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BP Neural Network Model-Based Physical Exercises and Dietary Habits Relationships Exploration

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Abstract: With the continuous progress of society and increment of social pressure, people have paid little and little attentions to physical exercises and dietary necessity. Taking Beijing, Shanghai, Guangzhou, Shenzhen, Shijiazhuang and Baotou university students as research objects, targeted at physical exercises time and dietary habits, it starts investigation. Making principal component analysis of investigation results, it indicates that cereal intake is principal component in dietary habits; strenuous exercise time and general physical exercise time are the principal components in physical exercise. Utilizing BP neural network model, and analyzing these seven cities' physical exercises and dietary habits conditions, the result indicates that except for Shenzhen, all the other six cities haven't reached the standard.

Keywords: BP neural network, dietary habits, physical exercises, principal component analysis.

1. INTRODUCTION

Good dietary habits and necessary physical exercises are important principles to ensure human health. As far as an office worker is concerned, as social pressure increases, pace of life speeds up, more and more people have started neglecting physical exercises and dietary necessity. As far as student is concerned, learning and video game have occupied their whole time of life. People who possesse toned body is the important factor to the prosperity of the country; therefore, physical exercises and dietary are especially important [1].

In 2012, Gao Min implemented lifestyle and physical health research on Shandong Medicine and Food Career College's students, and took freshman as research objects. Research results indicated that students' physical conditions were good, but excellent comprehensive evaluation people amount was fewer; most students were in the level of pass line [2, 3]. Students' bad dietary habits was one of reasons that led to a decline in health level. Most students replaced sleep and physical exercise time with the time of watching TV and surfing online. The writer pointed out that students' lifestyle and physical health had obvious correlation. Students of good physical exercise habits had comparatively high mental health level and physical test performances [4].

In 2003, Gao Gen-Di and others researched on Shanghai teenagers' dangerous behaviors, from which it included daily dietary and physical exercises status research. They conducted a questionnaire survey on 105 schools' partial students. Survey contents were weekly dietary contents and physical exercises conditions. The survey result indicates that nearly half students' dairy product intake was lower, above quarter

students excessively took in sweets, and even fewer students took in deep-fried and pickled food every day. Half the students strenuous exercise amount was not enough, above half students didn't participate in extracurricular exercises, and as students' ages increased, phenomenon of not participating in physical exercise became even more serious [5]. At the same time, it indicated that schoolgirls physical exercise level was even lower than that of schoolboys. The writer pointed out that it was quite necessary to develop dietary education and physical exercise ideological education targeted at teenagers.

In 2013, Xu Ya-Nan researched on elementary and secondary school students' food safety education problem. Firstly it explained food safety current status, and then applied multiple research methods to carry out questionnaire survey on Nanjing city elementary and secondary school students. Finally, targeted at present problems, it presented solution. Investigation result indicated that local primary and secondary school students' emphasis on food safety was high, but in students' contiguous education, school food safety education ranked the last. Most of students suggested integrating food safety education into physical health education course [6-8].

The paper adopted questionnaire survey, researched on physical exercises and dietary necessity, and pointed out current existing issues and presented corresponding countermeasures.

2. QUESTIONNAIRE SURVEY AND RESULTS

Taking seven cities-Beijing, Shanghai, Guangzhou, Shenzhen, Shijiazhuang, Tianjin and Baotou- as investigation sites, and regarding university students as investigation objects, the questionnaire contents include daily dietary behaviors and physical exercises behaviors.

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Table 1. Dietary habits investigation result table.

City	Cereal<250g	Fruit and vegetable<350g	Protein<70g	Fried food>50g	Sugared beverage>50g
Beijing	35%	21%	15%	26%	29%
Shanghai	28%	19%	13%	21%	27%
Guangzhou	46%	15%	10%	19%	31%
Shenzhen	39%	20%	12%	16%	35%
Shijiazhuang	26%	25%	25%	29%	29%
Tianjin	29%	29%	23%	32%	23%
Baotou	35%	35%	19%	23%	28%

Table 2. Physical exercises behaviors investigation result table.

City	Strenuous exercises<20min	General exercises<40min	Physical exercises<50min	Electronic entertainment>100min
Beijing	80%	65%	69%	86%
Shanghai	76%	68%	72%	79%
Guangzhou	83%	59%	79%	83%
Shenzhen	79%	52%	68%	76%
Shijiazhuang	89%	74%	83%	89%
Tianjin	82%	69%	76%	84%
Baotou	91%	64%	80%	81%

2.1. Investigation Contents

Using year 2001 American disease control center's teenagers' dangerous behaviors questionnaire survey as evidence, combining with Chinese current status, the questionnaire survey contents were designed. Among them, daily dietary habits investigation contents include cereal intake amounting to less than 250 gram, fruit and vegetable intake amounting to less than 350 gram, protein intake amounting to less than 70 gram, sugared beverage intake amounting to above 50 gram, and fried and other junk food intake amounting to above 50 gram. Physical exercises investigation contents include strenuous exercises less than 20 minutes, general exercises less than 40 minutes, physical exercises less than 50 minutes, and watching TV and surfing online such entertainment time above 100 minutes [7].

2.2. Investigation Results

Respectively a random sample of 100 university students in each investigation site, filled out questionnaire anonymously. Each subject is required to independently complete the questionnaire to ensure questionnaire survey results validity. By sorting out and making statistics of investigation results, it can get investigation result as shown in Table **1**, Table **2**.

From Table **1**, it is clear that all regions university students' dietary structure has certain differences including: Guangzhou students lack of cereal intake; Baotou students lack of fruit and vegetable intake; Shijiazhuang students lack of protein intake; Tianjin students fried food intake amount is larger; and Shenzhen students' sugared beverage intake amount is larger.

From Table **2**, it finds out that Baotou students lack strenuous exercises, whereas Shijiazhuang students lack general exercises and physical exercises as well as take too long time in electronic entertainment.

3. PRINCIPAL COMPONENT ANALYSIS

Main thought of principal component analysis is variable's dimension reduction. It is a statistical analysis method that transforms multiple variables into fewer main variables. It is generally used for data compression, system evaluation, regression analysis, weighted analysis and so on.

3.1. Definition of Principal Component Analysis Approach

The way of principal component analysis is reducing dimension of variables, which is recombining original many variables with correlation into a group of uncorrelated variables to replace original variables. Therefore, we can pay attention to every time observation's variables with maximum variation, and use every time observation's small changed variables as constant to process and get rid of them, so that

reduces variables number in question that needs to be considered.

Assume that there is m pieces of original indicators to do principal component analysis, which are recorded as $x_1, x_2, \cdots, x_m$, now it has pieces of samples, corresponding observation value is x_{ik} $(i=1,2,\searrow,n)$, and $k=1,2,\cdots,m$ takes standardization transformation, and then transform x_k into x_k^*, that:

$$x_k^* = \frac{x_k - \overline{x_k}}{s_k}, \quad k=1,2,\cdots,m \tag{1}$$

Among them, $\overline{x_k}$ and s_k are respectively x_k average number and standard deviation; x_k^* average number is 0, standard deviation is 1.

According to each sample original indicator observation value x_{ik}^* or after standardization observation value x_{ik}, it solves coefficient b_{kj}, establishing indicator x_k^* that is transformed through standardization to express comprehensive indicator z_j equation

$$z_j = \sum_k b_{kj} x_k^*,$$

which can also establish equation that uses original indicator x_k to express comprehensive indicator z_j

$$z_j = \sum_k \tilde{b}_{kj} x_k^* + a_j \tag{2}$$

There are two requirements for comprehensive indicators:

(1) Comprehensive indicators are completely independent of each other or uncorrelated.

(2) Every comprehensive indicator that reflected each sample gross information content is equal to corresponding feature vector (comprehensive indicator coefficient) feature values. In general, it is required that selected comprehensive indicator feature values contribution ratios sum is as mentioned above.

3.2. Principal Component Analysis General Steps

(1) According to observed data, calculate $\overline{x_k}$ and s_k $(k, j = 1,2,\cdots,m)$.

(2) By correlation coefficient matrix, it can get feature value R and $(j=1,2,\searrow,m)$ each principal component variance contribution、 contribution ratio and accumulative contribution ratio, p and define principal component reserved number with accumulative contribution ratio as evidence.

(3) m pieces of basic equations are as follows：

$$\begin{cases} r_{11}x_1^{(j)} + r_{12}x_2^{(j)} + \cdots + r_{1m}x_m^{(j)} = \lambda_j x_1^{(j)} \\ r_{21}x_1^{(j)} + r_{22}x_2^{(j)} + \cdots + r_{2m}x_m^{(j)} = \lambda_j x_2^{(j)} \\ \cdots \\ r_{m1}x_1^{(j)} + r_{m2}x_2^{(j)} + \cdots + r_{mm}x_m^{(j)} = \lambda_j x_m^{(j)} \end{cases} \tag{3}$$

Among them， $j = 1,2,\cdots,m$.

Proceeding with Schmidt orthogonalization， for every λ_i, solve its basic equations solution

$$x_1^{(j)}, x_2^{(j)}, \ldots, x_m^{(j)} \left(j=1,2,\cdots,m\right),$$

and then let

$$b_{kj} = \frac{x_k^{(j)}}{\sqrt{\sum_k \left(x_k^{(j)}\right)^2}} \tag{4}$$

It can be expressed by $x_1^*, x_2^*, \ldots, x_m^*$ as principal component

$$z_j = \sum_k b_{kj} x_k^*,$$

or input

$$x_k^* = \frac{x_k - \overline{x_k}}{s_k}$$

and then can be expressed by x_1, x_2,..., x_m as principal component .

(4) Input x_1, x_2, …, x_m observed values into principal component expressions, calculate each component value.

(5) Calculate original indicator and principal component correlation coefficient that is also factor loading to explain principal component significances.

3.3. Principal Component Analysis Result

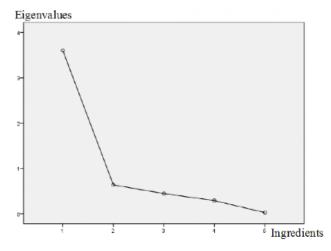For dietary habits investigation result, it makes principal component analysis; result are shown in Fig. (**1**).

Fig. (1). Scree plot.

In Fig. (**1**)， "1" represents cereal intake amount， "2" represents fruit and vegetable intake amount， "3" represents protein intake amount， "4" represents fried food intake amount， and "5" represents sugared beverage intake amount. From the figure, it is clear that cereal intake amount is the

principal component in dietary habits, therefore cereal intake is regarded as analysis factor.

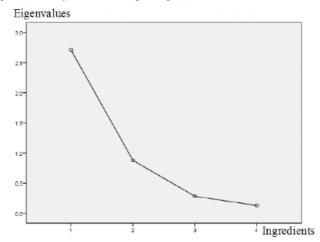Targeting at physical exercises, it makes principal component analysis, and can get Fig. (**2**).

Fig. (2). Scree plot.

In Fig. (**2**)，"1" represents strenuous exercises，"2" represents general exercises, "3" represents physical exercises, "4" represents electronic entertainment. From Fig. (**2**), it is clear that strenuous exercise and general exercise are main factors that affect physical exercises.

In the following, by utilizing neural network model, an evaluation model has been established that targeted at dietary habits and physical exercises.

4. NEURAL NETWORK MODEL

4.1. Neural Network Model Concept

Neural network model is originated from neurobiology. Its computation process is similar to biology nerve cell reaction process. In neural network, lots of different nerve cells contained axon ends that could enter into the same nerve cell Dendron and form into lots of synapses. All synapses of different origins liberative neurotransmitter can exert effects on same nerve cell membrane potential. Therefore, it is clear that with nerve cell space integrated information capacity, a nerve cell can integrate information of different origins input via Dendron. Based on the capacity, people imitate nerve cell reaction process and create artificial nerve cell model as shown in Fig. (**3**). Symbols description in Figure is shown as Table **3**.
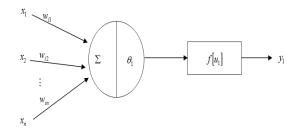

Fig. (3). The schematic of mathematical models of neurons.

Table 3.   Mathematical model's symbol definition.

Symbol	Definition
$x_1, x_2, \cdots, x_n$	Nerve cell input part that is information released by previous level
θ_i	Nerve cell threshold value
y_i	Nerve cell output
$f[u_1]$	Excitation function

$f[u_1]$ decides the output form that arrives at threshold value θ_i under common effects of inputting $x_1, x_2, \cdots, x_n$. Fig. (**4**) shows two kinds of excitation functions images. The paper adopted models with the second kind of excitation function.
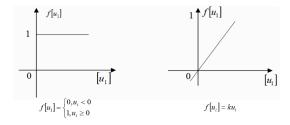

Fig. (4). Typical excitation functions.

Among them,

$$u_i = \sum_j w_{ij} x_i - \theta_i \qquad (5)$$

Therefore

$$y_i = f[u_i] = f\left(\sum_j w_{ij} - \theta_i \right) \qquad (6)$$

Formula (2) is individual nerve cell full mathematical model expression.

4.2. BP Neural Network Model Computational Steps

BP Neural network is a kind of multiple layer forward network, which adopts minimum mean square error computation way. In order to apply counter propagation algorithm into feed forward multiple network, utilize *Sigmoid* as excitation function, and use following steps to make recursion solving on w_{ij} that is network weight coefficient. In case every layer has n pieces of nerve cells, such as for the k layer the i nerve cell, then it has n pieces of weight coefficients as follows: $w_{i1}, w_{i2}, \cdots, w_{jn}$. In addition, select one more w_{jn+1} to express θ_i. When input sample is x, take $x = (x_1, x_2, \diagdown, x_n, 1)$.

1. Align value to w_{ij}. To every layer of w_{ij}, align a very little non-zero random number, and meanwhile $w_{jn+1} = -\theta_i{}^\circ$. As the model utilizes Matlab to operate, the alignment pro-

cess is computer's random process, and just because of that, same programming codes are used in different running processes; different results may appear.

2. Input sample value $x = (x_1, x_2, \searrow, x_n, 1)$, and corresponding expected output $y = (y_1, y_2, \searrow, y_n, 1)$.

3. Calculate each layer output, for the k layer the i nerve cell output x_{ik}, it has:

$$y_i^k = f[u_i^k] \tag{7}$$

Among them,

$$u_i^k = \sum_j w_{ij} x_j^{k-1} - \theta_i^k \tag{8}$$

In formula, $x_{n+1}^{k-1} = 1$, $w_{i(n+1)} = -\theta$

4. Solve each layer computation error d_i^k, for output layer, it has $k = m$, then it has:

$$d_i^m = x_i^m (1 - x_i^m)(x_i^m - y_i^m) \tag{9}$$

For other layers, it has

$$d_i^k = x_i^k (1 - x_i^k)\left(\sum_j w_{ij} x_j^{k-1} - \theta_i^k\right) \tag{10}$$

5. Correct w_{ij} and θ_i, it has

$$w_{ij}(t+1) = w_{ij}(t) - \eta d_i^k x_j^{k-1} \tag{11}$$

6. After solving each layer's each weight coefficient, it can be judged whether it conforms to the established requirements. If not, then return to the step 3, otherwise, end computing.

4.3. Model Establishment

Regard dietary habits and physical exercises principal components as evaluation objects, dietary habits is taken as vertical coordinate, and physical exercises is taken as horizontal coordinate. According to experiences, set up dietary habits and physical exercises feature values; feature values distribution is shown as Fig. (**5**).
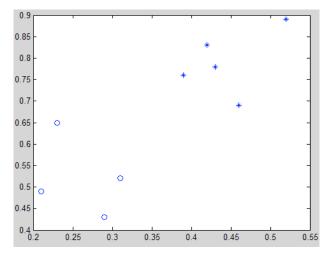
Fig. (5). Eigen value distribution.

Input principal component analysis result factor parameters into the model, through Matlab operational calculation, and get Fig. (**6**).
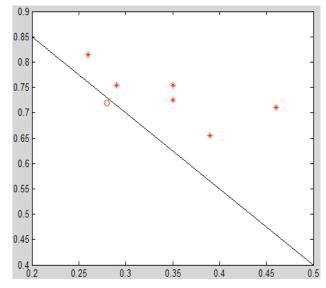
Fig. (6). Evaluation results diagram.

CONCLUSION

It is clear from Fig. (**6**) that Shenzhen is a city of better physical exercises and dietary habits that lies in the lower boundary, but closely linked to the upper boundary. Except for Shenzhen, the rest of six cities- Beijing, Shanghai, Guangzhou, Shijiazhuang, Tianjin and Baotou, could not reach the standard. Therefore, it is clear that physical exercises and dietary habits of people are needed to develop in China.

The paper utilizes principal component analysis approach, takes BP neural network as theoretical basis, and establishes an evaluation model in order to theoretically state the current status of Chinese people's physical exercises and dietary habits. As far as practical life issues are concerned, it still needs to make specific analysis and take corresponding improvement measures.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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