Relationship between Erythrocyte Count and Volume in Humans and Rats

V. B. Matyushichev, V. G. Shamratova, and I. V. Savrasova

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The mean corpuscular volume and concentration of blood erythrocytes in intact male rats are inversely related in the entire fluctuations range. In healthy men and women the correlation between these parameters is described by a parabola with alternating zones of positive and negative relationships. These covariations are unstable; in disease they change and sometimes are transformed into monotonous reciprocal correlations.

Key Words: *blood; rat and human erythrocytes; volume; content; relationship*

Studies of the relationship between erythrocyte content in the circulation and their size are justified because these parameters play a significant role in blood rheology [1]. A negative correlation between erythrocyte size and number was detected in rats [4,6], dogs [9], and other mammals [3]. There is nothing uncommon in the reciprocal correlation of erythrocyte properties and their count in the circulation, as such relationships are regarded as manifestations of individual adaptive reactions aimed at adaptation of the blood system to the environment [2]. Surprisingly, these correlations were not detected in humans [5]. Such selectivity seems to be interesting, and we therefore analyzed these statistical relations in detail.

MATERIALS AND METHODS

Blood was collected from intact random-bred male albino rats (n=32) weighing 180-200 g kept under standard vivarium conditions and decapitated under ether narcosis. Peripheral blood from clinically healthy men and women (n=98) aged 18-50 years, patients with respiratory diseases (chronic bronchitis, asthma, and pneumonia, n=66) and iron-deficiency anemia (n=78) was analyzed. The correctness of using mixed samples with equal representation by sex was determined by the absence of correlation between erythrocyte volume and count in both men and women [5]. Blood was collected at rest after overnight fasting. The count and mean volume of erythrocytes were evaluated automatically on a Coulter hematological analyzer. Regression analysis of the initial data was performed using Statistica software.

Institute of Physiology, St. Petersburg State University; Bashkortostan State University, Ufa

RESULTS

Measurements confirmed a negative correlation between erythrocyte count and mean volume in rats (r=-0.89), but this relationship is more correctly, completely, and demonstratively described by a parabolic curve. The mean corpuscular volume of erythrocytes decreases with increasing their number (Fig. 1, *a*), but within the entire range of variations in the erythrocyte number (4.0-6.3×10^{12}/liter) the changes are more pronounced at erythrocyte concentration above 5.3×10^{12}/liter. In humans the relationship between these parameters is less evident (Fig. 1, *b*). Theoretical curve is also presented by a third-order parabola, but the slopes of its branches are different and the peak is shifted to the left from the center of the range of cell count fluctuations. Changes of erythrocyte count to both sides from the peak (Fig. 1, *b*) are paralleled by a decrease in their volume (smooth at lower concentration and abrupt at higher concentration). In other words, we found an inverse relationship between these parameters above the erythrocyte concentration of 4.3×10^{12}/liter (this relationship is virtually linear at concentrations of 4.4-

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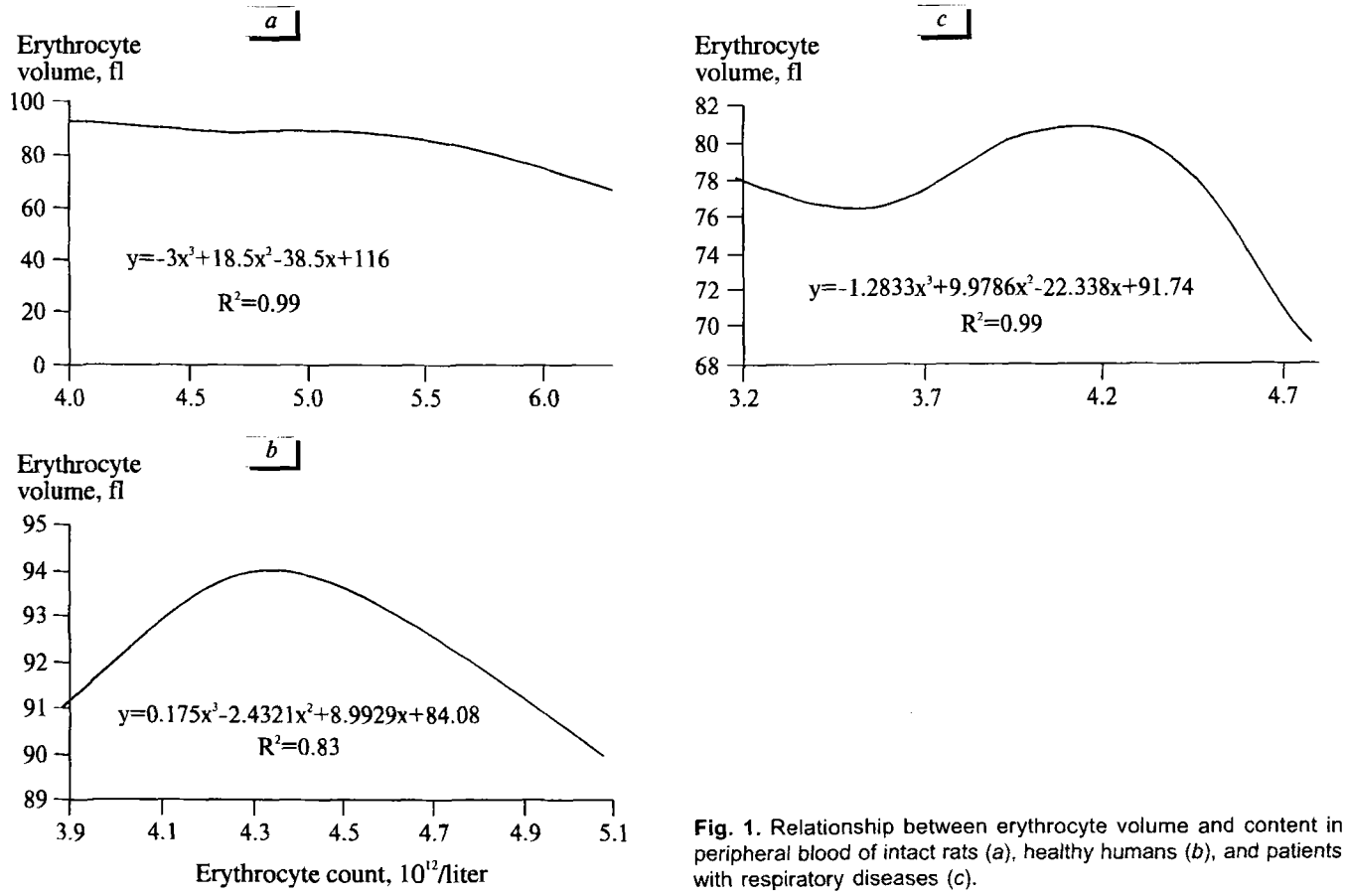

Fig. 1. Relationship between erythrocyte volume and content in peripheral blood of intact rats (*a*), healthy humans (*b*), and patients with respiratory diseases (*c*).

5×10^{12}/liter), while at erythrocyte concentrations below 4.3×10^{12}/liter this relationship became direct. These opposite deviations equilibrate each other, the resultant value approximates the zero, which masks the actual structure of the relationship between these parameters.

This fact illustrates the known statement that failure to detect a correlation between the signs is not the proof of the absence of relationships between the parameters, because traditional correlation coefficient is just the measure of direct relationship. Our findings suggest that changes in the erythrocyte count and mean volume in human blood and in rats are mutually determined. The fact that this correlation is clear-cut in rats but not in humans, with nonlinear relationship formally similar in both, does not cancel the presence of this correlation. In rats the empirical curve is adequately approximated by a straight line equation, thus ensuring the efficiency of the correlation analysis. In healthy humans at rest this relationship depends on the erythrocyte concentration range.

It is true only for healthy individuals, because in patients with respiratory diseases associated with a significant decrease in the mean erythrocyte volume the relationship is inverted twice with increasing cell count (Fig. 1, *c*): direct relationship between the parameters in a wide range of concentrations and reciprocal relationship at marginal cell counts. In iron-deficiency anemia, the relationship between erythrocyte size and concentration remains linear virtually in the entire range of fluctuations in the parameters: decrease of cell count from 4.8 to 2.6×10^{12}/liter is paralleled by an increase in their mean volume from 72 to 90 fl. All this indicates instability of the discussed co-variations which are modified with changes in the general status. The same instability in the relationship between the parameters is characteristic of rats as well [4,6], and therefore it is hardly possible to speak about principal differences in the relationships of this kind in humans and rats. The physiological essence of these relationships consists in the following: both signs are involved in the regulation of rheological characteristics (viscosity) and oxygen capacity of the blood [8]. As for deviations observed in health, they can be explained by the status of the mean characteristics: erythrocyte concentration in rat blood 60% surpassed that in humans but rat erythrocytes are 40% smaller human cells. This fact determines the initial species specificities of the spectrum of permissible proportions of this type, corrected by a regulatory mechanism which is determined in both cases by the task of preserving the total erythrocyte mass and their general respiratory surface while maintaining a sufficient level of blood

viscosity [7,8]. On the other hand, complex time course of changes in the studied relationships indicates that they are determined by the causes not directly related to the studied parameters, and points to separate regulation of erythrocyte size and content in the blood.

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