Influencing Factors of Static Balance Posture Diagram

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Abstract
Balance ability is an important physiological function of the human body and a guarantee for people's daily life and work. In recent years, with the wide application of electronic computer technology in medicine, static posture maps have been widely used in the testing of balance functions such as nervous system disorders, prostheses and vestibular dysfunction due to their simple, reliable, effective and time-saving features. It is one of the effective and reliable methods that rehabilitation doctors often use in the treatment and monitoring of balance functions. However, the research on the influencing factors of static equilibrium posture map is not deep enough, and the factor analysis is incomplete. Therefore, this article used the Israeli TETRAX balance and stability test system to test 162 healthy people and 30 patients with tertiary balanced Parkinson's disease with mild balance dysfunction. It also includes two experimental modes: blinking and closing eyes. The parameters tested included the total center of gravity of the center of gravity, the length of the track per unit area, the average speed of motion before and after, the average speed of left and right movement, the length of exercise, age, height, weight and body type. The analysis was performed by statistical methods such as significance test, t test and principal component analysis. The experimental results show that the balance of the blinking situation is better than the closed eye state, whether it is a healthy person or a patient. Age is the influencing factor of the balance posture map, and the balance function decreases with age. The body shape also has an effect on the balance of the human body. Under other conditions with the same objective conditions such as age, the stability of the short-skinned subjects is better than that of the moderate and lean subjects. Through the principal component analysis method, the health group and the patient group were comprehensively scored, and the healthy group was significantly better than the patient group. The static equilibrium posture diagram is simple and convenient. The research on the influencing factors of static equilibrium posture map has certain auxiliary value for the diagnosis of human balance function.

Keywords: Balance Function, Element, Static Posture Map, Stability

Factores que influyen en el diagrama de postura de equilibrio estático

Resumen
La capacidad de equilibrio es una función fisiológica importante del cuerpo humano y una garantía para la vida diaria y el trabajo de las personas. En los últimos años, con la amplia aplicación de la tecnología de computación electrónica en medicina, los mapas de postura estáticos se han usado ampliamente en la evaluación de funciones de equilibrio como trastornos del sistema nervioso, prótesis y disfunción vestibular debido a su simplicidad, fiabilidad, eficacia y ahorro de tiempo características. Es uno de los métodos efectivos y confiables que los médicos de rehabilitación utilizan a menudo en el tratamiento y monitoreo de las funciones de equilibrio. Sin embargo, la investigación sobre los factores que influyen en el mapa de postura de equilibrio estático no es lo suficientemente profunda, y el análisis factorial es incompleto. Por lo tanto, este artículo utilizó el sistema israelí de prueba de equilibrio y estabilidad TETRAX para evaluar a 162 personas sanas y 30 pacientes con enfermedad de Parkinson con equilibrio terciario y disfunción leve del equilibrio. También incluye dos modos experimentales: parpadear y cerrar los ojos. Los parámetros probados incluyeron el centro de gravedad total del centro de gravedad, la longitud de la pista por unidad de área, la velocidad media del movimiento antes y después, la velocidad media del movimiento izquierdo y derecho, la duración del ejercicio, la edad, la altura, peso y tipo de cuerpo. El análisis se realizó mediante métodos estadísticos como la prueba de significación, la prueba t y el análisis de componentes principales. Los resultados experimentales muestran que el equilibrio de la situación de parpadeo es mejor que el estado de ojo cerrado, ya sea una persona sana o un paciente. La edad es el factor que influye en el mapa de postura de equilibrio, y la función de equilibrio disminuye con la edad. La
1. Introduction

Balance usually refers to a posture in which the body is located and an ability to automatically adjust and maintain posture when exercising or when subjected to external forces [1]. The maintenance of human balance depends on the appropriate sensory input, normal muscle tone, brain integration, interneuronal inhibition or dominance, skeletal muscle system and other aspects [2]. Normal posture control is largely maintained by visual cues, vestibular function, and lower body proprioception [3-5]. As long as any posture maintenance system is abnormal, it may adversely affect the normal posture control ability of the human body. For example, if a normal person does not sleep for 24 hours, it will have an adverse effect on posture control [6]. Static balance posture map has been widely used in balance function test and training monitoring of nervous system diseases [7], prosthetic limbs [8] and vestibular dysfunction [9] because of its simple operation, reliability, efficiency, and time saving. One of the common methods of rehabilitation assessment. The stability of the human body in an upright position depends on the integrity of the visual, vestibular and proprioceptive systems. The physical and morphological indicators of the body are also factors that cannot be ignored. Therefore, the study of static equilibrium posture maps will have a very important meaning in medicine.

The relative complexity of balancing physiology and the delicate connection between factors that maintain balance make it difficult to assess balance and posture stability in a comprehensive and detailed manner. For the research and measurement of human body balance function, domestic and foreign scholars have conducted in-depth research, but the research results are not the same. Foreign scholars' research in this area is relatively deeper. As early as 1851, Romberg developed a method for detecting the balance function, also known as the "closed-eye upright detection method" [10]. In 1929, Basler [11] used the balance of the balance to indicate the movement of the person's weight. In the 1970s, the force platform technology was used to record the trajectory of static body swing [12]. In the 1990s, the dynamic dynamic computer model was used to detect static and dynamic balance and balance training [13-14]. Tinetti obtained the balance function of the exercise index evaluator by testing the clinical manifestations of gait and balance [15]. In the treatment of hemiplegia, some methods for assessing the degree of rehabilitation of hemiplegia have been developed, including the assessment of equilibrium responses, such as the Flug-Meyer assessment [16]. All of the above assessment methods are based on visual methods or questionnaires, and are evaluated in the form of scoring. The results are rough, the process is cumbersome, and the characteristics of the balance are not accurate. Since the 1980s, North America, Western Europe, Japan and other countries have developed the pressure plate method, and then developed a computerized balance tester to quantitatively evaluate the balance function of the human body and the therapeutic effect of the disease that affects balance function. In 1988, the Department of Rehabilitation of the Affiliated Hospital of Shanghai Second Medical University and Shanghai Shengkang Technology Co., Ltd. jointly developed the “PJ-1 Computerized Human Body Balance Function Tester” [17]. Zhu Kemin and He Wei et al. [18] of the Chinese People's Liberation Army Hangzhou Sanatorium also developed a posture balancer. Domestic scholars have introduced some foreign balance detectors from the 1990s to carry out research in this area. Some scholars have used domestic balancers to study the reliability and balance of balanced parameters, which proves that the balance meter can accurately reflect people's balance function can be used as an effective means of balancing function evaluation [19]. Meng Xiaolu, Xie Lijing, Yang Yumei, etc. also made a small sample (more than 100 cases), Xu Benhua did 588 normal people's center of gravity to check the normal value of the mouth [20-23], has a certain reference value. Many rehabilitation hospitals in China have used the balance of gravity instruments of Japan and Italy to test the balance function of rehabilitation patients. Some hospitals have carried out comprehensive tests on the balance ability of normal people. Wen Shiguang, Liu Ming, et al [24] of the Department of Neurology, Beijing Hospital of the Ministry of Health, tested the posture of 30 normal people and 12 patients with subcutaneous combined degeneration (SCD) using the G5500 gravity center oscillating instrument produced by AXTMA, Japan, and related materials, objectively understand the static posture balance of SCD patients and treatment left and right changes. Cai Haiou [25] of the rehabilitation department of Ruijin Hospital affiliated
to Shanghai Second Medical University used the Japanese ANLMA center of gravity oscillating instrument to detect the balance function of patients with cervical spondylosis. It was found that the detection coefficients of SCD patients were significantly different from those of normal people. In addition, people use the center of gravity oscillating device to compare the balance of treatment of stroke patients in the elderly [26], to assess the balance ability of Parkinson's disease [27], and to evaluate the effect of single-turn and four-corner on the balance ability of patients with hemiplegia [28].

All of these are pathological studies. The methods used by the researchers have identified some relevant factors and normal range of balance ability, but they did not evaluate the balance ability of normal people, and did not divide a certain grading index. In addition, from the above review, it is found that: (1) no one evaluates the balance function of the elderly; (2) in the evaluation of the balance function of the human body, only the normal indicator range is given, but the health status of the elderly within the normal indicator range is also different; (3) In terms of factors related to balance function, only age and gender are involved, but the influence of the elderly's illness and body shape on balance function is not discussed. This discussion can provide some useful information for the improvement of the balance function of the elderly; (4) When doing pathological analysis and detecting normal people's balance function indicators, the selected indicators are not the same. It is necessary to find out the indicators with significant differences in different situations as the main and related indicators.

Static posture diagram is one of the quick and effective objective quantitative test methods for obtaining static or static posture performance of human body. At present, it has become a widely used evaluation method in clinical medicine and scientific research in foreign countries. Static posture map analysis can be used to evaluate the peripheral function of the vestibule, to determine the type of impairment of the balance function and the degree of injury, and to help the clinician diagnose the disease of the patient. In particular, it plays an important role in the differential diagnosis of Unilateral Vestibular Lesion (UVL) and Bilateral Vestibular Lesion (BVL) balance, as well as the diagnosis of central vertigo patients. It is difficult to select a static balance test for most of the balance assessment of UVL, because this patient can have a balance compensation after one month of injury to maintain a static balance. For some typical vestibular peripheral lesions, such as Meniere's disease, static posture map analysis has a higher positive detection rate and can quantitatively evaluate the degree of balance damage. Foreign scholars have confirmed that the indicators of static posture maps have certain relevance to the Stanford sleepiness scale scores and cognitive ability scores under sleep deprivation. The static balance posture map test in China has been gradually applied to the departments of otolaryngology, neurology, rehabilitation, etc., and has achieved good results in clinical medicine.

The main problems in research today are that one is incomplete analysis of factors, and the second is that there is no analysis in one outcome. In order to make up for the above deficiencies, this paper studies the factors of balance such as age, body type, disease, etc., and collects the balance of subjects in two different situations: blinking and closing eyes. First, the general situation of the subjects is counted and grouped by age group and gender. The statistical information includes average age, average height, weight and so on. Statistical inference is performed after the required data is collected by the test instrument. Experiments have shown that in the case of blinking, the balance between healthy subjects and patient subjects is better than that of the respective groups. In the exploration of age factors, there are significant differences in parameters of different age groups, such as Average front-back moving speed (AFBMS), Average left-right moving speed (ALRMS), Sports length (SL), sports area (SA). The statistical results show that the balance function declines with age. Body shape also has an impact on the body's ability to balance. In general, subjects with a short stature type have lower center of gravity than those with moderate and lean subjects. In other cases where the other objective conditions, such as age, are the same, the stability of the short-sex subjects is better than that of the moderate and lean subjects. Finally, through the principal component analysis method, the health group and the patient group were comprehensively scored, and the scores showed that the healthy group was significantly better than the patient group. So far, we are still developing quantitative evaluation equipment, exploring evaluation indicators with good sensitivity, stability and reliability, establishing the relationship between health and disease status and quantitative assessment balance ability indicators, and deepening the mechanism of balance obstacles caused by various diseases. At the same time as the characteristics and understanding, it also lays a foundation for the detection and prevention of the disease course [29].

2. Proposed Method

2.1. Static Posture Map Detection

The static balance tester (EAB-100, Japan [30]; TETRAX, Israel [31]) can record changes in the entire body pressure center through a pressure sensor and then convert it into a change track of the body's center of gravity through a computer processing program. Based on this center of gravity trajectory, the time domain and frequency domain indicators of body sway can be automatically calculated. These
parameters include the Whole Path Length of Body Gravity (WPL), the length of the track per unit area, and so on.

The center of gravity coordinates of the subject can be obtained by processing the signals of the four pressure sensors. The center of the gravity center platform is the coordinate origin, and the coordinates of the four pressure sensors are A(x₁, y₁), B(x₂, y₂), C(x₃, y₃), and D(x₄, y₄), respectively. Obtained by the symmetry of the center of gravity platform:

\[
x_1 = -x_2 = -x_3 = x_4
\]
\[
y_1 = y_2 = -y_3 = -y_4
\]

Let the current center of gravity of the subject be E(xᵢ, yᵢ), according to the principle of torque balance:

\[
x_1 = \frac{(f_{1i} - f_{2i} - f_{3i} + f_{4i})}{(f_{1i} + f_{2i} + f_{3i} + f_{4i})} x_i
\]
\[
y_1 = \frac{(f_{1i} + f_{2i} - f_{3i} - f_{4i})}{(f_{1i} + f_{2i} + f_{3i} + f_{4i})} y_i
\]

In the middle, \( f_{1i}, f_{2i}, f_{3i}, f_{4i} \) are the values of the i-th sampling point of the four pressure sensors, respectively, and \( E(x_i, y_i) \) represents the heart coordinate of the i-th sampling point of the subject. The coordinates of the center of gravity of each sampling point are sequentially drawn, and the desired trajectory of the center of gravity is displayed.

1. The center of gravity track length is an intuitive indicator commonly used in detecting the balance function of the human body. The longer the length is within the prescribed experimental time, the worse the patient's balance ability is. When the sampling frequency is high enough, the length of the track between two adjacent sampling points can be approximated by a line connecting two points, so that the length of the center of gravity track can be:

\[
L_{ng} = \sum_{i=1}^{n-1} \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}
\]

2. The length of the unit area track refers to the distance of the center of gravity on the unit area, reflecting the subject's perceived posture control ability. The smaller the unit area trajectory, the stronger the body posture control ability. Taking the average coordinate \( \overline{E(x_i, y_i)} \) of the gravity center projection coordinate \( E(x_i, y_i) \) as the coordinate origin, and drawing the coordinate system, the track area is equally divided into 360 parts according to the radians, and each area is approximately fan-shaped. The distance from the origin of the points falling in each area is obtained, and the maximum radius is the sector radius of the area, and then the fan-shaped area of each area is obtained, and the algebraic sum of all the fan-shaped areas is the track area. According to the calculation method of the track length described above, the track length per unit area is obtained, wherein the coordinate origin is:

\[
x = \frac{1}{n} \sum_{i=1}^{n} x_i
\]
\[
y = \frac{1}{n} \sum_{i=1}^{n} y_i
\]

The fan-shaped area formed by the center of gravity trajectory is:

\[
Area = \sum_{i=1}^{360} \frac{1}{360} \pi r_i
\]

Where \( r_i \) is the maximum radius of each region.
The length of the track per unit area is:

$$L_{ng} \cdot A^1 = L_{ng} / \text{Area}$$

### 2.2. Statistical Methods

#### 1. t-test

The t-test, also known as the Student's t test, is primarily applicable to normal distributions where the sample content is small (e.g., $n < 25$) and the population standard deviation $\sigma$ is unknown. The t-test uses the t-distribution theory to infer the probability of occurrence of the difference, thereby comparing whether the difference between the two means is significant. It is juxtaposed with the f-test and the chi-square test. The t-test was invented by Gosset to observe the quality of the wine and was published on Biometrika in 1908. The t-test can be divided into a single overall test and a double overall test, as well as a paired sample test.

- **(1) Single population test**

  The single population t-test is to test whether the difference between a sample mean and a known population mean is significant. When the population distribution is a normal distribution, if the population standard deviation is unknown and the sample size is less than 25, then the dispersion statistic of the sample mean and the population mean is t-distributed. The single population t-test statistic is:

  $$t = \frac{\bar{x} - \mu}{\sigma_x \sqrt{n}}$$

  Where $i = 1, \ldots, n, \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ is the sample mean, $s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$ is the sample standard deviation, and $n$ is the number of samples. The statistic $t$ obeys the t-distribution with a degree of freedom of $n-1$ under the condition of zero hypothesis: $\mu = \mu_0$ is true.

- **(2) Double population test**

  The double population t-test is used to test whether the difference between the average of the two samples and the population they represent is significant. The double population t-test is divided into two cases. One is the independent sample t-test (there is no correlation between the experimental treatment groups, that is, independent samples), which is used to test the difference in the data obtained by two groups of non-related samples; the second is the paired sample t-test, which is used to test the difference between the data obtained by the two groups of participants or the data obtained by the same group of subjects under different conditions. The sample consisting of these two cases is the relevant sample. The independent sample t-test statistic is:

  $$t = \frac{X_1 - X_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}}$$

  $S_1$ and $S_2$ are two-sample variance; $n_1$ and $n_2$ are two-sample capacity.

- **(3) Paired sample test**

  The paired sample t-test can be viewed as being extended on the basis of a one-sample t-test, but the test object is the difference between a group of observations from a normal assignment independent sample to a two-group paired sample. If the difference between the two paired samples $x_{1i}$ and $x_{2i}$ is $d_i = x_{1i} - x_{2i}$ independent and comes from the normal assignment, then the maternal expected value $\mu$ of $d_i$ is $\mu_0$. The following statistics can be used:

  $$t = \frac{\bar{d} - \mu_0}{S_d / \sqrt{n}}$$
Where \( i = 1, \ldots, n \), \( \bar{a} = \frac{\sum_{i=1}^{n} d_i}{n} \) is the average of the paired sample differences, \( S_d = \sqrt{\frac{\sum_{i=1}^{n} (d_i - \bar{d})^2}{n-1}} \) is the standard deviation of the paired sample difference, and \( n \) is the number of paired samples. The statistic \( t \) obeys the \( t \)-distribution with a degree of freedom of \( n-1 \) under the condition of zero hypothesis: \( \mu = \mu_0 \) is true.

2. Principal Component Analysis

Principal component analysis is also called principal component transformation analysis. This method is mainly based on the idea of reducing the dimension, and transforming multiple indicators into several multi-statistic methods of comprehensive indicators under the premise of losing little information. The basic steps of principal component analysis are as follows: Let the study of a certain thing involve \( p \) indicators, which are represented by \( X_1, X_2, \ldots, X_p \), respectively, and these \( p \) indicators constitute a \( p \)-dimensional random vector \( X = (X_1, X_2, \ldots, X_p) \). Let the random vector \( X \) have a mean of \( \mu \) and the covariance matrix be \( \Sigma \).

(1) Data standardization. Let \( Z_i = \frac{X_i - \mu_i}{\sigma_{ii}}, i = 1, 2, \ldots, p \). Where \( \mu_i \) and \( \sigma_{ii} \) represent the expectation and variance of the random variable \( X_i \), respectively.

(2) Establish a correlation matrix. Let

\[
\sum^{1/2} = \begin{bmatrix}
\sqrt{\sigma_{11}} & 0 & \cdots & 0 \\
0 & \sqrt{\sigma_{22}} & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & \sqrt{\sigma_{pp}}
\end{bmatrix}
\]

Then there is:

\[
\text{cov}(Z) = (\sum^{1/2})^{-1} \Sigma (\sum^{1/2})^{-1} = \begin{bmatrix}
1 & \rho_{12} & \cdots & \rho_{1p} \\
\rho_{12} & 1 & \cdots & \rho_{2p} \\
\vdots & \vdots & \ddots & \vdots \\
\rho_{1p} & \rho_{2p} & \cdots & 1
\end{bmatrix}
\]

Where \( \rho_{ij} \) represents the correlation coefficient of the random variables \( X_i \) and \( X_j \).

(3) Find the non-zero eigenvalue \( \lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \) of the correlation matrix and the corresponding standard orthogonal feature \( \gamma_1, \gamma_2, \ldots, \gamma_p \), and calculate the variance contribution rate \( \alpha_k = \lambda_k / \sum_{i=1}^{p} \lambda_i \) of the principal component \( Y_k \) and the cumulative contribution rate \( \sum_{j=1}^{k} \alpha_j \) of the principal components \( Y_1, Y_2, \ldots, Y_m \). Usually, the smallest integer having a cumulative contribution rate of 85% or more is taken as the number of principal components.

\[
\begin{align*}
Y_1 &= \gamma_{11} Z_1 + \gamma_{12} Z_2 + \cdots + \gamma_{1p} Z_p \\
Y_2 &= \gamma_{21} Z_1 + \gamma_{22} Z_2 + \cdots + \gamma_{2p} Z_p \\
&\vdots \\
Y_m &= \gamma_{m1} Z_1 + \gamma_{m2} Z_2 + \cdots + \gamma_{mp} Z_p
\end{align*}
\]

(4) Principal component expression
In the formula, $\gamma_i$ represents the component of the normalized feature vector $\gamma_i$. Using the above formula, the score of the sample points on each principal component can be calculated.

3. Significant test

The significance test is also called hypothesis test, which is one of the important areas of statistical inference. From the concept of sampling error, it can be seen that if two different nursing methods are used to treat patients with certain diseases, if there are differences in nursing effects, there may be two reasons: the first one is completely caused by sampling errors. Second, in addition to the sampling error, it is true that the effects of the two different care methods are different. Statistics is the application of the "significance test of differences" to identify the cause of the difference. The steps are as follows: (1) Establish a test hypothesis, assuming two sample questions, or the difference between the sample and the population is purely caused by the sampling error. (2) Determine the "$P$" value, and use the probability distribution principle to determine the size of the probability of the test hypothesis, that is, the magnitude of the probability $P$. The $p$ value is a decreasing indicator of the credibility of the result. The larger the $p$ value, the less we can think that the association of the variables in the sample is a reliable indicator of the correlation of the variables in the population. The $p$ value is an error probability that the observation result is considered to be effective and has an overall representativeness. (3) Explain that, in general, we use $P = 0.05$ as the level of significance. In many fields of research, the $p$-value of 0.05 is generally considered to be the boundary level at which errors can be accepted. $P = 0.01$ as a highly significant level. The accepted standard is: when $P > 0.05$ difference was not significant; when $0.01 < P \leq 0.05$ difference was significant; when $P \leq 0.01$, the difference was highly significant.

3. Experiments

3.1. Test Objects and Environment

There were 162 healthy subjects with an age range of 11 to 80 years. The initial group was 11 to 20 years old, 21 to 30 years old, 31 to ..., and healthy subjects were divided into 7 groups in the 71 to 80 age group. All health test subjects are normal people who have no neurological system, otolaryngology, internal medicine, orthopedics and other diseases that affect balance function. Healthy subjects include hospital staff and their families, taxi drivers, students and other volunteers.

The patients were all patients with Parkinson's disease with mild balance dysfunction: 22 males, aged 36-46 years, weighing 59-69 kg, height range 167-177 cm; 16 females 16, the age range is 33 to 43 years old, the weight range is 44 to 54 kg, and the height range is 153 to 163 cm. When compared with the patient subjects, the control subjects were healthy people who matched the case group in terms of gender, age, height, and body weight.

There was no drug or alcohol intake within 48 hours before the test. The experimental environment requires noise below 20 dB, illumination in the range of 260-340 Lux, temperature between 20 and 25 °C, and humidity in the range of 45% to 65% RH.

3.2. Test Parameters and Methods

Adopt Israel's TETRAX balance and stability test system, which consists of pressure sensors, computers and related software. The subject's head is straight and the feet are close together on the test platform. The hands are naturally drooping. The center of the foot is consistent with the reference point of the examination platform. The two arms naturally hang down on both sides of the body and breathe calmly. When the subject is standing on the pressure plate, the left heel, the left sole, the right heel, and the right sole correspond to the four pressure sensors A, B, C, and D respectively, and the center of pressure(COP) is recorded according to the pressure changes on the different sensors. During the test, the center will change with the shaking of the human body, forming a trajectory of human body shaking, and the test time is 30 seconds. Do not speak or give hints to the subject during the test. The system's pressure sensor records changes in the entire body's pressure center and then converts it into a change in the body's center of gravity through a computer processing program. Based on this center of gravity trajectory, the time domain and frequency domain indicators of body sway can be automatically calculated. These parameters include the Whole Path Length of Body Gravity (WPL), the length of the unit area track, Average front-back moving speed(AFBMS), Average left-right moving speed(ALRMS), Sports length(SL), the age, the height, the weight, and the body shape data. After collecting the required data, the balance parameters were analyzed by SPSS statistical software, and the gender of each age group was analyzed by t test. Principal component analysis was used to analyze the parameters of age, height, weight, body type, disease and balance posture map by gender.
4. Results

4.1. Descriptive Statistics

The general condition of the subjects is shown in Table 1. Among them, the body type is expressed by the ratio of height (cm) to body mass (kg), and is divided into three types: short fat body type 1.75 to 2.40, medium body type 2.41 to 2.90, thin high body type 2.91 ~ 4.12.

Table 1. Statistics of normal age groups of normal subjects

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>n</th>
<th>Average age (years)</th>
<th>Average height (cm)</th>
<th>Average weight (kg)</th>
<th>Body type</th>
</tr>
</thead>
<tbody>
<tr>
<td>15~19</td>
<td>male</td>
<td>8</td>
<td>17.56±0.67</td>
<td>170.34±7.01</td>
<td>66.12±4.52</td>
<td>3.12±0.24</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>10</td>
<td>17.43±0.51</td>
<td>160.28±6.21</td>
<td>55.37±7.94</td>
<td>2.99±0.27</td>
</tr>
<tr>
<td>20~35</td>
<td>male</td>
<td>17</td>
<td>27.53±4.37</td>
<td>171.20±5.68</td>
<td>65.78±3.66</td>
<td>2.87±0.13</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>20</td>
<td>27.36±4.29</td>
<td>160.24±3.27</td>
<td>55.32±5.79</td>
<td>2.64±0.16</td>
</tr>
<tr>
<td>36~50</td>
<td>male</td>
<td>25</td>
<td>42.70±4.23</td>
<td>161.15±5.20</td>
<td>67.34±3.62</td>
<td>2.57±0.40</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>24</td>
<td>41.61±4.03</td>
<td>160.27±3.87</td>
<td>57.45±4.11</td>
<td>2.51±0.29</td>
</tr>
<tr>
<td>51~65</td>
<td>male</td>
<td>19</td>
<td>59.34±3.38</td>
<td>170.19±4.23</td>
<td>70.82±6.89</td>
<td>2.49±0.36</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>18</td>
<td>57.68±3.54</td>
<td>158.26±6.35</td>
<td>57.60±9.92</td>
<td>2.52±0.24</td>
</tr>
<tr>
<td>66~79</td>
<td>male</td>
<td>12</td>
<td>68.49±4.09</td>
<td>165.23±3.77</td>
<td>69.24±4.78</td>
<td>2.48±0.40</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>9</td>
<td>67.57±1.26</td>
<td>155.09±5.45</td>
<td>58.84±9.68</td>
<td>2.60±0.34</td>
</tr>
</tbody>
</table>

4.2. Statistical inference

(1) Comparison of static posture map parameters in different age groups

The stability of a person in two different situations of blinking and closing eyes is different. To further explore the influencing factors, subjects are collected in the case of blinking and closed eyes: Average front-back moving (AFBMS), Average left-right moving speed (ALRMS), Sports length (SL), Sports area (SA). In order to make the results of differentiation more obvious, the subjects in the age group of 15~19 years old, 36~50 years old, and 66~79 years old were selected. The measured parameters are shown in Table 2.

Table 2. Comparison of static posture map parameters of normal people in different age groups

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Experimental mode</th>
<th>AFBMS (mm/s)</th>
<th>ALRMS (mm/s)</th>
<th>SL (mm)</th>
<th>SA (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15~19</td>
<td>18</td>
<td>Blink</td>
<td>4.37±0.21</td>
<td>4.21±1.18</td>
<td>159.6±27.35</td>
<td>88.26±47.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed eyes</td>
<td>7.13±0.59</td>
<td>5.67±2.10</td>
<td>230.3±70.18</td>
<td>189.7±132.2</td>
</tr>
<tr>
<td>36~50</td>
<td>49</td>
<td>Blink</td>
<td>4.56±1.28*</td>
<td>4.49±2.58</td>
<td>179.4±48.16*</td>
<td>103.9±41.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed eyes</td>
<td>7.81±2.44*</td>
<td>7.54±3.19</td>
<td>288.2±110.6*</td>
<td>210.7±12.87</td>
</tr>
<tr>
<td>66~79</td>
<td>21</td>
<td>Blink</td>
<td>6.52±2.92***</td>
<td>5.17±1.49</td>
<td>189.7±49.9**</td>
<td>225.1±79.35**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed eyes</td>
<td>11.37±5.16**</td>
<td>7.10±2.07</td>
<td>385.1±117.3**</td>
<td>270.1±118.4**</td>
</tr>
</tbody>
</table>

Note: *P<0.05 for the 15-19 year old group compared with the 36-50 year old group; P<0.05 for the 15-19 year old group compared with the 66-79 year old group.

It can be seen from Table 2 that the average movement speed, exercise length and exercise area before and after the 15-19 age group are the smallest among the groups participating in the test. Regardless of blinking or closed eyes, AFBMS and SL were statistically different between the 15-19 years old group and the 36-50 age group (P<0.05); Compared with the 66-79 age group, the AFBMS, SL and SA were statistically different (P<0.05); There was no significant difference between the 36-50 years old group and the 66-79 years old group (P>0.05).

(2) The effect of normal human body type factors on static equilibrium posture map

The results of each parameter of the static posture map of normal (healthy) different body types are shown in Table 3.

As can be seen from the data in Table 3, among the short fat, medium, and thin high subjects corresponding to each age group, the short-fat-type subjects had the lowest AFBMS, ALRMS, SL, and SA. The AFBMS, ALRMS, SL, and SA of the medium-type subjects were the largest. The data for the thin-high-type subjects were intermediate levels.
Table 3. Comparison of static posture map parameters of normal different body types

<table>
<thead>
<tr>
<th>Body type</th>
<th>age</th>
<th>AFBMS (mm/s)</th>
<th>ALRMS (mm/s)</th>
<th>SL (mm)</th>
<th>SA (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>short fat body type</td>
<td>15~19</td>
<td>4.30±0.15</td>
<td>4.22±1.23</td>
<td>152.43±9.21</td>
<td>56.29±15.13</td>
</tr>
<tr>
<td></td>
<td>36~50</td>
<td>5.34±0.26</td>
<td>4.95±1.45</td>
<td>160.44±6.69</td>
<td>81.35±27.31</td>
</tr>
<tr>
<td></td>
<td>66~79</td>
<td>7.27±1.20</td>
<td>6.26±2.38</td>
<td>181.19±46.27</td>
<td>179.31±35.61</td>
</tr>
<tr>
<td>medium body type</td>
<td>15~19</td>
<td>4.51±0.24</td>
<td>4.30±1.45</td>
<td>157.72±24.25</td>
<td>65.37±16.21</td>
</tr>
<tr>
<td></td>
<td>36~50</td>
<td>5.41±0.27</td>
<td>5.22±1.19</td>
<td>166.85±17.68</td>
<td>94.29±21.37</td>
</tr>
<tr>
<td></td>
<td>66~79</td>
<td>9.21±3.06</td>
<td>8.93±1.16</td>
<td>213.21±36.24</td>
<td>201.36±22.39</td>
</tr>
<tr>
<td>thin high body type</td>
<td>15~19</td>
<td>4.59±0.12</td>
<td>4.41±0.98</td>
<td>162.18±20.36</td>
<td>87.23±15.30</td>
</tr>
<tr>
<td></td>
<td>36~50</td>
<td>5.52±0.34</td>
<td>5.37±0.87</td>
<td>180.26±15.47</td>
<td>110.67±23.68</td>
</tr>
<tr>
<td></td>
<td>66~79</td>
<td>11.16±2.21</td>
<td>10.32±1.62</td>
<td>231.68±36.24</td>
<td>220.39±25.36</td>
</tr>
</tbody>
</table>

(3) Principal component analysis result

There is also a difference between the normal person and the patient. In order to avoid one-sidedness, consider analyzing the following parameters of normal people and patients in blinking and closing eyes: the length of the center of gravity track (Lng), the length of the track per unit area (Lng·A⁻¹), the average front-back moving speed (AFBMS), Average left-right moving speed (ALRMS). The parameter values are shown in Table 4.

Table 4. Comparison of parameters between patient group and health group

<table>
<thead>
<tr>
<th>Experimental mode</th>
<th>Group type</th>
<th>Lng/cm</th>
<th>Lng A⁻¹/cm</th>
<th>AFBMS (mm/s)</th>
<th>ALRMS (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blink</td>
<td>Healthy group</td>
<td>50.38±2.37</td>
<td>25.67±1.58</td>
<td>4.51±0.24</td>
<td>4.30±1.45</td>
</tr>
<tr>
<td></td>
<td>Patient group</td>
<td>61.59±1.85</td>
<td>42.86±4.59</td>
<td>10.26±1.37</td>
<td>9.45±1.29</td>
</tr>
<tr>
<td>Closed eyes</td>
<td>Healthy group</td>
<td>60.97±1.79</td>
<td>37.33±1.24</td>
<td>7.81±2.44</td>
<td>7.54±3.19</td>
</tr>
<tr>
<td></td>
<td>Patient group</td>
<td>75.32±3.28</td>
<td>61.07±2.95</td>
<td>19.19±3.21</td>
<td>17.62±4.84</td>
</tr>
</tbody>
</table>

It can be seen from Table 4 that in different experimental modes (blinking, closed eyes), the Lng, Lng·A⁻¹, AFBMS, and ALRMS of the healthy group were lower than the case group, and there was a significant difference (P<0.01).

Principal component analysis was performed on the health group sample data, and the eigenvalues, variance contribution rates, and cumulative variance contribution rates of the four principal component factors were as shown in Table 5. It can be seen that the cumulative contribution rate of the four principal component factors reaches 86.198%, and the information loss is less, so it can be explained by four principal component factors.

Table 5. Main component information of health group

<table>
<thead>
<tr>
<th>Principal component factor</th>
<th>Eigenvalues</th>
<th>Variance contribution rate /%</th>
<th>Cumulative contribution rate /%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.506</td>
<td>30.013</td>
<td>30.013</td>
</tr>
<tr>
<td>2</td>
<td>2.013</td>
<td>25.962</td>
<td>55.975</td>
</tr>
<tr>
<td>3</td>
<td>1.482</td>
<td>16.625</td>
<td>62.600</td>
</tr>
<tr>
<td>4</td>
<td>1.357</td>
<td>13.598</td>
<td>86.198</td>
</tr>
</tbody>
</table>

The comprehensive evaluation adopts the 10-point system, and the sample data of the case group and the control group are respectively subjected to principal component analysis to obtain the comprehensive evaluation value of the subject. Among them, the statistical value of the comprehensive evaluation value of the healthy group was 8.137±0.540, and the statistical value of the comprehensive evaluation value of the patient group was 4.1164±0.685.
4. Discuss

The length of motion refers to the length of the center of gravity trajectory. The area of motion is the area of the trajectory of the trajectory; the larger the area, the larger the range of center of gravity and the worse the stability of the body, which is more practical than the length of the movement. The length of exercise and the area of exercise are important for determining the degree of balance dysfunction.

According to the results of Table 2, the static posture maps of different age groups showed that the parameters of the static posture maps of the 15-19 years old group were more stable than those of the 36-50 age group and the 66-79 age group, indicating that age is the influencing factor of the balance posture map, suggesting that as the age increases, the balance function declines. The reasons for the decline in the balance function with age may be related to factors such as decreased visual acuity, decreased vestibular system function and proprioceptive function, and decreased neuromuscular reactivity in the control position. It may also relate to the musculoskeletal system and the degeneration of the cardiovascular system. In this study, ALRMS was also found to be lower than AFBMS, indicating that the balance between left and right is strong, and the analysis may be related to the high stability of the ankle joint. The selection of 88 normal people compared the parameters of the posture map in the case of blinking and closed eyes revealed that the stability of the balanced posture decreased in the case of closed eyes. The attitude stability of healthy subjects tested by Vanden Heuvrl showed that subjects who provided visual feedback were more stable than did not provide visual feedback. Tips Vision plays an important role in maintaining the posture of the human body.

Normal human body factors have an effect on the static balance posture map. The human body is constantly changing in quality due to physiological activities such as breathing, blood circulation, and digestion. When it is relatively stationary, the position of the center of gravity will also vary within the range of 1.5-2 cm. In addition, the center of gravity will vary depending on the size of the body: ① A person with a strong upper body has a slightly higher center of gravity than a person with a strong lower limb. ② The lower limbs are slightly taller than the lower limbs. The higher the center of gravity, the more difficult the body balance control is. Therefore, this also explains the distribution characteristics of the data information of the short-fat-type, the medium type, and thin-high-type subjects in Table 3. At the same age, the weight of the short-fat subjects is lower than that of the medium and thin-high-type, which can better control the balance of the whole body and thus have a relatively good balance ability.

The data in Table 4 shows that the comprehensive evaluation value is higher in the control group than in the case group, reflecting that the balance function of the control group is stronger than that of the case group. Moreover, the comprehensive evaluation value of the control group fluctuated less, indicating that the focus of the control group was more stable. The comprehensive evaluation value obtained by the experiment is consistent with the balance function of the human body, reflecting the strength of the balance function of the subject. In order to effectively verify the evaluation effect of the method, the author used SPSS software to discriminate the experimental results, and the accuracy rate reached 100%. This shows that the designed balance function detection and evaluation method has application promotion ability.

5. Conclusion

Static posture map can quantitatively and objectively evaluate the static posture balance function of the human body, and provide accurate detection means for screening high-risk groups of balance disorders, preventing falls, false vertigo, and special occupations. The exercise length and exercise area in the static posture map have certain auxiliary value for the localization diagnosis of peripheral vertigo and central vertigo, but the cause diagnosis also needs to be combined with clinical related examination. At present, static posture maps have been widely used in neurology, otolaryngology and rehabilitation in China. There are some scholars who study the influencing factors of static posture maps, but the parameters considered in the existing research are one-sided.

In summary, this article has experimented with a large number of real-world examples, and studies have shown that the same person’s ability to balance in both blinking and closed eyes will be different. At the same time, age, body weight and disease have an impact on the balance function of the static balance posture map. Age, body weight and disease factors cannot be ignored in the balance function test. Because in many literatures, many researchers have studied a lot of the effects of gender in static equilibrium posture maps, and will not go into details here. Of course, there are still many factors influencing the static balance posture map, which is waiting for other researchers to explore, in order to further pave the way for the deep development of static balance posture map in the field of medical diagnosis and rehabilitation.

Acknowledgements

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References


