ingegneria sismica
International Journal of Earthquake Engineering
Anno XLIII - Num. 1 - 2026

A multidimensional assessment system for the improvement of students' athletic ability in the modern model of physical education

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SUMMARY: *As regards to the evaluation of the students' athletic abilities under the modern model of physical education, this research uses both Delphi approach and DEMATEL approach to establish the multi-dimensional assessment index system of the students' athletic abilities. In addition, the AHP–entropy weighting approach is utilized to identify the integrated weights of the assessment indicators. Based on that, the Cloud Model method will be used to assess the level of the athletic abilities of students from University A. The results of the study showed that sports display and competition, physical condition, sports cognition, technical and tactical use, and safety awareness were the main dimensions for assessing students' athletic ability, and the corresponding weights were 0.372, 0.222, 0.191, 0.135, and 0.080, respectively. According to the findings, the similarity degree between the comprehensive evaluation cloud and the standard cloud of the "good" level of the students' athletic abilities is the highest, which is 0.3458. Moreover, the comprehensive evaluation cloud is located between the standard clouds of "medium" and "good", being closer to the "good" one. It implies that the general athletic abilities of the students in University A can be assessed as "good". Thus, it can be concluded that the current model of physical education implemented in this university can produce good results.*

KEYWORDS: *athletic ability; multidimensional evaluation; Delphi method; DEMATEL method; hierarchical analysis; entropy weighting; cloud modeling*

1 Introduction

Compared with the traditional education model, physical education has always occupied an important position in the modern education system [1]. The modern model of physical education shows the tendency of subject-centeredness as well as the scientificization of the curriculum, and the purpose of skill transmission and physical fitness enhancement is becoming clearer and clearer [2, 3]. Modern physical education has begun to focus more on practicality, which is significant for students who lack sports life, not only improves students' physical fitness, but also helps to improve students' mental health and teamwork ability [4-6].

With the proposal of core literacy in physical education, athletic ability in recent years has attracted a lot of attention from those engaged in school physical education teaching, teaching and research, training, research, and administrators, ranging from the theoretical correlation of athletic ability to the elements of athletic ability influence [7-9]. Among them, the assessment of athletic ability has attracted much attention. The traditional assessment of students' athletic ability is based on the final examination of physical education courses, and teachers make

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https://doi.org/10.65102/is2026408
Published: 30 April, 2026

comprehensive scores, which is subjective and cannot effectively observe the improvement effect of students' athletic ability. At present, most studies have assessed the athletic ability of athletes, and some studies have constructed a sports assessment system for students, but most of the assessment of students' athletic ability is based on a single data index as a measure of athletic ability [10-12]. With the establishment of multi-dimensional data-based evaluation systems for students' sports ability, the subsequent evaluation of the results of the physical education program is significant in terms of enhancing the strict management of student sports ability development.

In order to evaluate whether students' athletic ability changes in the current physical education program, there are some steps to be taken to conduct this evaluation process. First, the Delphi technique will be used to construct an initial index system of student athletic ability evaluation. Second, by the use of the DEMATEL technique, the key factors affecting student athletic ability evaluation can be determined to finally form the evaluation system. In order to enhance the evaluation function of this system, the analytic hierarchy process and entropy weight method are combined in this research. On this basis, College A's students are used to evaluate their athletic ability through the cloud model.

2 Construction of a multi-dimensional assessment system for students' athletic ability

In this chapter, the Delphi approach and the DEMATEL approach have been combined to build an evaluation system that can assess improvements in students' athletic capability in the modern physical education framework.

2.1 Preliminary construction of the evaluation index system for students' athletic ability

After conducting two rounds of surveys and discussions among experts through the Delphi approach, the candidates for the observation indicators were filtered, and the preliminary evaluation index system for assessing students' athletic capability in the modern physical education framework was developed, as shown in Table 1.

There are five first-level indicators, including physical fitness (A1), sports knowledge (A2), techniques and tactics application (A3), sports performance and competition (A4), and safety consciousness (A5).

There are 15 secondary indicators, including: physical form (B1), physical function (B2), physical fitness (B3), occupational fitness (B4), sports awareness (B5), sports memory (B6), sports awareness (B7), thinking ability (B8), technical level of the program learned (B9), tactical level of the program learned (B10), psychological condition of the display (B11), physical body of the display condition of the display (B12), results of the display (B13), safety of self (B14), and safety of others (B15).

The tertiary indicators include the following 41 items: BMI (C1), WHR (C2), lung capacity (C3), step test (C4), 50-meter (C5), seated forward bend (C6), standing long jump (C7), pull-ups/abdominal curls (C8), 800/1000 meters (C9), T-type run (C10), grip weight index (C11), prone backward extension (C12), throwing the solid ball (C13), plank hold (C14), stork test (C15), overhead squat (C16), understanding basic knowledge of physical exercise (C17), understanding methods of professional physical training (C18), being able to quickly remember the key points of movements (C19), being able to complete the learned movements well (C20), being able to perceive the spatial position of one's own body (C21), being able to perceive the rhythm of one's own technical movements (C22), having the ability to analyze the structural characteristics of technical movements (C23), being able to make response strategies in a short time (C24), having a clear understanding of one's own technical movements (C25), expressing tactical ideas clearly (C26), being able to master 1-2 sports skills (C27), mastering the basic techniques of the learned project (C28), mastering the offensive tactics of the learned project (C29), mastering the defensive tactics of the learned project (C30), being able to regulate emotions during the game (C31), calmly facing the game results (C32), the degree of movement completion (C33), the proficiency of movement (C34), the number of times participating in sports competitions (C35), the evaluation of competitors (C36), the ability to judge the safety of sports (C37), the ability to predict and avoid sports dangers (C38), mastering methods for preventing and rehabilitating common occupational diseases (C39), mastering simple methods for handling sports injuries (C40), mastering knowledge and skills of cardiopulmonary resuscitation and drowning rescue (C41).

Table 1: Evaluation index system for students' athletic ability

First-level indicator	Secondary indicators	Third-level indicators
A1	B1	C1
		C2
	B2	C3
		C4
	B3	C5
		C6
		C7
		C8
		C9
		C10
	B4	C11
		C12
		C13
		C14
		C15
		C16
A2	B5	C17
		C18
	B6	C19
		C20
	B7	C21
		C22
	B8	C23
		C24
		C25
		C26
A3	B9	C27
		C28
	B10	C29
		C30
A4	B11	C31
		C32
	B12	C33
		C34
	B13	C35
		C36
A5	B14	C37
		C38
		C39
	B15	C40
		C41

2.2 DEMATEL-based screening of key indicators

In this part, the DEMATEL method is used to determine the indicators that represent the students' athletic capability based on the evaluation indicator system developed using the Delphi method.

2.2.1 DEMATEL methodology

DEMATEL, also referred to as the Decision-making Trial and Evaluation Laboratory, is a methodology in the field of systems science that relies heavily on the knowledge and experience of domain experts. This approach studies the interactions between the elements within a particular system of influence, and by using a direct influence matrix and associated computations, determines the correlation, importance, and causal relationships of each element, and the mutual influence and status of influencing factors in the influencing factor system can be determined by comparing the centrality and causality of influencing factors. This method can visualize and precise complex social problems, propose targeted countermeasures and recommendations, and identify key factors.

The procedures of using the DEMATEL approach are provided as follows:

(1) Selecting the influencing factors of the system concerning the research issue, represented as:

$$a_1, a_2, a_3, \ldots, a_N \tag{1}$$

(2) Based on the scoring by experts, identifying the direct relationships of influence between the factors and adopting an equal scale of influence. The direct influence matrix of the system can be represented as:

$$X = \begin{pmatrix} 0 & a_{12} & \cdots & a_{1n} \\ a_{21} & 0 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{N1} & a_{N2} & \cdots & 0 \end{pmatrix} \tag{2}$$

(3) Establishment of a normalized direct impact matrix D:

$$D = sX, (s > 0) \tag{3}$$

To wit:

$$d_{ij} = sa_{ij}, i, j = 1, 2, \ldots N \tag{4}$$

The factor s is usually taken as:

$$s = \frac{1}{\max\limits_{1 \le i \le N} \sum_{j=1}^{N} |a_{ij}|} \tag{5}$$

(4) Develop the overall influence matrix T for the influencing factors.

$$T = \sum_{i=1}^{\infty} D^i = D(I - D)^{-1} \tag{6}$$

(5) Measure the degree of influence D_i and the degree of being influenced C for each factor:

$$T = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} S(i, j) \tag{7}$$

(6) Find the centrality and causality of each factor. Centrality and causality are the two important measures that determine the importance of each factor in the network. Centrality M_i is given by the equation:

$$T = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} S(i, j) \tag{8}$$

The degree of cause R_i is calculated as:

$$T = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} S(i, j) \tag{9}$$

2.2.2 DEMATEL-based attribute analysis of influencing factors

(1) Selection of decision-making expert group

(1) Formation of the Expert Group

In order to determine the major indices of students' athletic ability in the new physical education system, an expert group consisting of 20 people who belong to such areas as physical education and training, teaching in the classroom, and sport training studies was formed.

(2) Establishment of the Direct Influence Matrix X

Matrix X will be utilized to define the direct connections between the assessment indices of students' athletic ability. Four different values are assigned to reflect the extent of influence between two factors: 0 for no effect, 1 for slight effect, 2 for moderate effect, and 3 for considerable effect.

The 20 experts independently evaluated the interactions between all 42 indices of students' athletic ability. The most frequent score was chosen to serve as the representative score for each pair of indices, which eventually resulted in the matrix X.

(3) Calculation of the Comprehensive Influence Matrix

Based on the direct influence matrix X, the normalization matrix D is first derived using equations (3) through (5). With $s = 0.0547$, the comprehensive influence matrix T for students' athletic ability indicators is then computed through formula (6) using Excel.

(4) Calculation of Centrality M_i and Causality R_i for Each Indicator

The integrated influence matrix T is substituted into formulas (7) through (9) to obtain each indicator's influence degree D_i, being influenced degree C_i, centrality M_i, and causality R_i. Specifically, the sum of elements across each row of matrix T yields the influence degree D_i, while the sum of elements down each column produces the influenced degree C_i. From these two values, the centrality M_i and causality R_i for each factor are derived accordingly. The resulting DEMATEL correlation coefficients for all influencing factors are presented in Table 2.

Table 2: DEMATEL correlation coefficients of influencing factors

Factor	D_i	C_i	M_i	R_i
C1	0.7342	0.4636	1.1978	0.2706
C2	1.2933	0.3321	1.6254	0.9612
C3	0.8267	1.0725	1.8992	-0.2458
C4	0.8573	1.6481	2.5054	-0.7908
C5	1.3818	1.6749	3.0567	-0.2931
C6	0.4334	1.6827	2.1161	-1.2493
C7	0.9711	0.6563	1.6274	0.3148
C8	1.5324	0.8677	2.4001	0.6647
C9	1.0843	0.4327	1.5170	0.6516
C10	0.5972	1.0924	1.6896	-0.4952
C11	1.3679	0.2365	1.6044	1.1314
C12	1.0929	0.5193	1.6122	0.5736
C13	0.8781	0.4345	1.3126	0.4436
C14	1.4562	0.6878	2.1440	0.7684
C15	0.6633	1.1787	1.8420	-0.5154
C16	1.3147	0.6419	1.9566	0.6728
C17	1.2451	0.7993	2.0444	0.4458
C18	1.4643	0.3573	1.8216	1.1070
C19	0.5949	0.4976	1.0925	0.0973
C20	1.1097	0.7381	1.8478	0.3716
C21	0.5489	0.9745	1.5234	-0.4256
C22	0.9413	1.1023	2.0436	-0.1610
C23	0.2726	1.1901	1.4627	-0.9175
C24	0.5678	0.7357	1.3035	-0.1679
C25	0.9037	1.1849	2.0886	-0.2812
C26	0.5542	1.1817	1.7359	-0.6275
C27	0.6483	0.7259	1.3742	-0.0776
C28	0.5167	1.2454	1.7621	-0.7287
C29	0.6198	0.9715	1.5913	-0.3517
C30	1.6792	0.9994	2.6786	0.6798
C31	1.0634	0.2532	1.3166	0.8102
C32	0.2367	0.6849	0.9216	-0.4482
C33	1.1757	0.5195	1.6952	0.6562
C34	0.8509	0.5691	1.4200	0.2818
C35	0.5842	0.3934	0.9776	0.1908
C36	1.8386	1.2494	3.0880	0.5892
C37	1.1388	0.9371	2.0759	0.2017
C38	1.3205	1.2287	2.5492	0.0918
C39	1.2484	0.8267	2.0751	0.4217
C40	1.4949	0.4891	1.9840	1.0058
C41	0.1634	1.0284	1.1918	-0.8650

(5) Establishment of causality diagram

To analyze the evaluation indicators of students' athletic ability more visually, centrality M_i is taken as the horizontal axis and causality R_i as the vertical axis, from which a causality diagram is constructed and presented in Figure 1. A higher centrality value M_i indicates that factor a_i plays a more central and consequential role within the evaluation system. When $R_i > 0$, factor aia_i ai exerts greater influence on other factors and is thus classified as a cause factor. When $R_i < 0$, factor a_i is more susceptible to the influence of other indicators and is accordingly classified as a result factor.

Combining Table 2 and Figure 1, it can be seen that competitors' evaluation (C36), 50 meters (C5), mastery of defensive tactics of the studied events (C30), anticipation and avoidance of sports hazards (C38), step test (C4), and pull-ups/sit-ups (C8) are at the core of students' athletic ability index system, and they should be considered as the main focus in improving students' athletic ability.

Among the 41 indicators for evaluating students' athletic ability, there are 24 causal factors, in the following order of magnitude: C9, C8, C7, C6, C5, C41, C40, C4, C39, C38, C37, C36, C35, C34, C33, C32, C31, C30, C3, C29, C28, C27, C26, and C25.These indicators are not only the active factors that drive the improvement of students' athletic ability, but also have a significant effect on the indicators of other aspects. As for the outcome factors, there are 17 of them, and the order of their absolute value is as follows: C24, C23, C22, C21, C20, C2, C19, C18, C17, C16, C15, C14, C13, C12, C11, C10, and C1. These factors are affected by other factors and thus affect the students' athletic ability.

The analysis of the centrality and causality between the performance indicators shows that there is a strong interrelatedness between the 41 elements under the five dimensions in the evaluation system of students' athletic ability identified in the previous section through literature analysis and expert consultation, and that this interrelatedness will have an impact on students' athletic ability in the modern physical education model.

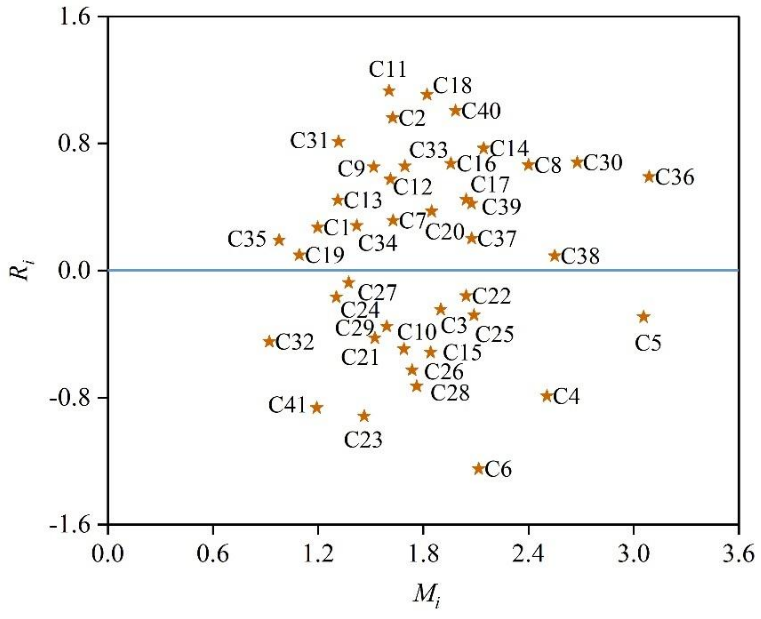

Figure 1: The causal relationship of factors related to students' athletic ability

2.2.3 Determination of key indicators of student athletic ability

In order to ensure the accuracy of the degree of importance of the factors of students' athletic ability and to screen out the key indicators more quickly, and to clarify which elements should be prioritized for improvement in the system of indicators of students' athletic ability, this paper refines the importance index of each factor according to the M_i and R_i of the factors of students' athletic ability, and obtains the comprehensive importance of the factors of students' athletic ability through the value of the M_i and R_i of each influence factor, which is recorded as the KPI. Based on the importance degree can determine the order of the influence of each indicator on students' athletic ability, KPI calculation is shown below:

$$KPI_i = \frac{M_i(1-P_i)}{\sum_{i=1}^{n}\left[M_i(1-P_i)\right]} \tag{10}$$

$$P_i = \frac{R_i}{\sum_{i=1}^{n}|R_i|} \tag{11}$$

According to the formula (10) to (11), the KPI of each student athletic ability evaluation index is calculated.By comparing the size of the importance value, the importance ranking of the impact of each evaluation index on student athletic ability is derived as shown in Table 3.

The maximum value of KPI of the indicators in this paper is 0.0422, and the KPI values of most of the indicators are also concentrated in the range of 0.0165~0.0422, so we can select the indicators with the importance degree of 0.0165 and above as the key factors according to this principle. Therefore, four indicators, BMI (C1), being able to memorize the main points of movements faster (C19), the number of sports competitions attended (C35), and facing the results of the competitions calmly (C32), are not considered as the main factors, and the remaining 37 indicators are identified as the key influencing factors in the evaluation of the students' athletic ability.

Table 3: KPI ranking of factors influencing students' athletic ability

Factor	KPI	Sorting	Factor	KPI	Sorting
C1	0.0161	38	C23	0.0208	29
C2	0.0212	27	C24	0.0179	34
C3	0.0262	14	C25	0.0288	8
C4	0.0354	4	C26	0.0243	20
C5	0.0422	1	C27	0.0188	33
C6	0.0305	7	C28	0.0248	18
C7	0.0219	25	C29	0.0220	24
C8	0.0317	6	C30	0.0354	3
C9	0.0201	31	C31	0.0173	36
C10	0.0236	22	C32	0.0128	41
C11	0.0208	30	C33	0.0224	23
C12	0.0214	26	C34	0.0191	32
C13	0.0175	35	C35	0.0132	40
C14	0.0282	9	C36	0.0410	2
C15	0.0257	17	C37	0.0281	11
C16	0.0259	15	C38	0.0346	5
C17	0.0273	13	C39	0.0278	12
C18	0.0236	21	C40	0.0258	16
C19	0.0148	39	C41	0.0169	37
C20	0.0248	19	C23	0.0208	29
C21	0.0212	28	C24	0.0179	34
C22	0.0281	10			

2.3 Finalization of the index system for evaluating students' athletic ability

Based on the screening results of the evaluation indicators outlined above, the final evaluation index system for students' athletic ability was established, as presented in Table 4.

Table 4: The Final Evaluation Index System for Students' Athletic Ability

First-level indicator	Secondary indicators	Third-level indicators
A1	B1	C2
	B2	C3
		C4
	B3	C5
		C6
		C7
		C8
		C9
		C10
	B4	C11
		C12
		C13
		C14
		C15
		C16
A2	B5	C17
		C18
	B6	C20
	B7	C21
		C22
	B8	C23
		C24
		C25
		C26
A3	B9	C27
		C28
	B10	C29
		C30
A4	B11	C31
	B12	C33
		C34
	B13	C36
A5	B14	C37
		C38
		C39
	B15	C40
		C41

3 Evaluation of students' athletic ability based on AHP-entropy weight and cloud modeling

Based on the evaluation index system of students' athletic ability established in the previous section, this chapter utilizes the AHP-entropy weighting method and cloud model to comprehensively evaluate students' athletic ability.

3.1 AHP-entropy based index combination assignment method

3.1.1 AHP-based indicator assignment

The Analytic Hierarchy Process (AHP) is a hierarchical weighting and decision analysis method. It treats a complex problem as multi-objective and multi-criteria, decomposing its constituent factors into interrelated and ordered levels to facilitate structured analysis.

The main steps of AHP assignment are as follows:

((1) Construct the Judgment Matrix

The judgment matrix represents pairwise comparisons of the relative importance of all factors within a given layer against a factor in the layer above. It is constructed using the 1–9 scale method, with the pairwise comparison matrix A derived through the Delphi expert scoring approach.

The 1–9 scale is defined as follows: when comparing factor i with factor j, scores of 1, 3, 5, 7, and 9 indicate that the former is equally important, slightly more important, notably more important, strongly more important, and extremely more important than the latter, respectively. Scores of 2, 4, 6, and 8 represent intermediate values between adjacent judgments. When the importance ratio of factor i to factor j is a_{ij}, the corresponding ratio of factor j to factor i is its reciprocal, such that $a_{ji} = 1/a_{ij}$.

(2) Hierarchical Single Ranking and Consistency Test

Hierarchical single ranking refers to calculating the relative importance of factors at the same level with respect to a factor in the level above, thereby determining each factor's weight. This involves identifying the maximum eigenvalue $\lambda_{\max}$ and eigenvector W of the judgment matrix A, after which W is normalized to obtain the relative weight W_j of each factor at that level. To mitigate the subjective influence of human scoring in the judgment matrix and to ensure that the index scoring reflects actual conditions, a consistency test on the hierarchical single ranking is necessary. This requires quantitatively examining the maximum eigenvalue $\lambda_{\max}$ and eigenvector W of an n-order judgment $A = \lambda_{\max} W$ W, with the consistency index CICI CI serving as the test criterion, calculated by the following formula:

$$T = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} S(i, j) \tag{12}$$

where n is the order of the matrix.

The consistency ratio CR is formed by comparing the consistency index CI with the average random consistency index RI, and the formula is shown below:

$$T = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} S(i, j) \tag{13}$$

When the consistency ratio CR is less than 0.1, then the judgment matrix passes the consistency test. The correspondence between order and RI is shown in Table 5.

Table 5: The RI value of an n-order matrix

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.58	0.89	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54

3.1.2 Assignment of indicators based on the entropy weighting method

The process of determining the entropy weight does not need external judgments but depends upon the data itself to determine the weight objective for the indicators. In other words, this technique is employed through the calculation of entropy weight that indicates the information content in the data and then assigning the weight based on the extent of influence on the whole system. This is done as follows:

(1) Establish evaluation matrix Q.

There are m evaluation indicators and evaluation objects, T_{ij} is the first i evaluation object of the j evaluation indicator value, you can get the original data to build the matrix

$$Q = \left(T_{ij}\right)_{m\times n} \tag{14}$$

(2) Dimensionless processing of data

Normalize the data to obtain the standard state matrix U, and the normalization formula for the positive indicator is as follows:

$$U = \left(X_{ij}\right)_{m\times n} \tag{15}$$

$$X_{ij} = \frac{T_{ij} - \min\left(T_{ij}\right)}{\max\left(T_{ij}\right) - \min\left(T_{ij}\right)} \tag{16}$$

where $X_{ij}\,(i = 1,2,3,\cdots,n;\ j = 1,2,3,\cdots,m)$ is the j of the i evaluation object.

(3) Normalize the data to obtain the criterion matrix $\left(P_{ij}\right)_{m\times n}$:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \left(0 \le P_{ij} \le 1\right) \tag{17}$$

(4) Calculate the entropy value F_j for each indicator:

$$F_j = -\frac{1}{\ln m} \sum_{i=1}^{n} P_{ij} \ln P_{ij} \tag{18}$$

(5) Calculate the weights V_j for each indicator:

$$V_j = \frac{1 - F_j}{n - \sum_{j=1}^{n} F_j} \tag{19}$$

3.1.3 Subjective and objective combination assignment based on AHP-entropy weighting method

The use of AHP analysis and entropy weight method to obtain the subjective and objective integrated weight analysis approach ensures that we have reflected both the professional experience of experts and the preferences of managers, while also obtaining the inherent rule through scientific analysis to achieve the optimal weight combination δ_j :

$$\delta_j = \frac{W_j V_j}{\sum_{j=1}^{m} W_j V_j} \tag{20}$$

W_j is the evaluation index weight obtained by AHP method, V_j is the evaluation index weight obtained by entropy weight method.

3.2 Cloud-based model for evaluating students' athletic ability

3.2.1 Cloud models

The cloud model is grounded in fuzzy set theory, bridging qualitative concepts and quantitative indexes through a mutual mapping and conversion relationship. This structure effectively addresses the subjective randomness inherent in fuzzy concepts, making it widely applicable to problems involving various fuzzy phenomena.

Definition: Let A be a quantitative domain comprising several values, and let xx x be one such value, expressed as $x \in A$. Let C be a qualitative concept defined on domain A, and let x be a random realization of C. The random number $\mu(x) \in [0,1]$ with stable tendency is the degree of affiliation of x to C, reflecting the certainty of x on C. The distribution of x on A is called a cloud, i.e., $\mu(x): A \to [0,1], \forall x \in A, x \to \mu(x)$. A cloud consists of a large number of droplets, and the greater the probability of a droplet appearing, the higher its degree of certainty, which in turn confirms that the droplet more strongly embodies the qualitative concept.

Expectation Ex, entropy En, and hyperentropy He are the three numerical characteristics of the cloud model, collectively representing the mathematical properties of linguistic values. The expectation Ex is the central value of the qualitative concept and the most representative point of the cloud drop in quantitative domain A. Entropy En reflects the vagueness of the qualitative concept and the probability of its occurrence, used to represent both the dispersion and the range of values of the cloud drop. Hyperentropy He is a measure of entropy's own entropy, representing the thickness of the cloud distribution. In practice, the cloud model operates through cloud generator algorithms, the most common of which are the forward cloud generator, the inverse cloud generator, and the X conditional cloud generator.

(1) Forward cloud model

The forward cloud model uses a forward cloud generator to perform the mapping algorithm from qualitative concepts to quantitative indices. The forward cloud generator operation flow is shown in Figure 2.

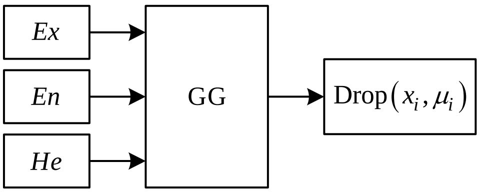

Figure 2: Forward cloud generator

The specific steps are as follows:

Step 1: Generate a normal random number En_i' with expected value En and variance He^2, which is calculated as:

$$En_i' = \text{NORM}\left(En, He^2\right) \tag{21}$$

In Eq. (21): NORM is a function in MATLAB for finding the number of paradigms.

Step 2: Generate a normal random number x_i with expectation Ex and variance $En_j'^2$, calculated as:

$$x_i = \text{NORM}\left(En, En_i'^2\right) \tag{22}$$

Step 3: Calculate μ_i with the formula:

$$\mu_i = \exp\left[-\frac{\left(x_i - Ex\right)^2}{2En_i'^2}\right] \tag{23}$$

Step 4: Input cloud droplets x_i, μ_i.

Step 5: Loop the above steps 1~4 until the set N th cloud droplet appears to form a cloud.

(2) Reverse Cloud Model

The inverse cloud model uses the inverse cloud generator for the evaluation system data construction. Input cloud droplets $\left(x_i, \mu_i\right)$, and calculate the required value by inverse cloud CG^{-1}. The operation flow of the inverse cloud generator is shown in Figure 3.

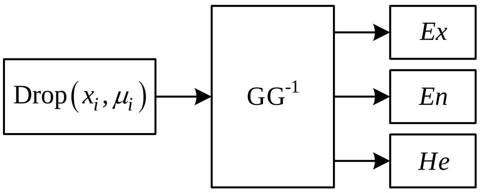

Figure 3: Reverse clouds generator

The specific calculation process is as follows:

Step 1: Calculate the expectation Ex_{ij} for each evaluation metric with the value x_b of the h th cloud droplet among N cloud droplets:

$$Ex_{ij} = \frac{1}{N}\sum_{h=1}^{N} x_h \tag{24}$$

Step 2: Calculate the period En_{ij} for each evaluation indicator:

$$En_{ij} = \frac{\sqrt{\frac{\pi}{2}}}{N} \sum_{h=1}^{N} \left(x_h - Ex_{ij} \right) \tag{25}$$

Step 3: Calculate the superentropy $H_{e,ij}$ for each evaluation metric by the sample variance S^2:

$$S^2 = \frac{1}{N-1} \sum_{h=1}^{N} \left(x_h - Ex_{ij} \right)^2 \tag{26}$$

$$He_{ij} = \sqrt{\left| S^2 - En_{ij}^2 \right|} \tag{27}$$

3.2.2 Evaluation process based on cloud modeling

(1) Establish the comment set

All possibilities regarding the result of evaluation are included in the comment set. In our case study, five terms are used to describe the students' sports abilities. The terms include: "poor," "average," "medium," "good" and "excellent." Hence, the comment set is represented by V ={poor, average, medium, good, excellent}. The corresponding score will range from 0 to 10 and will be divided into five sets: poor [0, 2), average [2, 4), medium [4, 6), good [6, 8) and excellent [8, 10]. It is clear that the higher the score, the higher the athletic ability of the student. The following formulas (28)-(30) may be used to derive numerical parameters of cloud model:

$$E_x = \frac{C_{\max} + C_{\min}}{2} \tag{28}$$

$$E_n = \frac{C_{\max} - C_{\min}}{6} \tag{29}$$

$$H_e = K \tag{30}$$

where $C_{\max}$ and $C_{\min}$ denote the maximum and minimum boundaries of a particular rubric, K is a constant and should not be too large, so this paper sets K to be 0.1. The resulting numerical features of the cloud model for each rubric are listed in Table 6.

Table 6: Comment cloud model digital characteristics

Comment	Poor	General	Medium	Good	Excellent
Interval	[0,2)	[2,4)	[4,6)	[6,8)	[8,10]
E_x	1	3	5	7	9
E_n	1/3	1/3	1/3	1/3	1/3
H_e	0.1	0.1	0.1	0.1	0.1

The numerical characteristics of the comment-level cloud model are fed into the forward cloud generator, and the standard cloud map corresponding to each evaluation level is produced using Matlab, as shown in Figure 4.

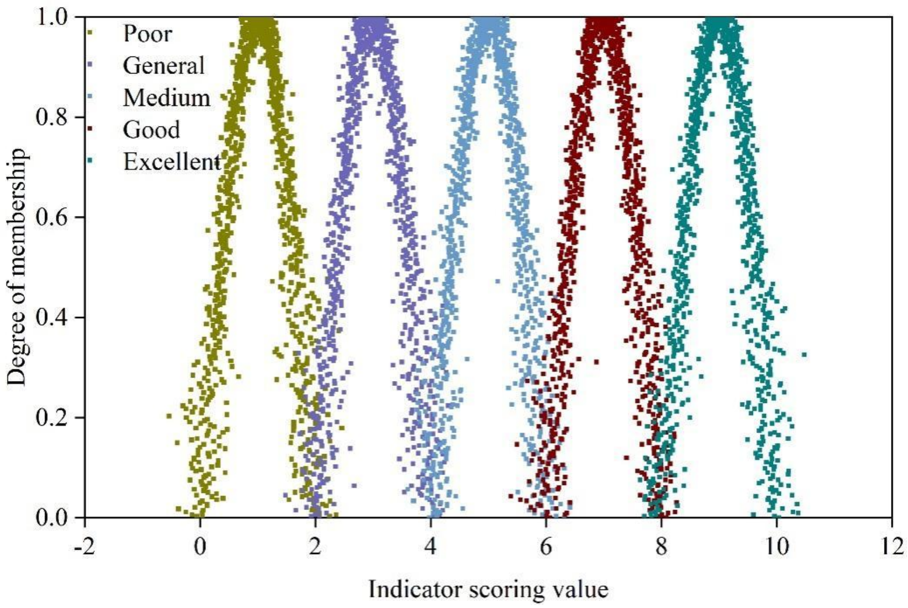

Figure 4: Standard cloud model

(2) Generate indicator evaluation cloud

Invite experts to evaluate students' athletic ability according to the above rubric set, we can get the evaluation matrix: $Y\left(y_{i1}, y_{i2}, \cdots, y_{im}\right), i=1,\cdots,n, n$ denotes the number of people who have filled out the questionnaire, and m denotes the number of indicators. Then through the cloud model inverse cloud generator to find the numerical characteristics of each indicator, i.e., indicator evaluation cloud. The specific formula is shown below:

$$E_{xj} = \frac{\sum_{i-1}^{n} x_{ij}}{n} \tag{31}$$

$$E_{nj} = \sqrt{\frac{\pi}{2}} \frac{1}{n} \sum_{i-1}^{n} \left| x_{ij} - E_{xj} \right| \tag{32}$$

$$H_{ej} = \sqrt{\left| S_j^2 - E_{nj}^2 \right|} \tag{33}$$

$$S_j^2 = \frac{1}{n-1} \sum_{i-1}^{n} \left(x_{ij} - E_{xj} \right)^2 \tag{34}$$

(3) Validation

According to the fogging property of the cloud model and the 3δ principle of the normal distribution, when $H_e < E_n / 3$, the cloud model is in a satisfactory state and meets the necessary requirements. Otherwise, the fogging effect becomes pronounced and the scores require recalibration.

(4) Calculate the Comprehensive Evaluation Cloud

The AHP-entropy weighting combination weights δ_j and the index evaluation clouds derived from the cloud model are computed according to formulas (35) through (38), from which the comprehensive evaluation cloud $C\left(E_x, E_n, H_e\right)$ for the multi-dimensional assessment of students' athletic ability is obtained:

$$E_x = \sum_{j-1}^{m} E_{xj}\delta_j \tag{35}$$

$$E_n = \sqrt{\sum_{j-1}^{m}\left(E_{nj}\delta_j\right)} \tag{36}$$

$$H_e = \sum_{j-1}^{m}\left(H_{ej}\delta_j\right) \tag{37}$$

$$\sum_{j-1}^{m}\delta_j = 1, j = 1,2,,\cdots m \tag{38}$$

The comprehensive evaluation cloud of the case study is mapped onto the standard cloud diagram presented in Figure 4 and compared against the comment set cloud model. The final evaluation result is then determined according to the maximum similarity principle.

3.3 Case Studies

In this section, students from college A were selected for a case study to assess their multidimensional motor competence in a modern educational model.

3.3.1 Assignment of indicators for evaluating students' athletic ability

First, 20 experts made judgments on the importance of each indicator of the multidimensional assessment system of students' athletic ability, established judgment matrices for primary, secondary and tertiary indicators respectively, and solved the results of subjective weights of indicators at all levels according to the hierarchical analysis method as shown in Table 7.

Table 7: The subjective weights of indicators at all levels

First-level indicator	Weight	Secondary indicators	Weight	Third-level indicators	Weight
A1	0.322	B1	0.135	C2	1.000
		B2	0.152	C3	0.515
				C4	0.485
		B3	0.351	C5	0.192
				C6	0.145
				C7	0.161
				C8	0.145
				C9	0.180
				C10	0.177
		B4	0.362	C11	0.142
				C12	0.217
				C13	0.209
				C14	0.149
				C15	0.141
				C16	0.142
A2	0.231	B5	0.246	C17	0.528
				C18	0.472
		B6	0.192	C20	1.000
		B7	0.194	C21	0.509
				C22	0.491
		B8	0.368	C23	0.272
				C24	0.249
				C25	0.275
				C26	0.204
A3	0.124	B9	0.491	C27	0.524
				C28	0.476
		B10	0.509	C29	0.442
				C30	0.558
A4	0.211	B11	0.322	C31	1.000
		B12	0.353	C33	0.521
				C34	0.479
		B13	0.325	C36	1.000
A5	0.112	B14	0.584	C37	0.427
				C38	0.305
				C39	0.268
		B15	0.416	C40	0.461
				C41	0.539

Consistency testing was performed on the judgment matrices of first level indicators, second level indicators, and third level indicators respectively. CR values of all matrices are less than 0.1, implying that all the judgment matrices meet the consistency test requirement.

Using the entropy weighting approach, scores from third level indicators are taken as input to generate the third level indicator layer's initial matrix. Using arithmetic average scores from individual indicator layers, the first and second level indicators' initial matrices are created. Objective weights of all indicators at various levels were calculated using further computations and are shown in Table 8 below.

Table 8: The objective weights of indicators at all levels

First-level indicator	Weight	Secondary indicators	Weight	Third-level indicators	Weight
A1	0.304	B1	0.151	C2	1.000
		B2	0.154	C3	0.514
				C4	0.486
		B3	0.339	C5	0.179
				C6	0.151
				C7	0.161
				C8	0.148
				C9	0.176
				C10	0.185
		B4	0.356	C11	0.154
				C12	0.209
				C13	0.202
				C14	0.149
				C15	0.145
				C16	0.141
A2	0.226	B5	0.251	C17	0.513
				C18	0.487
		B6	0.188	C20	1.000
		B7	0.192	C21	0.507
				C22	0.493
		B8	0.369	C23	0.271
				C24	0.249
				C25	0.282
				C26	0.198
A3	0.142	B9	0.493	C27	0.519
				C28	0.481
		B10	0.507	C29	0.427
				C30	0.573
A4	0.213	B11	0.327	C31	1.000
		B12	0.346	C33	0.521
				C34	0.479
		B13	0.327	C36	1.000
A5	0.115	B14	0.548	C37	0.417
				C38	0.302
				C39	0.281
		B15	0.452	C40	0.462
				C41	0.538

By adding the subjective and objective weights of each indicator, the overall weight is derived from equation (20), which is tabulated below in Table 9. In the first level, the weights arranged from high to low are as follows: sports display and competition A4 (0.372), physical fitness A1 (0.222), sports cognition A2 (0.191), technical and tactical use A3 (0.135), and safety awareness A5 (0.080). It can be seen that the performance of sports demonstration and competition, physical fitness condition, the level of cognition of the sport, and the ability to use techniques and tactics are the main factors in judging the students' athletic ability, while the level of safety awareness also has a certain impact on the students' athletic ability.

Table 9: The comprehensive weights of indicators at all levels

First-level indicator	Weight	Secondary indicators	Weight	Third-level indicators	Weight
A1	0.222	B1	0.275	C2	1.000
		B2	0.158	C3	0.543
				C4	0.457
		B3	0.270	C5	0.200
				C6	0.133
				C7	0.150
				C8	0.133
				C9	0.184
				C10	0.200
		B4	0.297	C11	0.121
				C12	0.258
				C13	0.242
				C14	0.137
				C15	0.121
				C16	0.121
A2	0.191	B5	0.262	C17	0.540
				C18	0.460
		B6	0.298	C20	1.000
		B7	0.152	C21	0.517
				C22	0.483
		B8	0.288	C23	0.291
				C24	0.236
				C25	0.309
				C26	0.164
A3	0.135	B9	0.481	C27	0.538
				C28	0.462
		B10	0.519	C29	0.371
				C30	0.629
A4	0.372	B11	0.387	C31	1.000
		B12	0.223	C33	0.542
				C34	0.458
		B13	0.390	C36	1.000
A5	0.080	B14	0.537	C37	0.512
				C38	0.279
				C39	0.209
		B15	0.463	C40	0.432
				C41	0.568

3.3.2 Evaluation of student athletic ability

(1) Determine the evaluation cloud of students' athletic ability

Using the standard cloud of athletic ability levels provided in Table 6 and Figure 4, the evaluation cloud for each criterion and the comprehensive evaluation cloud for athletic ability levels of students can be determined based on the scores given by 20 experts. These evaluation clouds are shown in Table 10.

Table 10: The evaluation cloud of students' athletic ability

Serial number	Indicator	Index evaluation cloud	Serial number	Indicator	Index evaluation cloud
1	C2	(7.326,1.403,0.366)	20	C22	(6.074,1.954,0.610)
2	C3	(7.219,1.398,0.152)	21	C23	(6.544,1.221,0.436)
3	C4	(6.446,1.717,0.291)	24	C24	(6.518,1.627,0.219)
4	C5	(7.148,1.531,0.381)	23	C25	(6.008,0.938,0.187)
5	C6	(6.449,0.714,0.112)	24	C26	(6.256,0.860,0.261)
6	C7	(5.622,1.442,0.388)	25	C27	(6.287,1.868,0.396)
7	C8	(5.973,1.147,0.305)	26	C28	(5.875,1.687,0.517)
8	C9	(6.211,1.428,0.096)	27	C29	(6.395,1.522,0.258)
9	C10	(6.188,1.199,0.315)	28	C30	(6.816,1.246,0.372)
10	C11	(6.194,1.518,0.285)	29	C31	(7.101,1.488,0.157)
11	C12	(6.013,1.617,0.382)	30	C33	(6.550,0.866,0.124)
12	C13	(7.006,1.511,0.381)	31	C34	(5.073,1.366,0.357)
13	C14	(7.084,1.212,0.173)	32	C36	(6.310,1.321,0.312)
14	C15	(6.298,1.684,0.443)	33	C37	(5.967,1.259,0.090)
15	C16	(6.521,1.437,0.492)	34	C38	(6.807,1.015,0.320)
16	C17	(6.018,2.114,0.402)	35	C39	(5.528,1.385,0.305)
17	C18	(6.516,1.255,0.201)	36	C40	(5.875,1.657,0.393)
18	C20	(6.571,1.516,0.425)	37	C41	(6.637,1.399,0.386)
19	C21	(6.527,1.687,0.442)	Comprehensive evaluation cloud		(6.497,1.192,0.303)

(2) Determine evaluation grade by calculating similarity

The measure of closeness of two clouds (MCM), based on the geometrical aspects of the cloud model, is used to determine inter-cloud similarity in this study. Positional similarity between the comprehensive evaluation cloud and standard clouds of “excellent,” “average,” and “poor” gives values less than 0 and are thus considered equal to 0. The similarity between this sample student's movement ability grade and other standard clouds is shown in Table 11. Since 0.3458 > 0.3164, according to the theorem, the movement ability grade of this sample student is determined to be "good".

Table 11: Results of similarity calculation

Standard cloud	Poor	General	Medium	Good	Excellent
Similarity	0	0	0.3164	0.3458	0

Finally, MATLAB programming was used to draw a comparison graph between the comprehensive evaluation cloud of students' athletic ability and the evaluation cloud of each standard to verify the reasonableness of the evaluation level. The comprehensive evaluation cloud of students' athletic ability is shown in Figure 5.

The level of athleticism among the subjects selected ranges from “medium” to “good,” closer to the latter, reflecting positively on the result of the analysis through similarities calculation. Hence, the method employed by the researchers using the MCM to measure similarity holds a certain degree of validity and reliability.

The total athleticism of the students of College A may be classified as “good,” signifying that the present model being used in physical education should continue to be followed at its present standard. Nevertheless, more work needs to be done in the following aspects: improving physical fitness levels, enhancing their comprehension regarding sports principles, increasing technical and tactical skills, increasing safety measures, and promoting athletic competition.

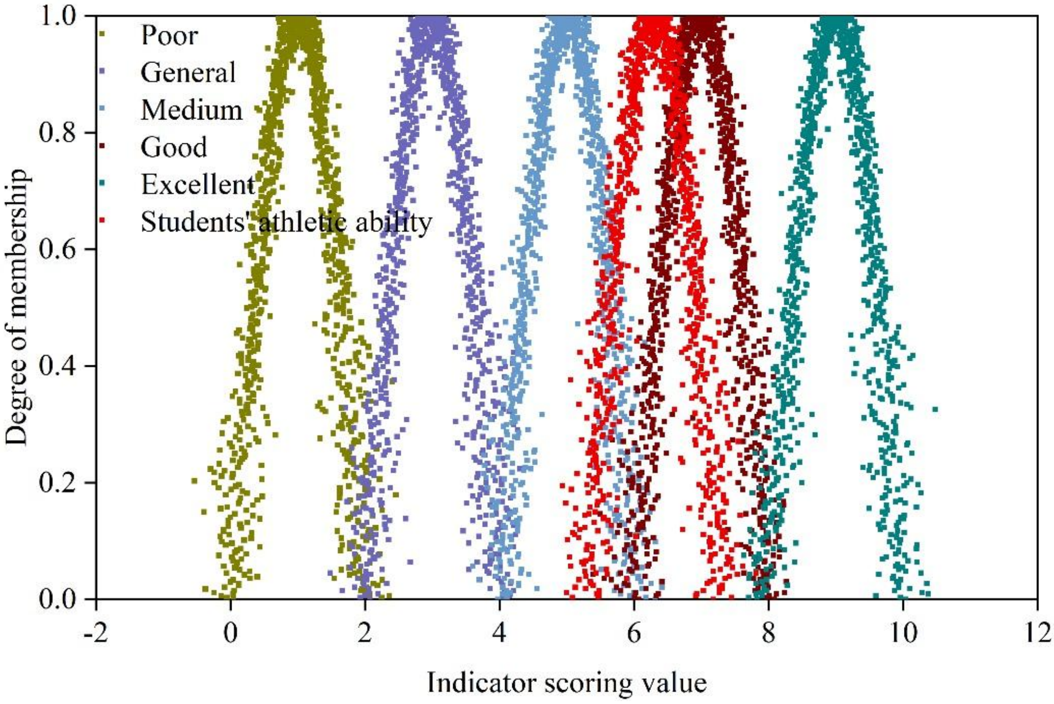

Figure 5: Comprehensive cloud chart of evaluation

4 Conclusion

This research creates the evaluation indicator system for the improvement of students' physical abilities by combining the Delphi method and the DEMATEL method, while using the AHP-entropy weighting model in conjunction with the cloud model for assessing athletic ability enhancement under the contemporary physical education system.

The designed evaluation model consists of five first-level evaluation indicators, including physique, sport understanding, application of technical and tactical skills, athletic performances, and awareness of safety, among 15 second-level evaluation indicators and 37 third-level evaluation indicators. The first-level evaluation indicators are listed from the heaviest to lightest weight as follows: sports presentation and competition (0.372), physical fitness (0.222), sports cognition (0.191), technical and tactical utilization (0.135), and safety awareness (0.080). This indicates that sports display and competition performance, physical fitness condition, level of cognition of sports, and technical and tactical utilization are the main dimensions in judging students' athletic ability in the modern model of physical education, while the level of safety awareness, as a secondary dimension, also has a certain impact on students' athletic ability. The students of college A were selected for case study, and the comprehensive evaluation of their athletic ability was “good”, indicating that the modern physical education model implemented in this college has a good effect on the improvement of students' athletic ability.

From the results obtained from this research study, the following recommendations can be made concerning the implementation of the contemporary physical education program:

(i) More attention should be paid to emphasizing the basic competencies of physical education and health-related fields. Through the complementarity of fitness, healthy practices, and sporting character, learners will be encouraged to develop holistically.

(2) Skillfully combine physical education with the occupational characteristics of various professions, so that students can learn about the prevention of occupational diseases while improving their occupational fitness.

(3) Expanding the coverage and participation of sports competitions, vigorously supporting and carrying out sports programs that are popular among students, attracting more students to participate in them, creating a new perspective for the assessment of students' athletic ability, and realizing diversified evaluation.

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