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Reference Value of Presenile Human Hematocrit and Geographical Factors

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The aim of this study was to provide a scientific basis for a unified standard of the reference value of healthy presenile human hematocrit in China. We studied the relationship between the reference values of healthy presenile human hematocrit, tested according to Wintrobe's laws, and five geographical factors. It was found that altitude is the most important factor affecting the reference value of the hematocrit. As the altitude gradually increases, the reference value of the hematocrit also increases. The relationship is quite significant. By using the method of stepwise regression analysis, two multivariate regression equations were deduced: $\hat{Y}_1 = 39.7 + 0.00328X_1 + 0.00169X_2 + 0.00117X_5 \pm 2.3$, $\hat{Y}_2 = 38.8 + 0.00275X_1 + 0.000578X_2 - 0.00298X_4 \pm 2.2$ In these equations, $\hat{Y}_1$ is the reference value of presenile men's hematocrit (%); $\hat{Y}_2$ is the reference value of presenile women's hematocrit (%); X_1 is altitude (m); X_2 is the average annual hours of sunshine (h); X_4 is the average annual temperature (°C), and X_5 is the average annual precipitation (mm). If the geographical index values in a particular area in China are known, the reference value of presenile human hematocrit in this area can be calculated approximately by means of the regression equations. J. Clin. Lab. Anal. 16:26–29, 2002.

Key words: hematocrit; reference value; geographical factors; regression analysis

INTRODUCTION

Hematocrit is an important index of hemorheology. At present, it is difficult to achieve accuracy in clinical practice because of the lack of a unified standard for the reference value of presenile human hematocrit in China. Many researchers have measured the reference value (Wintrobe) of local presenile human hematocrit (1–17), but we found no reports on the relationship between the reference value of the hematocrit and geographical factors. Using correlation and stepwise regression analysis to examine the relationship between the reference value of presenile human hematocrit and geographical factors showed that there are certain regular patterns in this relationship.

MATERIALS

Reference Value (Wintrobe) of Presenile Human Hematocrit

The reference values of healthy presenile human hematocrit from various administrative units (hospitals, research institutes, and universities) in China were collected. This included the reference values of 28,803 presenile men's hematocrit tested in 270 units, and the reference values of 17,562 presenile women's hematocrit tested in 229 units. The ages of the volunteers ranged from 46 to 59 years. The mean value of the hematocrit in each area was used, and 40–180 random samples were studied in each area. These units are located in 34 provinces, cities, special administrative regions, and autonomous regions in China. The determination of the reference value of presenile human hematocrit was performed according to Wintrobe (18). Following this routine method, 2.5 ml of venous blood was collected and poured into an anticoagulant (heparin) test tube. After that, the mixture was stirred slightly and absorbed into a Wintrobe test tube to a "10" graduation, without any air bubbles. Then the tube was put into a centrifugal machine and centrifuged for 30 min at 2,300 g, after which the reference value of the hematocrit was read.

Geographical Factors

The geographical factors used in this study were gathered from relevant geographical works and dictionaries (19,20).

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The selected geographical factors included altitude (0–5,500 m), average annual hours of sunshine (1,000–3,600 h), relative humidity (30–85%), average annual temperature (–10 to 26 °C), and annual precipitation (30–2,500 mm).

REGRESSION ANALYSIS

Correlation Analysis

Using mathematical correlation analysis (21), single correlation coefficients between the reference value of presenile human hematocrit and five geographical factors (altitude, annual hours of sunshine, relative humidity, annual average temperature, and annual precipitation) can be calculated (Table 1).

Regression Equations

Using stepwise regression analysis, two regression equations are given according to the reference value of presenile human hematocrit and geographical factors:

$$\hat{Y}_1 = 39.7 + 0.00328X_1 + 0.00169X_2 + 0.00117X_5 \pm 2.3$$
$$\hat{Y}_2 = 38.8 + 0.00275X_1 + 0.000578X_2 - 0.00298X_4 \pm 2.2$$

In the above equations, $\hat{Y}_1$ is the reference value of presenile men's hematocrit (%); $\hat{Y}_2$ is the reference value of presenile women's hematocrit (%); X_1 is altitude (m); X_2 is the average annual hours of sunshine (h); X_4 is the average annual temperature (°C); X_5 is the average annual precipitation (mm); and 2.3 and 2.2 are the values of the residual standard deviations (22).

Using the F-test, $F_1 = 393.24$ (indicating that the correlation is quite significant in presenile men's hematocrit), and $F_2 = 231.15$ (indicating that the correlation is quite significant in presenile women's hematocrit).

DISCUSSION

From single correlation coefficients, it was found that the reference value of presenile human hematocrit increases with altitude, the correlation is quite significant, and the relation is the closest. With an increase in the annual hours of sunshine, the reference value of the hematocrit also increases; the correlation is quite significant. With an increase in relative humidity, the reference value decreases; the correlation is quite significant. With an increase in annual average temperature, the reference value decreases; the correlation is not significant, and the relation is the slightest. With an increase in annual precipitation, the reference value decreases; the correlation is quite significant. From this analysis, it can be concluded that altitude is the main factor affecting the reference value of presenile human hematocrit. As altitude increases, the air becomes thin and the oxygen content gradually decreases. In response to the lack of oxygen, the amount of red blood cells in the human body gradually increases (Table 2), causing a rise in the reference value of the hematocrit (23).

If the geographical factors of a particular area are known, the reference values of presenile human hematocrit in this area can be calculated according to the regression equations. For example, in the Beijing area, the altitude is 31.2 m, the average annual hours of sunshine is 2780.2 hr, the average annual temperature is 11.5 °C, and the annual precipitation is 644.2 mm. By means of the regression equations, the following can be calculated:

$$\hat{Y}_1 = 39.7 + 0.00328 \times 31.2 + 0.00169 \times 2780.2 + 0.00117 \times 644.2 \pm 2.3$$
$$\hat{Y}_2 = 38.8 + 0.00275 \times 31.2 + 0.000578 \times 2780.2 - 0.00298 \times 11.5 \pm 2.2$$

According to the calculation, the reference value of presenile men's hematocrit is 45.3 ± 2.3%, and the reference value of presenile women's hematocrit is 40.5 ± 2.2%. It was found that the reference value of presenile men's hematocrit is higher than that of presenile women's.

The topographical outline of China is a three-step West–East staircase. It is high in the western area and low in the eastern area. It begins with the Qingzang plateau, which is mostly 4,000 m above sea level. Crossing the Kunlun and Qilian ranges on the plateau's northern edge and the Hengduan Mountains on its eastern edge, the land slopes away to highlands and basins that are mostly 1,000–2,000 m above sea level; it then descends farther eastward to hilly regions and plains, mostly below 500 m. With the gradual reduction of annual sunshine hours in a Northwest–Southeast direction, the annual average temperature gradually rises from North to South, and the relative humidity and annual precipitation gradually increase in a Northwest–Southeast direction. The population is much denser higher in the eastern area than in the western area.

According to the similarities in the reference value of pres-

TABLE 1. Correlation coefficient of hematocrit with selected geographical factors

Variable	Men (*n* = 270)	*P* value	Women (*n* = 229)	*P* value
Altitude	0.898	<0.01	0.864	<0.01
Annual sunshine hour	0.403	<0.01	0.364	<0.01
Relative humidity	–0.638	<0.01	–0.596	<0.01
Annual average temperature	–0.100	>0.05	–0.114	>0.05
Annual precipitation	–0.433	<0.01	–0.419	<0.01

TABLE 2. Red blood cell count of different altitude

Typical area	Altitude (m)	Men's value	Women's value
Naqu	4600.0	6.21×10^{12}/L	6.09×10^{12}/L
Lhasa	3658.0	5.59×10^{12}/L	5.17×10^{12}/L
Xining	2275.0	5.46×10^{12}/L	4.68×10^{12}/L
Lanzhou	1517.2	5.13×10^{12}/L	4.58×10^{12}/L
Chongqing	260.6	4.94×10^{12}/L	4.30×10^{12}/L
Beijing	31.2	4.75×10^{12}/L	4.25×10^{12}/L

TABLE 3. Geographical indices values of six representative areas

District	Typical area	X_1 (m)	X_2 (h)	X_3 (%)	X_4 (°C)	X_5 (mm)
Qingzang	Lhasa	3658.0	3007.7	45.0	7.5	454.0
Southwest	Guiyang	1071.2	1371.0	79.0	15.3	1174.7
Northwest	Yinchuan	1111.5	3039.8	59.0	8.5	202.8
Southeast	Nanchang	46.7	1903.9	77.0	17.5	1596.4
North	Beijing	31.2	2780.2	60.0	11.5	644.2
Northeast	Changchun	236.8	2643.5	65.0	4.9	593.8

enile human hematocrit, and using altitude as the main differentiating factor, China can be divided into three parts: eastern, middle, and western. Furthermore, on the basis of altitude, referring to distribution of population density and other geographical factors, we can designate three districts in the eastern part (the Southeast, North, and Northeast districts), two districts in the middle part (the Southwest and Northwest districts), and one district in the western part (Qingzang District). Thus, we have the following six districts in China.

The Qingzang District includes the Tibet Autonomous Region and Qinghai Province. The Southwest District includes Sichuan Province, Chongqing City, Guizhou Province, and Yunnan Province. The Northwest District includes Shaanxi Province, Gansu Province, the Xinjiang Uighur Autonomous Region, the Ningxia Hui Autonomous Region, the Inner Mongolia Autonomous Region, and Shanxi Province. The Southeast 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, and Hubei Province. The North District includes Beijing City, Tianjin City, Hebei Province, Shandong Province, and Henan Province. The Northeast District includes Liaoning Province, Jilin Province, and Heilongjiang Province (Tables 3 and 4).

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TABLE 4. Comparable table of calculated values and actual values

	Men (mm/h)		Women (mm/h)	
Typical area	Calculate value	Actual value	Calculate value	Actual value
Lhasa	57.3±2.3	56.8±2.1	50.6±2.2	50.5±2.4
Guiyang	46.9±2.3	47.6±2.0	42.5±2.2	42.1±1.7
Yinchuan	48.7±2.3	48.6±2.5	43.6±2.2	43.0±1.9
Nanchang	44.9±2.3	44.9±2.5	40.0±2.2	40.5±2.0
Beijing	45.3±2.3	45.8±2.0	40.5±2.2	41.0±1.5
Changchun	45.6±2.3	46.5±2.3	41.0±2.2	41.3±2.2

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