Original Article

Normal Red Blood Cell Count Reference Values in Chinese Presenile Women Given by Geographical Area

Miao Ge,¹* Yaping Zhang,¹ Jinwei He,¹ Yanchun Yan,¹ Xin Wang,¹ Lixia Cao,¹ Haiyan Fu²

Background/Purpose: We aimed to standardize the normal reference value of red blood cell (RBC) counts in Chinese presenile women using an underlying scientific basis.

Methods: This research was conducted to study the relationship between the normal reference value of 31,405 RBC samples from presenile women in eight different geographical areas in China. RBC counts were determined using a microscopic counting method.

Results: There was a significant correlation between geographical factors and the normal reference RBC value in presenile women ($F = 187.82, p = 0.000$). Using stepwise regression analysis, one regression equation was obtained.

Conclusion: If geographical values are obtained in a certain area, the normal RBC reference value in presenile women in this area can be obtained using the regression equation.

Key Words: geographical factors, normal reference value, red blood cell count, regression analysis

Red blood cell (RBC) count is an important index in hematology. At present, it is difficult to achieve accuracy in clinical diagnosis due to the lack of a unified standard normal reference value for presenile women in China. To supply a scientific basis for standardizing the normal RBC reference value for Chinese presenile women, many researchers have measured the normal RBC reference value in local presenile women.¹⁻⁶⁶ However, the relationship between the normal RBC reference value in presenile women and geographical factors has not been reported.⁶⁷⁻⁶⁹ By stepwise regression analysis, this study illustrates that there are certain regular patterns between the normal RBC reference values for presenile women and geographical factors.

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Materials and Methods

Normal RBC reference value in presenile women

The normal RBC reference values in healthy presenile women from various administrative units (hospitals, research institutes and universities) were collected in China. These values included the normal RBC reference values of 31,405 presenile women tested in 279 units from eight geographical areas in China (Figure). The age of the volunteers ranged from 46 to 59 years. The mean value of RBC counts of presenile women in each area and 50–210 random samples of each area were studied. Normal RBC reference values were determined using a microscopic counting method. This procedure involved obtaining a minor test tube and adding 2 mL RBC diluents. Blood (10 μL) was then added to the RBC diluents. This was performed using a clean, dry micro-straw. Surplus blood was scraped off the tip of the micro-straw and gently injected to the bottom of the blood cell diluents. The remaining clear liquid was used to wash the micro-straw two to three times using repeated pipetting, whereupon the suspension was immediately mixed. After allowing the mixture to stand for 2–3 minutes, cell numbers were counted with a high powered microscope and a hemocytometer, visually counting cells that lie within the upper and left margins of the grid rather than the lower and right margins.

Geographical factors

Geographical factors are listed in relevant geographical works and dictionaries. We selected altitude, annual duration of sunshine, annual percentage of sunshine duration, annual mean air temperature, annual range of air temperature, annual mean relative humidity, annual precipitation amount, and annual mean wind speed as the factors that we wished to investigate.

The mean sea level is determined by continued observation of sea levels. Altitude is defined as the height (in meters) measured from the sea level.

Sunshine duration is the time from sunrise to sunset. When the sun is shaded by fog or affected by obstacles, the actual sunshine duration is called the observed sunshine hours. The number of observed sunshine hours in 1 year is called annual sunshine duration.

Annual percentage of sunshine duration is defined as the observed sunshine duration as a percentage of the total possible sunshine duration for a given year.

Air temperature (°C) is defined as the temperature at 1.5 m above the ground surface. The average observed values for a given year is called annual mean air temperature.

Annual range of air temperature (°C) is defined as the difference between mean temperatures of the warmest and the coldest months in 1 year.

The ratio of actual vapor pressure in the air to saturation vapor pressure at the current temperature is called relative humidity. The average observed values for a given year is called annual mean relative humidity (in %).

Precipitation amount (in mm) is defined as the accumulated depth in a horizontal container that collects the liquid or solid precipitation (after melting). The total precipitation for a given year gives the annual precipitation amount.

Wind speed (in m/s) is defined as the horizontal distance that the air moves in unit time. The
average observed values for a given year is called annual mean wind speed.

**Correlation and regression analysis**

Using mathematical correlation analysis, single correlation coefficients between the normal RBC reference values in presenile women and the eight geographical factors can be calculated. These values were: $r_1 = 0.888 \ (p_1 = 0.000)$, $r_2 = 0.487 \ (p_2 = 0.000)$, $r_3 = 0.477 \ (p_3 = 0.000)$, $r_4 = -0.791 \ (p_4 = 0.000)$, $r_5 = -0.209 \ (p_5 = 0.000)$, $r_6 = -0.657 \ (p_6 = 0.000)$, $r_7 = -0.552 \ (p_7 = 0.000)$, $r_8 = 0.112 \ (p_8 = 0.061)$, for altitude, annual duration of sunshine, annual percentage of sunshine duration, annual mean air temperature, annual range of air temperature, annual mean relative humidity, annual precipitation amount, and annual mean wind speed, respectively. A $p$ value < 0.05 indicated a significant correlation.

**Result**

According to the normal RBC reference value in presenile women and geographical factors, a regression equation was determined using stepwise regression analysis:

$$
\hat{Y} = 2.675 + 0.0003166X_1 - 0.0003861X_2 + 0.02658X_3 - 0.01745X_4 + 0.01277X_5 + 0.009396X_6 + 0.0003444X_7 \pm 0.44
$$

In the above equation, $\hat{Y}$ is the normal RBC reference value in presenile women ($\times 10^{12}/L$), $X_1$ is the altitude (m), $X_2$ is the annual sunshine duration (hr), $X_3$ is the annual percentage of sunshine duration (%), $X_4$ is the annual mean air temperature (°C), $X_5$ is the annual range of air temperature (°C), $X_6$ is the annual mean relative humidity (%), $X_7$ is the annual precipitation amount (mm), and 0.44 is the value of the 1.96 residual standard deviations.

The F-test gave a value of 187.82 and a $p$ value of 0.000, a quite significant correlation was demonstrated between RBC in presenile women and geographical factors.

**Discussion**

China is situated in the eastern part of Asia with the Pacific Ocean off the west coast. It has a vast territory of 9.6 million km$^2$. The distance from east to west is over 5000 km and from north to south over 5500 km. When the sun rises over Wusuli River in the northeast, the Pamirs in the west are still dark. When blizzards wrap the north in winter, spring sowing is under way on Hainan Island in the south. The Tsengmu Reef, the southernmost part of China, is close to the equator and stays hot year-round.

Chinese topography varies from cloud-capped peaks to basins of different shapes and sizes, from wide, rolling plateaus to low, broad plains. There are great deserts and wilds in the northwest, while rivers, streams and lakes are on the plains of the middle and lower reaches of the Changjiang River. The topographical outline of China is a three-step west-east staircase, having high western areas and low eastern areas. It begins from the Qinghai-Tibetan Plateau, which is mostly 4000 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 mostly 1000–2000 m above sea level. The land then descends further eastward to hilly regions and plains, mostly below 500 m above sea level.

In China, some areas are warm year-round while others have long winters and short summers. Most of the land lies in the temperate zone, which has four distinct seasons. A combination of high temperature and plentiful rain provides favorable conditions for farming in these areas.

In the east, winter often brings a dry, cold northwest wind from the hinterland towards the sea. Summer often brings a hot, moist southeast wind from the sea. The northwest, being far from the sea, has comparatively little rain and its temperature varies greatly even in the same day. The vivid saying of “fur coats in the morning, gossamer at noon” very well describes the arid regions in Xinjiang. By contrast, the temperature on the Qinghai-Tibetan Plateau in the southwest is relatively low because of its high altitude. Both Lhasa
<table>
<thead>
<tr>
<th>Region</th>
<th>Province</th>
<th>City</th>
<th>X1 (m)</th>
<th>X2 (hr)</th>
<th>X3 (%)</th>
<th>X4 (°C)</th>
<th>X5 (°C)</th>
<th>X6 (%)</th>
<th>X7 (mm)</th>
<th>Y (×10¹²/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast China</td>
<td>Liaoning, Jilin, Heilongjiang</td>
<td>Harbin</td>
<td>171.7</td>
<td>2641.0</td>
<td>60.0</td>
<td>3.6</td>
<td>42.2</td>
<td>67.0</td>
<td>523.3</td>
<td>4.59 ± 0.44</td>
</tr>
<tr>
<td>North China</td>
<td>Beijing, Tianjin municipalities, Hebei, Shandong, Henan</td>
<td>Beijing</td>
<td>31.2</td>
<td>2780.2</td>
<td>63.0</td>
<td>11.5</td>
<td>30.4</td>
<td>60.0</td>
<td>644.2</td>
<td>4.26 ± 0.44</td>
</tr>
<tr>
<td>Shanxi-Shaanxi-Inner</td>
<td>Shanxi, Shaanxi, Inner Mongolia autonomous region</td>
<td>Taiyuan</td>
<td>777.9</td>
<td>2675.8</td>
<td>60.0</td>
<td>9.5</td>
<td>30.1</td>
<td>60.0</td>
<td>459.5</td>
<td>4.42 ± 0.44</td>
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<tr>
<td>Mongolia</td>
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<tr>
<td>Middle and lower</td>
<td>Hubai, Hunan, Anhui, Jiangxi, Zhejiang, Jiangsu, Shanghai Municipality</td>
<td>Shanghai</td>
<td>4.6</td>
<td>2014.0</td>
<td>45.0</td>
<td>15.7</td>
<td>24.3</td>
<td>79.0</td>
<td>1123.7</td>
<td>4.26 ± 0.44</td>
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<td>reaches of the</td>
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<tr>
<td>Changjiang River</td>
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<tr>
<td>Southeast China</td>
<td>Fujian, Guangdong, Hainan, Taiwan, Hong Kong and Macau SAR</td>
<td>Haikou</td>
<td>14.1</td>
<td>2239.8</td>
<td>50.0</td>
<td>23.6</td>
<td>11.0</td>
<td>83.0</td>
<td>1691.0</td>
<td>4.23 ± 0.44</td>
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<td>Northwest China</td>
<td>Gansu, Ningxia Hui autonomous regions, Xinjiang Uyghur autonomous regions</td>
<td>Yinchuan</td>
<td>1111.5</td>
<td>3039.6</td>
<td>69.0</td>
<td>8.5</td>
<td>32.4</td>
<td>59.0</td>
<td>202.8</td>
<td>4.58 ± 0.44</td>
</tr>
<tr>
<td>Southwest China</td>
<td>Chongqing Municipality, Sichuan, Yunnan, Guizhou, Guangxi Zhuang Autonomous Region</td>
<td>Guiyang</td>
<td>1071.2</td>
<td>1371.0</td>
<td>31.0</td>
<td>15.3</td>
<td>19.1</td>
<td>77.0</td>
<td>1174.7</td>
<td>4.41 ± 0.44</td>
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<tr>
<td>Qinghai-Tibetan Plateau</td>
<td>Qinghai Province, the Tibet Autonomous Region</td>
<td>Lhasa</td>
<td>3658.0</td>
<td>3007.7</td>
<td>68.0</td>
<td>7.5</td>
<td>17.7</td>
<td>45.0</td>
<td>444.8</td>
<td>5.15 ± 0.44</td>
</tr>
</tbody>
</table>

*Y is the normal RBC reference value in presenile women (× 10¹²/L), X₁ is the altitude (m), X₂ is the annual sunshine duration (hr), X₃ is the annual percentage of sunshine duration (%), X₄ is the annual mean air temperature (°C), X₅ is the annual range of air temperature (°C), X₆ is the annual mean relative humidity (%), X₇ is the annual precipitation amount (mm).
in the west and Hangzhou in the east are at the latitude of 30°N, but the average July temperature of the former is 15°C, while the latter is 28°C.

Owing to monsoons, the temperature in the north and south varies greatly in winter, but little in summer. In January the difference in average temperature between Harbin in the northeast and Guangzhou in the south is as much as 33°C. When it is still cold winter along the banks of the Songhua River, the Zhujiang River valley is in spring. But in July the difference is only 5°C, and swimming can occur in both rivers. With a gradual decrease in rainfall in a southeast-northwest direction, a raincoat is a must in southeast China, but is practically useless in most parts of the northwest. With a gradual reduction of annual sunshine duration in a northwest-southeasterly direction, the annual mean air temperature gradually rises from north to south, and annual mean relative humidity and precipitation amount gradually increase in a northwest-southeasterly direction. The population is much larger in eastern areas than in western areas. Human beings depend on the geographical environment for living. This environment consists of an organic whole comprised of factors such as air, water, soil, living things and minerals. Humans are in a contradictory process of unity with the geographical environment. The living organism absorbs nutritious substances from the environment, but it also excretes waste materials into the environment. The process of metabolism, along with the exchange of energy, forms the dynamic balance of physical exchange between human beings and the geographical environment. Therefore, normal RBC reference values reflect the geographical environment and a dependent relationship between normal RBC reference values and geographical factors exists.

From single correlation coefficients, it was found that the normal RBC reference values in presenile women increased with altitude, annual sunshine duration, annual percentage of sunshine duration and annual mean wind speed. By contrast, an increase in annual mean air temperature, annual range of air temperature, annual mean relative humidity, and annual precipitation amount saw a decrease in normal RBC reference values. All correlations were significant, especially the relationship between altitude and RBC in the presenile women. From this analysis, it can be concluded that altitude is the main factor affecting normal RBC reference values in presenile women. As altitude rises, the air becomes thinner, and oxygen content gradually reduces. In response to the lack of oxygen, the amount of RBCs in the human body gradually increases, thereby inducing a rise in the normal reference values in presenile women.77

If the geographical factors of a particular area in China are known, the normal reference values for RBC counts in presenile women in this area can be calculated according to the regression equation. Examples are given in the Table.

Acknowledgments

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References

8. Yaohong S, Shengkai Y, Yongzhe L. A Necessary Book to Read When Going to See the Doctor And Have a Chemical


66. Li Z, Xuezeng L. *Investigation into normal reference values of venous blood using a blood analysis instrument*. J Pract Med Lab Tech 2001;8:60. [In Chinese]


