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MCM of Student's Physical Health Based on Mathematical Cone

Songyan Wang^{1†}, Sanaa Sharaf², Horiya Mohamed Ahmed Al Deeb³

¹ Department of Physical Education, Tangshan Normal University, Tangshan 063000, Hebei, China

² Department of Computer Science, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia

³ Applied Science University, Al Eker, Kingdom of Bahrain

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Abstract

The paper uses mathematical-statistics-related methods to conduct an MCM examination of the physical health of all freshmen in a particular university. The study found that taking first-year students as the research object enables the inference that the four primary factors of college students' physiological structure, physical form, psychological level and athletic ability can form a mathematical vertebral body model. This model can point out a new path for studying students' physical health and realise a comprehensive assessment of students' physical health.

Keywords: Mathematical statistics, mathematical vertebral model, physical health of college students

AMS 2010 codes: 91C20

1 Introduction

A healthy physique is a fundamental prerequisite for young people to serve the motherland and the people, and it is the embodiment of the vigorous vitality of the Chinese nation. Understanding the physical health status and development trend of college students in our country can provide a scientific basis for the macro decision-making of school sports and health work. The physical examination of contemporary college students is a research focus and a research difficulty [1]. At present, the evaluation of students' physical health mainly adopts the following three forms:

The first is the single index evaluation method. For the quality indicators that reflect the characteristics of students' strength and speed in the 'National Student Physical Health Standard', the student's physical fitness level is first distinguished by percentage. Then the segmented progressive scoring method is used to evaluate

[†]Corresponding author.

Email address: songyanw283@163.com

the value of each grade. The corresponding scores will be assessed [2]. In the ‘National Fitness Standards’ published in 2013, the evaluation of each index is divided into five grades, and percentiles establish the scoring standard. Evaluating individual indicators is relatively intuitive and straightforward. Still, it is difficult to achieve uniformity in the division of degrees and the formulation of weight coefficients if some researchers think that the ‘National Student Physical Health Standard’ has a large scoring standard span and a low scoring standard.

The second is the index evaluation method. The index evaluation method effectively compensates for the limitations characterising the evaluation of individual indicators. For example, the height and body mass index have a particular reference value in practical applications. Still, it is relatively mechanical in the evaluation and has a certain degree of one-sidedness. For example, the body mass index is an index published by the International Health Organization to evaluate the degree of obesity in adults. This index has been widely used in the evaluation of physical fitness [3]. However, some researchers believe that the BMI cannot accurately explain the body’s total body fat and lean body weight. Therefore it cannot be used as an index for evaluating body composition. The actual measurement of body composition is an accurate method for assessing body fat content.

The third is the evaluation method of mathematical models. In evaluating physical fitness, we often use single indicators and index evaluations that are one-sided in the formulation of grades and scores [4]. Therefore, some researchers have begun to explore the use of mathematical models to establish an evaluation system. The mathematical model can eliminate the difference in dimensions, but also because of its comprehensive evaluation in the multi-dimensional space, it is easier to see the main factors affecting the tester’s level, qualitatively and quantitatively evaluate the actual level of students and also ensure more convenient operation.

This study uses the mathematical cone method to measure the height and weight of Chinese college students. We established a discriminant analysis model of college students’ physical fitness, which can overcome the limitations of human evaluation and lay the foundation for formulating college students’ exercise prescriptions and promoting hierarchical teaching.

2 Research objects and methods

2.1 Research object

We conduct a physical examination for the 2019 freshmen of a particular university. We adopted the cluster sampling method to obtain adequate data of 3,570 people, of which 2,056 were boys, and 1,514 were girls [5]. There were 422 subjects to be judged, including 263 boys and 159 girls. At the same time, we selected 2018 students as test subjects by random sampling. All test subjects can engage in various physical exercises, and the test subjects are well-developed and healthy.

2.2 Research methods

2.2.1 Measurement method

The test indicators include height, weight, 1,000 m run (male)/800 m run (female), vital capacity, standing long jump and grip strength (male)/sitting forward flexion (female).

2.2.2 Factors of physical fitness evaluation

According to the ‘National Student Physical Fitness and Health Standards’, volunteers must complete six tests and five indicators for evaluation. The symptom self-rating scale SCL90 factor distribution compiled by LR Derogates includes 90 questions, and these deal with feelings, thinking, emotions, consciousness, behaviour and living habits. Interpersonal relationships, diet, sleep etc. are all involved [6]. A total of nine factors are somatisation, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, horror, delusion, psychosis etc. This check is to score the mental health of students.

2.2.3 Mathematical modelling of students' physical health

We will consider the factors that affect physical health. The National Student Physical Health Standard requires the completion of six tests and five indicators, and the SCL-90 self-evaluation scale [7]. After numerically processing the scores, we use the mathematical theory of cones to construct a student's physical health model. Its mathematical expression:

$$\begin{aligned} F(V) &= \frac{1}{3}F(S) \cdot F(H) \\ F(S) &\in [n_1, n_2, n_3, n_4, n_5] \\ F(H) &\in [n_{6i}] (i = 10) \end{aligned} \quad (1)$$

N_1 : Height standard weight, this is an indicator that we must measure. $f(n_1) \in \{n_1 | 0 \leq f(n_1) \leq 10\}$. N_2 : Vital capacity and body mass index; this is an indicator that we must measure [8]. $f(n_2) \in \{n_2 | 0 \leq f(n_2) \leq 20\}$. N_3 : 1,000-meter run (male), 800-meter run (female), step test; this is what we need to choose to test. $f(n_3) \in \{n_3 | 0 \leq f(n_3) \leq 30\}$. N_4 : Sitting forward bending, throwing a solid ball, sit-ups (female), pull-ups (male), grip strength and body mass index; this is what we need to choose. $f(n_4) \in \{n_4 | 0 \leq f(n_4) \leq 20\}$. N_5 : 50-meter running, standing long jump, skipping rope, basketball dribble, football dribble, volleyball dribbling; this is what we need to test. $f(n_5) \in \{n_5 | 0 \leq f(n_5) \leq 20\}$. N_6 : Symptom self-assessment $SCL-90 \circ f(n_{6i}) \in \{n_{6i} | 5 \leq f(n_{6i}) \leq 10\} \circ (i = 10)$.

1. The bottom surface $F(S)$ of the model. The value of $f(n_I)$ is the measured score value of the various indicators of the National Student Physical Health Standard.

$$F(S) = f(n_1) + f(n_2) + f(n_3) + f(n_4) + f(n_5) = \sum_{I=1}^5 f(n_I) \quad (2)$$

2. The high $F(H)$ of the model. The value of $f(n_{6i})$ is the value of the factor distribution of the self-rating symptom scale SCL-90 after digital processing.

$$F(H) = [f(n_{61}) + f(n_{62}) + \dots + f(n_{610})]/10 = \sum_{i=1}^{10} f(n_{6i})/10 \quad (3)$$

3. Physical fitness model.

$$F(V) = \frac{1}{3}F(S)F(H) = \frac{1}{30} \sum_{I=1}^5 f(n_I) \cdot \sum_{i=1}^{10} f(n_{6i}) \quad (4)$$

Following the 'National Student Physical Health Standard' and the latest national norm of the Symptom Self-Rating Scale SCL-90, we use the eligibility criteria of various indicators as primary data to establish a physical health standard model. $F(V) = 120$; V standard mode expresses a cone with radius $R = \sqrt{120/\pi}$ and height $H = 6$.

2.2.4 Mathematical statistics

We use Excel2010 and SPSS25.0 software to process and analyse the data statistically. The specific data processing is cluster analysis and discriminant analysis [9]. According to the cluster analysis, this study divides male and female students into three categories. The results are as follows (Tables 1 and 2).

Table 1 Clustering results of male college students.

	Height	Body weight	1,000 m/(s)
Class A (523)	168.78 ± 5.42	56.36 ± 6.75	238.5 ± 17.40
Class B (954)	170.52 ± 5.01	59.97 ± 6.99	237.51 ± 17.36
Class C (579)	173.79 ± 5.28	65.21 ± 8.26	237.87 ± 17.39
Total (206)	171 ± 5.52	60.53 ± 8.01	237.86 ± 17.38
	Vital capacity/(ml)	Standing long jump/(ml)	Grip strength/(kg)
Class A (523)	3264.39 ± 356.53	2.17 ± 0.16	41.81 ± 6.22
Class B (954)	4118.69 ± 238.03	2.21 ± 0.16	43.31 ± 5.74
Class C (579)	4853.76 ± 319.55	2.23 ± 0.16	45.53 ± 6.14
Total (206)	4136.54 ± 684.97	2.2 ± 0.16	43.55 ± 6.13

Table 2 Clustering results of female college students.

	Height/(cm)	Weight/(kg)	800m/(s)
Class D (440)	162.19 ± 4.83	55.16 ± 6.21	234.833 ± 14.59
Class E (691)	159.12 ± 4.83	50.98 ± 5.57	238.132 ± 14.42
Class F (383)	157.7 ± 4.74	49.26 ± 5.37	239.862 ± 15.38
Total (1514)	159.65 ± 5.10	51.76 ± 6.15	237.612 ± 14.83
	Vital capacity/(ml)	Standing long jump/(m)	Sitting forward bending/(cm)
Class D (440)	428.43 ± 258.20	1.6 ± 0.16	17.09 ± 4.77
Class E (691)	794.15 ± 185.94	1.56 ± 0.16	16.32 ± 5.50
Class F (383)	150.7 ± 278.04	1.51 ± 0.17	15.97 ± 5.39
Total (1514)	815.71 ± 525.33	1.56 ± 0.16	16.45 ± 5.28

3 Results

3.1 The establishment of the discriminant analysis model

We use the discriminant function to classify samples of unknown classification [10]. The general form of the discriminant function is:

$$F = b_0 + b_1x_1 + b_2x_2 + \cdots b_nx_n \quad (5)$$

The discriminant constant $b_1, b_2, \dots, b_n$ is the discriminant coefficient, F is the discriminant score and x is the characteristic variable reflecting the research object. This study uses the mathematical vertebral body discriminant method to establish a mathematical model. We obtain the three categories of male and female classification discriminant functions [11]. In the formula, $x_1, x_2, x_3, x_4, x_5, x_6$ represents height, weight, vital capacity, 1,000 m run (male)/800 m run (female), and grip strength (male), bend forward in sitting position (female) and standing long jump.

Boys:

$$\begin{aligned} A &= 6.311x_1 - 1.193x_2 + 0.02437x_3 + 1.123x_4 + 0.157x_5 + 83.597x_6 - 767.729 \\ B &= 6.276x_1 - 1.181x_2 + 0.03421x_3 + 1.125x_4 + 0.142x_5 + 84.987x_6 - 801.650 \\ C &= 6.294x_1 - 1.154x_2 + 0.04360x_3 + 1.129x_4 + 0.140x_5 + 85.756x_6 - 851.522 \end{aligned} \quad (6)$$

Girls:

$$\begin{aligned} D &= 7.702x_1 - 1.662x_2 + 0.0440x_3 + 1.620x_4 + 1.120x_5 + 67.690x_6 - 909.417 \\ E &= 7.695x_1 - 1.728x_2 + 0.03268x_3 + 1.625x_4 + 1.120x_5 + 67.263x_6 - 870.051 \\ F &= 7.733x_1 - 1.728x_2 + 0.02080x_3 + 1.619x_4 + 1.141x_5 + 66.237x_6 - 844.021 \end{aligned} \quad (7)$$

Eq. (7) holds when the mathematical cone linear discriminant function is established. We can use the mathematical cone discriminant coefficient to discriminate a new observation value directly [12]. The SPSS software can automatically generate the discrimination result and keep it in the original data file as a new variable.

3.2 Health under the mathematical vertebral model

We measured the relevant data and indicators of the ‘National Student Physical Health Standard’ for freshman Xiang (male). Xiang’s physical health is shown as:

$$F_1(V) = \frac{1}{3}F_1(S) \cdot F_1(H) = \frac{1}{3} \times 71.4 \times 5.4 = 128.52 \quad (8)$$

A cone with a radius of $R = \sqrt{128.52/\pi}$ and a height of $H = 5.4$ is determined (the sample model is shown in Figure 1).

Fig. 1 Standard model and sample model.

3.3 Test of the validity of the discriminant analysis model

3.3.1 Discriminant analysis statistics test

We calculate the eigenvalues of the discriminant function. The male eigenvalue is 4.396, which can explain 99.8% of all the variation, indicating that the established discriminant function is practical [13]. The male’s correlation coefficient is 0.903, and the Wilks’ Lambda statistic is 0.184. The probability $P < 0.0001$ is minimal, so the established discriminant function’s effect is considered significant.

Fig. 2 The typical discrimination of boys is scattered.

Fig. 3 The typical discrimination of girls is scattered.

3.3.2 Discriminant function canonical discriminant scatter plot

Figures 2 and 3 are, respectively, the scattered point diagrams of different types of canonical discrimination. The abscissa is the score of the first canonical discriminant equation. The ordinate is the score of the second canonical discriminant equation. As can be seen from Figures 2 and 3, the physical fitness levels of male and female college students in different categories have their distribution areas in the figures. The typical discriminant equation established in this way has better discrimination accuracy and provides better guiding value for practice.

3.3.3 Discriminant function application

We randomly select a subject, such as the male student No. 9 (see Table 3), and the cluster analysis belongs to the second category. We calculate the discriminant coefficients of three types of mathematical cones [14]. The three values are the largest of 765.91916. The discriminant function of 'B calculates this value', so this boy belongs to B's physical fitness level. At the same time, we can see from Table 3 that the No. 9 boy discriminates. Then, we analyse the probabilities of the three categories A, B and C. Among them, 0.91980 is the largest, so life is classified as category B; thus, we conclude that the results of cluster analysis, mathematical vertebral linear discrimination and probability discrimination are consistent.

Table 3 Example of comparison between male clustering and discriminative classification.

Numbering	9	362	1434	1908
height	170	166	163	182
body weight	59.9	56.4	57.8	65.4
Vital capacity	4304	4565	3625	5541
1000m	213	218	232	244
Grip	41.7	42	38.1	40
Standing long jump	2.1	2.3	2	2
Clustering	2	3	1	3
Discriminate	2	2	1	3
Class 1 probability	0.00256	0.00007	0.65276	0
Class 2 probability	0.9198	0.50363	0.34719	0.00007
Class 3 probability	0.07765	0.4963	0.00004	0.99993

Table 4 Example of comparison between girl clustering and discriminative classification.

Numbering	10	48	577	1033	1452
height	159	157	158	162	165
body weight	52	46.9	43.5	53	52.5
Vital capacity	2300	3132	2519	4786	2358
800m	245	237	233	228	253
Sitting forward bending	14.2	20.7	6.3	18.7	16
Standing long jump	1.4	1.7	1.6	1.5	1.6
Clustering	3	1	2	1	3
Discriminate	3	2	2	1	3
Class 1 probability	0.00001	0.39261	0.00045	1	0.00004
Class 2 probability	0.10301	0.60724	0.7018	0	0.16059
Class 3 probability	0.89699	0.00015	0.29776	0	0.83937

3.4 Test of discriminant function return rate

The paper uses SPSS11.0 statistical software to substitute all subjects into the mathematical model for discriminant analysis [15]. The research shows that all students belong to the category, and the back generation rate can be automatically tested to verify the pros and cons of the mathematical model building. In this study, the total return rate of male and female students and the total return rate of the cross-validation to establish the discriminant function are above 96%. This indicates that the established mathematical models of different types are effective. This method has good practical application value.

3.5 Application of samples to be judged

The mathematical model of the mathematical vertebral body established by this research can effectively solve the problem of physique and health classification of the sampled population. This model has passed the test of several methods. This study randomly selected 422 students to test the effect of their physical fitness classification. The total return effective rate for boys was 92.2%, and the real effective rate for girls was 90.1%. This study uses cluster analysis and discriminant analysis [16]. The combined method establishes a discriminant analysis model of the health of college students' physique. We can use this model to evaluate the physical health of individual students or groups comprehensively.

4 Conclusion

This article is about the MCM study of students' physical health, and the mathematical model of students' physical health is obtained. The modelling design is reasonable and unique. The thesis successfully organically combines the various factors involved in physical health research and transforms abstract and one-sided problems into scientific digital and vivid physical descriptions. Simultaneously, the theory is in line with people's standard concept of physical health based on biological material conditions and spirituality as the pillar. The student's physical health mathematical model can directly calculate the evaluation data of the physical health of a group or individual sample.

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