ORIGINAL CONTRIBUTION

Reference Values for Erythrocyte Sedimentation Rate of Middlescent People as a Function of Altitude

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The purpose of this paper is to provide a scientific basic for a unified standard for the reference value of middlescent people’s erythrocyte sedimentation rate (ESR) in China. ESR measurements for healthy middlescent people were collected according to the Wintrobe method and the relationship between the reference value of middlescent people’s ESR and altitude was tested in this paper. It was found that the reference value of middlescent people’s ESR decreases when the altitude gradually increases, and the relationship is quite significant. Univariate regression analysis was used to deduce two regression equations: \[ Y_1 = 13.14 - 0.00245X \pm 2.98 \text{ (males)} \] and: \[ Y_2 = 22.00 - 0.00397X \pm 4.85 \text{ (females)} \]. If the altitude value of a particular area of China is known, the reference value of middlescent people’s ESR can be calculated by means of these regression equations. Furthermore, depending on the altitude, China can be divided into three biogeographic districts: Qingzang District, Central District, and Eastern District.

INTRODUCTION

Erythrocyte sedimentation rate (ESR)\(^b\) is an important index of hemorheology. Although many local reference values of middlescent (age 26 to 45 years) people’s ESR have been measured [1-61], it is difficult to achieve accuracy in clinical practice, because of the lack of a unified standard of the reference value of middlescent people’s ESR. No reports on the relationship between the reference value of middlescent people’s ESR and altitude were found. By means of correlation and univariate regression analysis, it is shown that there are certain regular dependencies between the reference value of middlescent people’s ESR and altitude.

MATERIALS AND METHODS

Determination of ESR (Wintrobe)

The values of healthy middlescent people’s ESR from various administrative units (hospitals, research institutes and universities) were collected in China. These data include the values of ESR of 23,001 middlescent men tested in 301 units and the values of ESR of 20,028 middlescent women tested in 291 units. The

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\(^b\) Abbreviations: ESR, erythrocyte sedimentation rate.

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ages of the volunteers ranged from 26 to 45 years, and 40 to 80 random samples were studied in every area. A mean value of ESR in each area was calculated. These sampling units are located in 34 provinces, cities, special administrative regions, and autonomous regions in China. There are more data from the eastern plain than from the western plateau. The determination of the ESR was performed according to Wintrobe’s method [62]. In this routine method, 2.5 ml venous blood was collected in anticoagulant (heparin). The mixture was then stirred slightly and placed in the Wintrobe test tube filled to the zero graduation mark without any air bubbles. The tube was left for 1 hr at 25°C. The ESR determinations are expressed in mm/hr.

The altitude measurements came from relevant geographical works and dictionaries [63-64], the altitude is the height in meters (m) above sea level.

RESULTS

By using the method of mathematical correlation analysis [65], single correlation coefficients were ascribed to the reference value of middlecent people’s ESR and altitude, respectively. For middlecent men, \( r_1 = -0.610 \), degrees of freedom \( N-2 = 301-2 = 299 \), critical value of correlation coefficient is obtained from tables: \( r_{0.01} = 0.116 \). As \( |r| \) is higher than 0.116, the correlation is quite significant.

For middlecent women, \( r_2 = -0.603 \), degrees of freedom \( N-2 = 291-2 = 289 \), critical value of correlation coefficient is obtained from tables: \( r_{0.01} = 0.116 \). As \( |r| \) is higher than 0.116, the correlation is quite significant.

In the above equations, \( \hat{Y} \) is the reference value of middlecent men’s ESR (mm/hr); \( 2 \) is the reference value of middlecent women’s ESR (mm/h); \( X \) is altitude (m); 2.98 and 4.85 are the values of the residual standard deviations, respectively [66].

DISCUSSION

On the basis of correlation coefficients only, it was shown that the decrease in the reference value of middlecent people’s ESR follows the altitude increase. It was found that the ESR reference values of middlecent men are lower than that of middlecent women. As the altitude rises, the partial pressure of oxygen gradually decreases and in response to less available oxygen, the hematocrit increases (Table 1). This increase in red cell concentration is one known factor that contributes to a fall in the value of middlecent people’s ESR.

| Table 1. Red blood cell count of different altitude. |
|-----------------|-----------------|-----------------|-----------------|
| Typical         | Altitude (m)    | Men’s value     | Women’s value   |
| Naqu            | 4600.0          | \( 6.21 \times 10^{12} \) L | \( 6.09 \times 10^{12} \) L |
| Lhasa           | 3658.0          | \( 5.59 \times 10^{12} \) L | \( 5.17 \times 10^{12} \) L |
| Xining          | 2275.0          | \( 5.46 \times 10^{12} \) L | \( 4.68 \times 10^{12} \) L |
| Lanzhou         | 1517.2          | \( 5.13 \times 10^{12} \) L | \( 4.58 \times 10^{12} \) L |
| Chongqing       | 260.6           | \( 4.94 \times 10^{12} \) L | \( 4.30 \times 10^{12} \) L |
| Beijing         | 31.2            | \( 4.75 \times 10^{12} \) L | \( 4.25 \times 10^{12} \) L |
[67]. These data show that the relationship between red-cell count and altitude is non-linear and that the male-female difference across all altitudes is about $0.6 \times 10^{12}/L$. While the ESR is clearly correlated to the hematocrit, there is no simple correction of the ESR regression using the red-cell counts that eliminates the observed dependence of the ESR on altitude.

If the altitude of particular area in China is known, a standard reference value of middle-essen’s ESR in this area can be calculated from the regression equations. For example, in the Beijing area where the altitude is $31.2 \text{ m}$, the following reference standards can be calculated:

\[
\hat{V}_1 = 13.14 - 0.00245 \times 31.2 \pm 2.98 = 13.06 \pm 2.98 \\
\hat{V}_2 = 22.00 - 0.00397 \times 31.2 \pm 4.85 = 21.88 \pm 4.85
\]

The topographical outline of China is a three-step, West-East staircase. According to the reference value of middle-essen’s ESR and taking the altitude as the main differentiating factor, China can be divided into three districts, the Qingzang district, the Central district, and the Eastern district.
The highest western area, 4,000 m above sea level, includes the Qingzang plateau. It includes the Tibet Autonomous Region and Qinghai Province. Its altitude is the highest, so its ESR is the lowest in China. For example, in the Lhasa area, the altitude is 3658 m. Using regression equations, the calculated reference value of middlecent people’s ESR can be obtained as follows: the reference value of middlecent men’s ESR is 4.18 ± 2.98 mm/h, the reference value of middlecent women’s ESR is 7.48 ± 4.85 mm/h.

Further to the east, behind the Kunlun Mountains and Qilian Mountains on the plateau’s northern edge and the Hengdian Mountains on its eastern edge, the land slopes down to highlands and basins (2000 to 1,000 m above sea level). This district includes Sichuan Province, Chongqing city, Guizhou Province, Yunnan Province, Shaanxi Province, Gansu Province, the Xinjiang Uighur Autonomous Region, the Ningxia Hui Autonomous Region, the Inner Mongolia Autonomous Region and Shanxi Province. Its altitude is intermediate, so its ESR is intermediate in China. For example, in the Yinchuan area, the altitude is 1,112 m. Using regression equations, the calculated reference value of middlecent people’s ESR can be obtained as follows: the reference value of middlecent men’s ESR is 10.42 ± 2.98 mm/hr, the reference value of middlecent women’s ESR is 17.59 ± 4.85 mm/hr.

Further to the east from second staircase, it descends further eastward to hilly regions and plains mostly below 500 m. This district includes Taiwan Province, Hainan Province, Guangdong Province, Hongkong Special Administrative Region, Macao Special Administrative Region, the Guangxi Zhuang Autonomous Region, Shanghai City, Jiangsu Province, Zhejiang Province, Anhui Province, Fujian Province, Jiangxi Province, Hunan Province, Hubei Province, Beijing City, Tianjin City, Hebei Province, Shandong Province, Henan Province, Liaoning Province, Jilin Province and Heilongjiang Province. Its altitude is the lowest, so its ESR is the highest in China. For example, in the Beijing area the altitude is 31.2 m. Using regression equations, the calculated reference value of middlecent people’s ESR can be obtained as follows: the reference value of middlecent men’s ESR is 13.06 ± 2.98 mm/h, the reference value of middlecent women’s ESR is 21.88 ± 4.85 mm/h.

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