeed, the variation in blood type distribution across different studies could be attributed to differences in sample demographics and ethnic backgrounds [26].

The present study revealed a statistically significant difference only in ABO/ Rh blood group percentages (Rh +ve & Rh -ve) among pre- and post-menopausal hypertensive women. However, no statistically significant association between ABO/ Rh blood groups and hypertension indices was obtained which was consistent with recent findings [24,27-29]. This highlights the complex interplay between biological factors, particularly hormonal changes, genetic factor, cardiovascular, demographic, and sample-related factors [10]. For instance, the influence of hormones, such as oestrogen on blood vessel function and cardiovascular health is well-documented. The shift in hormonal profiles during menopause could potentially interact with genetic factors, such as ABO blood group types, resulting in varying susceptibility to hypertension [9, 11].

Our analysis did reveal some noteworthy trends when examining the relationship between specific blood types and BP readings. Pre-menopausal women with blood group A+ (Table 4) and A- (Table 5) were found to have the highest mean SBP (140.6 ± 14.35 mmHg and 143.3 ± 15.27 mmHg respectively) and highest mean DBP (82.3 ± 10.04 mmHg and 86.6 ± 5.77 mmHg respectively). Additionally, post-menopausal women with blood group A+ (Table 6) exhibited the highest average SBP (145.2 ± 18.49 mmHg), while those with blood group B+ (Table 6) had the highest average DBP (82.1 ± 10.75 mmHg). Meanwhile, AB- had the highest SBP and DBP (139 ± 8.48 mm/Hg and 91 ± 1.41 mm/Hg respectively)

(Table 7). Although these observed differences in the mean values of BP indices across ABO blood groups, it's crucial to emphasize that these differences were not statistically significant suggesting that ABO blood groups have no discernible correlation with the propensity to develop elevated BP. This notion is also supported by a recent study conducted by Siddiqui *et al.*, 2021 [24].

Several limitations should be acknowledged. Firstly, the sample size may have limited our ability to detect subtle associations. A larger, more diverse sample could provide more robust insights. Secondly, our study did not consider other relevant factors such as family history, lifestyle factors (e.g., diet, exercise), and genetics, which could interact with blood group to influence hypertension risk. Lastly, this study was cross-sectional, meaning causality cannot be inferred, and longitudinal studies would be required to assess the long-term relationships.

CONCLUSION

Our findings indicate that age factor is significantly associated with BP in pre- and post-menopausal women. Blood group O was found to be the most common blood group in our study. Although the percentages of the Rh +ve / Rh -ve ABO blood groups among pre- and post-menopausal subjects were statistically significant, ABO blood group system does not significantly affect BP indices, suggesting no correlation between the tendency to develop hypertension in a

particular blood group. In fact, the relatively small participant count was a limiting factor in this study. It would be interesting to conduct a large-scale survey with ABO/Rh +ve and ABO/Rh -ve blood group hypertensive samples from different regions or parts of Libya, as this would provide more insight into the relationship between different ABO/Rh +ve and -ve blood groups with those of hypertension. While certain trends were observed, these should be interpreted with caution, and further research is needed to elucidate the complex interplay between blood group factors and hypertension risk.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

REFERENCES

1. Iqbal, A. M., & Jamal, S. F. Essential Hypertension. StatPearls [Internet]. *Treasure Island* (FL): 2022; StatPearls Publishing.
2. Oparil, S., Acelajado, M. C., Bakris, G. L., Berlowitz, D. R., Cifková, R., Dominiczak, A. F., Grassi, G., Jordan, J., Poulter, N. R., Rodgers, A., & Whelton, P. K. Hypertension. *Nature reviews. Disease primers*. 2018; 4, 18014.
3. Farhadi, F., Aliyari, R., Ebrahimi, H. et al. Prevalence of uncontrolled hypertension and its associated factors in 50–74 years old Iranian adults: a population-based study. *BMC Cardiovasc Disord*. 2023;23, 318
4. Mills, K. T., Stefanescu, A., & He, J. The global epidemiology of hypertension. *Nature reviews. Nephrology*. 2020; 16(4), 223–237.
5. Beaney, T., Ster, A. C., Poulter, N. R., et al. May Measurement Month 2018: an analysis of blood pressure screening in Libya. *European heart journal supplements: Journal of the European Society of Cardiology*. 2020;22 (Suppl H), H77–H79.
6. Maas, A. H., & Franke, H. R. Women's health in menopause with a focus on hypertension. *Netherlands heart journal: monthly journal of the Netherlands Society of Cardiology and the Netherlands Heart Foundation*. 2019; 17(2), 68–72.
7. Garovic, V. D., Bailey, K. R., Boerwinkle, E., Hunt, S. C., Weder, A. B., Curb, D., Mosley, T. H., Jr, Wiste, H. J., & Turner, S. T. Hypertension in pregnancy as a risk factor for cardiovascular disease later in life. *Journal of hypertension*. 2010; 28(4), 826–833.
8. Pérez-López, F. R., Larrad-Mur, L., Kallen, A., Chedraui, P., & Taylor, H. S. Gender differences in cardiovascular disease: hormonal and biochemical influences. *Reproductive sciences (Thousand Oaks, Calif.)*. 2010; 17(6), 511–531.
9. Zhou, Y., Zhou, X., Guo, X., Sun, G., Li, Z., Zheng, L., Yang, H., Yu, S., Li, W., Zou, L., & Sun, Y. Prevalence and risk factors of hypertension among pre- and post-menopausal women: a cross-sectional study in a rural area of northeast China. *Maturitas*. 2015; 80(3), 282–287.
10. Abegaz S. B. Human ABO Blood Groups and Their Associations with Different Diseases. *BioMed research international*. 2021; 6629060.

- 11.** Chandra, T., & Gupta, A. Association and Distribution of Hypertension, Obesity and ABO Blood groups in Blood Donors. *Iranian journal of pediatric hematology and oncology*. 2012; 2(4), 140–145.
- 12.** Hiteshkumar K Solanki, Omnath Yadav & Anita J Gojiya. Relationship between hypertension and ABO blood groups: A cross-sectional study. *MedPulse International Journal of Physiology*. 2021; 20(3) ,22-25
- 13.** Kaur, Maninder. Association between ABO Blood Group and Hypertension among Post-menopausal Females of North India. *Anthropologist*. 2014;17. 677-680.
- 14.** Taher, Yousef & Emhemed, H.M. & Tawati, Ahmed. The menopausal experience of Libyan women. *Jamahiriya Medical Journal*. 2009; 9. 184-190.
- 15.** Shah, H., Majmudar, . F., Shah, . S. & Malhotra, . S. Comparison of blood pressure readings among premenopausal and postmenopausal women and evaluation of factors associated with hypertension in women. *Natl J Physiol Pharm Pharmacol*. 2023;13 (7), 1385-1390.
- 16.** Kotila, T. R., Odukogbe, A. A., Okunlola, M. A., Olayemi, O., & Obisesan, K. A. The pregnant Rhesus negative Nigerian woman. *The Nigerian postgraduate medical journal*. 2005; 12(4), 305–307.
- 17.** Okeke, T. C., Ocheni, S., Nwagha, U. I., & Ibegbulam, O. G. The prevalence of Rhesus negativity among pregnant women in Enugu, Southeast Nigeria. *Nigerian journal of clinical practice*. 2012; 15(4), 400–402.
- 18.** Ekanem, U. S., Opara, D. C., & Akwaowo, C. D. High blood pressure in a semi-urban community in south-south Nigeria: a community-based study. *African health sciences*. 2013;13(1), 56–61.
- 19.** Chima, O., Mohammed, T.B., Aisha, K., Alhaji, S.A., Muhammad, B.M., & Kwaru, A.H. ABO and rhesus blood groups among blood donors in Kano, North-Western Nigeria. *Nigerian Journal of Basic and Clinical Sciences*. 2012;9, 11.
- 20.** Shekhar Gogoi, H., & Bora, B. A Cross Sectional Study of Prevalence of ABO and Rh Positive Blood Groups among the Pre-menopausal and Post-menopausal Women in Relation to Hypertension in Kamrup (Metropolitan) District. *Journal of Dental and Medical Sciences*. 2016; 15(4), 47–54.
- 21.** O'Donnell, J., & Laffan, M. A. The relationship between ABO histo-blood group, factor VIII and von Willebrand factor. *Transfusion medicine (Oxford, England)*. 2001; 11(4), 343–351.
- 22.** Haque, K. M., & Rahman, M. An unusual case of ABO-haemolytic disease of the newborn. *Bangladesh Medical Research Council bulletin*. 2000;26(2), 61–64.
- 23.** Ojeka, S. O., Dapper, D. V., & Egbejimi, A. M. (2021). Influence of ABO and Rhesus Blood Group on Blood Pressure and Hypertension in Bayelsa State. *Asian Journal of Research in Medical and Pharmaceutical Sciences*. 2021;10(1), 33–40.
- 24.** Siddiqui N I, Soni A, Gaur V B, Akhani P, Shoeb M (2021). ABO Blood Type does not Influence Blood Pressure Levels in Healthy Indian Adolescents. *RABMS*. 2021; 7(1):46-52
- 25.** Jawed, S., Zia, S., & Tariq, S. Frequency of different blood groups and its association with BMI and blood pressure among the female

medical students of Faisalabad. JPMA. *The Journal of the Pakistan Medical Association*. 2017;67(8), 1132–1137.

26. Enawgaw, B., Aynalem, M., & Melku, M. Distribution of ABO and Rh-D Blood Group Antigens Among Blood Donors in the Amhara Regional State, Ethiopia. *Journal of blood medicine*. 2022; 13, 97–104.

27. GAO Jiang-ling, CUI Ze, PAN Li. Association of ABO blood group with hypertension among Han population in Hebei province. *Chinese Journal of Public Health*. 2021; 37(5): 803-806

28. Suwito, B. E., Kalanjati, V. P., & Abdurachman, A. Blood Type and Blood Pressure Correlations to Body Mass Index in Young Adults. *Folia Medica Indonesiana*. 2020; 56(3), 203–207.

29. Asafa MA, Ogunlade O, Bolarinwa RA. Effect of ABO Blood Group on Blood Pressure Indices among Apparently Healthy Young Adults of Yoruba Ethnicity in Ile-Ife. *J Blood Lymph*. 2018; 8: 198.