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RESEARCH PAPER

Identifying and analyzing the effects of electric fields on erythrocyte sedimentation rate.

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A B S T R A C T:

Introduction: The influence of electric field on the nature of blood flow and cells is controversial. Erythrocytes sedimentation rate (ESR) examination is a recommended approach to diagnose a few health conditions such as polymyalgia rheumatic and temporal arteritis.

Aim: In this study, we aimed to evaluate the effect of electric field on ESR of human male and female blood samples.

Method: Healthy blood samples were exposed with electric field (in-vitro) with various exposure intensities. The Westergren method used to examine ESR in-vitro.

Results: An increase of ESR was shown in blood samples of both genders at low to high exposure intensities. Female blood samples got a higher ESR than that of male blood samples at low exposure filed. However, that trend turned to opposite at high exposure electric field. Compare to untreated blood samples, the largest rate of ERS variation, for male and female blood samples, were about 140% versus a 135% respectively due to 72 V/m of exposure.

Conclusion: Consequently, electric field produces an influence on the blood red cells sedimentation depending on the exposure intensity.

KEY WORDS: Erythrocyte sedimentation rate, Electric field, Westergren, human blood exposure, blood aggregations.
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1. INTRODUCTION:

Blood consists of main blood cells; red blood cells (RBCs), white blood cells (WBCs) and platelets (PLTs), participating to enhance blood viscosity, mainly with RBCs (Mustafa et al., 2020a, Mustafa et al., 2019, Mustafa et al., 2020b). Erythrocytes sedimentation rate (ESR) is defined with the nature of RBCs in blood streams. ESR levels of blood is critical to diagnose a few clinical disorders. ESR test is un-expensive and easy to perform. The reference range of ESR of healthy human is between 0 to 15 and 0 to 20 mm/hr for male and female, respectively (Brigden, 1999).

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This range is slightly higher for elderly people. Several factors affecting ESR ranges including age, pregnancy, diseases such as anemia and abnormality of RBCs (Sox Jr and Liang, 1986).

The surfaces of red cells carry negative charges due to the ionization of the carboxyl group of NeuNac (N-acetyl neuraminic acid). Red cells attract positively charged Na+, and an ionic cloud forms around each of the cells (Heloise et al, 2011). The electric field enhances RBCs aggregation since the charge cloud affects the surface charges of red cell (Heloise et al, 2011). ESR occurs in three phases; precipitation, RBC packing (rouleaux formation) and RBCs aggregation (Vennapusa et al., 2011).

Aggregations is focused from researches and it leads to several extreme health conditions such as blocking blood vessels and cardiovascular diseases (Baskurt and Meiselman, 2013). Internal and external factors affect the aggregation of red blood cells and ESR levels. External electric field effect on ESR has attracted into attention. This study aimed to evaluate the influence of electric field on ESR (in-vitro) of healthy human blood samples, under different electric field intensities.

2. MATERIALS AND METHODS

2.1. Human participation

Sixteen healthy individuals, age ranged from 19-20 years old, (divided into two groups; male and female) have participated. Fresh blood samples were collected (6mL/individual) and divided into 6 potassium-EDTA tubes (1mL each). Individuals inhabited to take breakfast and other food consumption 6 hrs prior sample collection. They were collected at 8:00 AM local time and taken to exposure immediately. The Westergren method was carried out of 1 mL of EDTA anticoagulated blood samples without dilution and at room temperature. The falling rate in Westergren tubes calculated in millimeters (mm) per one hour.

2.2 Exposure setup

In-vitro exposure setup was designed using two similar plated (figure 1) separated with a distance of (d) (air distance), and the experiment was carried out at room atmosphere (26±1 ^{0}C).

Figure 1: Electric field exposure setup and Westergren tubes.

An electric field obtained and measured mathematically using equation (E = V/d). The exposure was carried out for 1hr remaining samples inside the electric field. Several electric field intensities were used to evaluate its impacts on the values of ESR.

3. RESULTS AND DISCUSSION

Table 1 illustrates the erythrocytes sedimentation rates under the influence of electric field for both genders. The curve lines have been shown for male and female, figure 2 and 3, respectively. Measurement was taken in respect of number of lines blood dropped in ESR capillary tube (each line is considered as 1 mm), percentage variation also calculated. Female blood samples were reacted a slightly higher compare to that of male samples for lower exposure intensities. Male increased ESR with about 5% (from 12.333±2.517mm/hr to 13.000±3.606mm/hr), yet female increased with 41.2% (from 6.667±1.528mm/hr to 9.417±4.260mm/hr) under 9 V/m intensity. This trend continued significantly with 91% and 122% at doubled exposure intensity (18 V/m) of male and female respectively. On the other hand, the high exposure intensity (such as 109 V/m electric field) rated an increase of ESR with 27% and 20% for male and female respectively, which is a lower change trend of female samples corresponding to the low exposure field.

ESR shows how fast RBCs sediment in test-tube container. Electric field has variated ESR in both genders. The variation occurred proportionally to the intensity of the electric field. The reason of how intensity of electric field variated the ESR is not clear. Yet, external electric field can influence fibrinogen and gamma globulins since those biological molecules elevate aggregations. Iino (1997) believes that the cell orientation enhanced cell aggregation and thereby to an increase of ESR (Iino, 1997). Yamagishi (1990) claimed that SMF controls blood cells orientation. Its results illustrated that RBCs and PLTs are fully orientated parallel to the applied SMF at 4T and 3T respectively (Yamagishi, 1990). Theoretical calculation illustrated the corelation between ESR and RBCs morphology (Kizilova et al., 2018). Similar to electric field exposure, magnetic field caused ESR to enhance slightly in saline solution and significantly in plasma. The effect in plasma occurred 20min after the first exposure.

Regarding to RBCs morphology, Ali et al., (2003) indicated that erythrocyte membrane elasticity and membrane permeability decreased and HGB and RBCs physiological structure has changed. The RBCs morphology began to variate regularly under PMF (Ali et al., 2003). Optical microscopic images revealed that Platelets separated under the effect of the magnetic field in most of the exposure conditions. A few RBC shape distortion was found, but we could not find cells damaging under the effect of magnetic fields (Mustafa et al., 2020b). Similar effect of electric field can happen to red blood cells and lead ESR to variate. It has been shown that the nonlinearity dependency of ESR and electric field, which is in agreement with our results (Juutilainen and Lahtinen, 1985). The larger of RBCs aggregations causes a larger cluster of RBCs to produce in blood that own higher mass. Hence, a lager gravitational force attracts the cluster to sediment.

4. CONCLUSION

We have investigated the influence of electric field on ESR in-vitro. Treated blood samples with electric field enhanced ESR level of male and female blood samples significantly. ESR of the male blood samples responded to electric field relatively higher in compare to female blood samples. The maximum increase of ESR were 140% and 135% of male and female blood samples respectively. We recommend to limited electric field exposure into minimum in purpose to preserve the normal limit of the ESR during blood circulation.

Conflict of interest: The authors declared that they have no conflicts of interest.

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(Table 1) ESR of human blood under the influence of electric field of male and female. Colored data with green is the minimum increase and the red data is the maximum increase. The percentage change was calculated in respect of control sample results.

Male			**Female**		
E (V/m)	**Decline mm/hr**	**% Change**	**E (V/m)**	**Decline mm/hr**	**% Change**
0.000 **(control)**	12.333±2.517	0	0.000 **(control)**	6.667±1.528	0
9.091	13.000±3.606	5.41	9.091	9.417±4.260	41.25
18.182	23.667±14.572	91.89	18.182	14.833±5.252	122.5
36.364	17.000±15.875	37.84	36.364	11.333±5.508	70
72.727	29.667±18.771	140.54	72.727	15.667±4.933	135
109.091	15.667±12.097	27.03	109.091	8.000±2.646	20

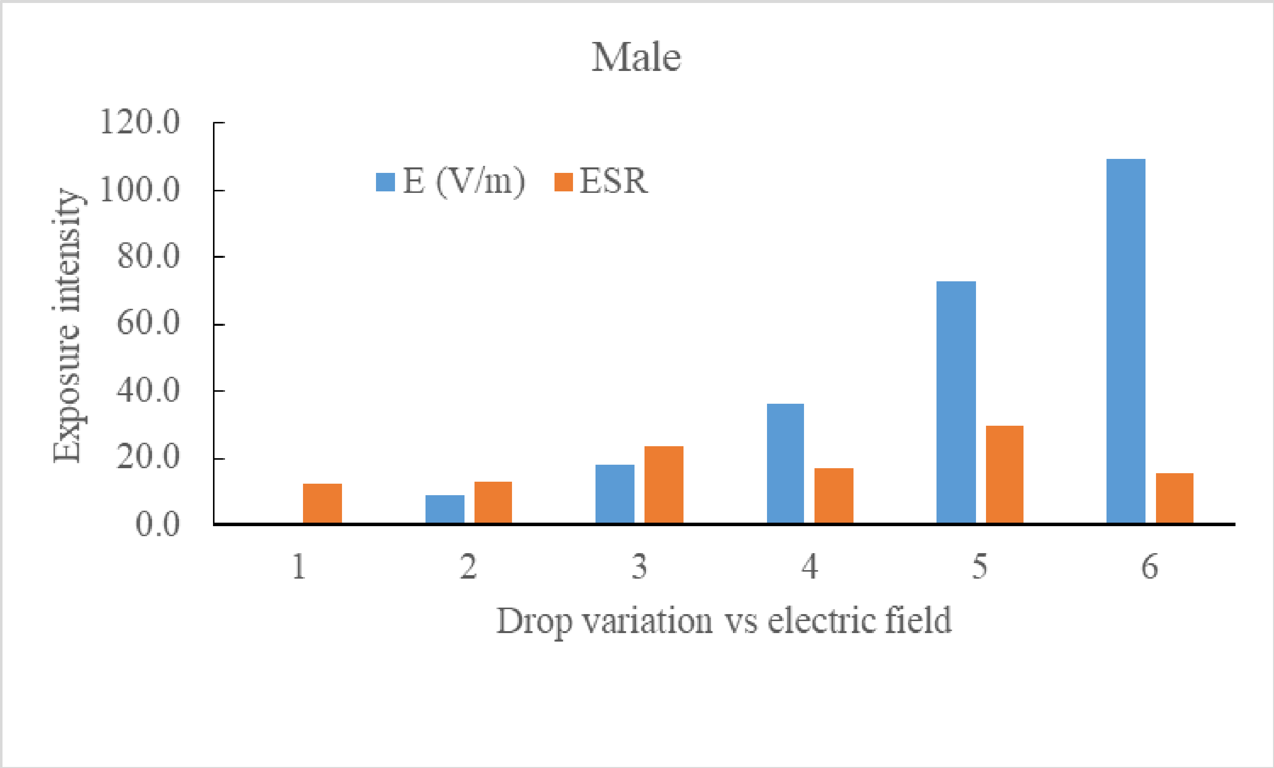

Figure 2: Response of ESR to the electric fields of male blood samples.

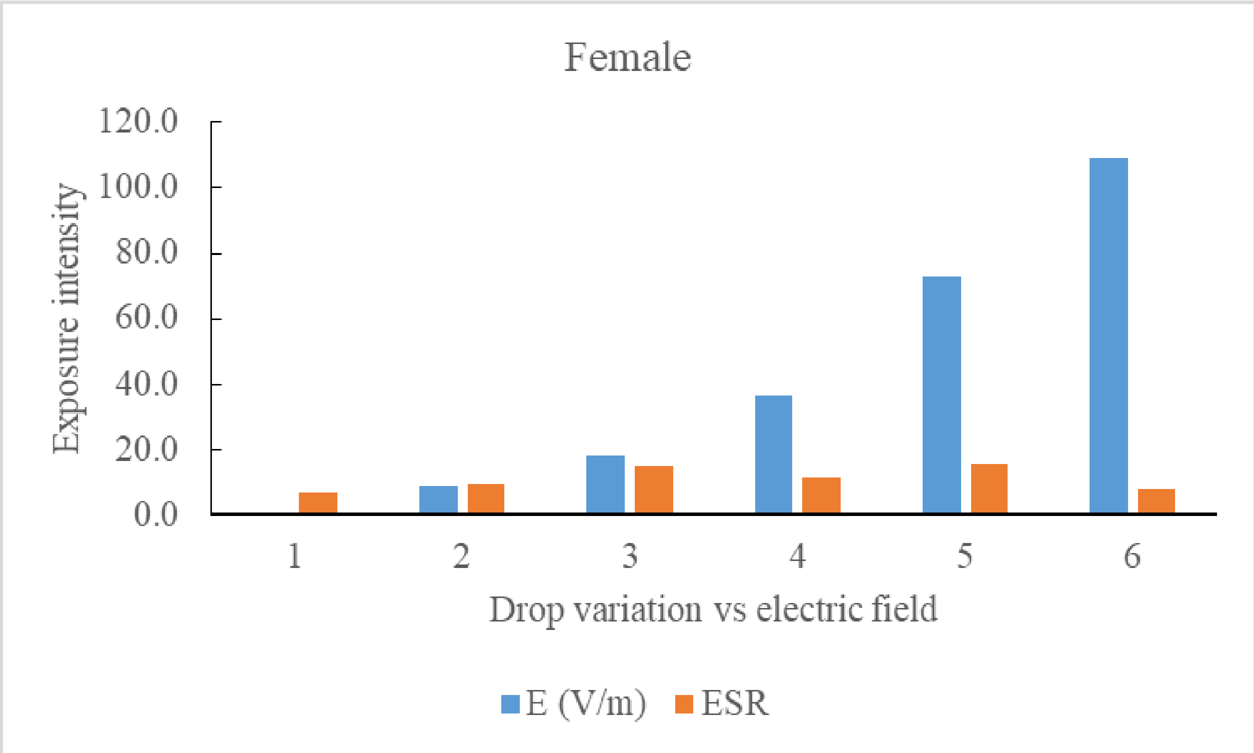

Figure 3: ESR of female blood samples in respect of unexposed samples.

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