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Physical Exercise Effect Evaluation Based on Data Envelopment Analysis

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Abstract: Data envelopment analysis is a new field of interdisciplinary research in operations research management science and mathematical economics. Data envelopment analysis uses mathematical programming to evaluate the relationship between decision-making units with multiple inputs and outputs (abbreviated as DMU). Effectiveness (DEA is effective) is to judge whether DMU is located on the "frontier surface" of the production possibility set. This paper proposes a method for evaluating the effect of physical exercise based on the data envelopment analysis method. First, a multiple logistic regression analysis was performed to examine the relationship between physical exercise effects and physical exercise outcomes. Secondly, the exercise combination efficiency analysis based on data envelopment analysis is used to select the physical exercise time optimally. Then use the historical data for training to obtain the evaluation effect. The results show that the data envelopment analysis method can evaluate the effect of physical exercise well and can also provide decision-making strategies related to sports performance.

Keywords: Data envelopment analysis, Physical exercise, Effect.

1. Introduction

After nearly a hundred years of development, China's sports cause has made remarkable achievements, which have greatly improved China's international status and enhanced national cohesion. The Chinese sports management system has also gone through continuous exploration and progress[1]. In order to adapt to the world's scientific and technological progress and the development of national conditions, the exploration and research on the future management system of China's sports have attracted extensive attention from scholars and formed many essential achievements. The future sports management system must actively transform government functions and realize the real socialization of sports management; the future development of China's sports management system will be an optimized combination structure model of planning and market mechanisms; in the absence of sports systems, The leading role of the government should be brought into play at the same time, and attention should be paid to the changes of the induced sports system; the development model of sports should not only conform to China's current social reality but also converge with the direction of China's social reform and development. "organizational system[2].

In previous research, most of the evaluations of physical exercise effects in China were qualitative research based on theoretical analysis. In contrast, quantitative researches were only unilateral quantitative research on resource allocation of China's sports undertakings, economic evaluation of the Olympic Games, etc[3]. Aiming at the deficiencies of the existing research, this paper uses the data envelopment analysis (DEA) performance evaluation method to analyze the efficiency generated by each redistribution of interests in the change process of China's sports management system to provide a basis for the future sports management system. Path selection provides a quantitative scientific decision-making basis[4], see Figure 1.

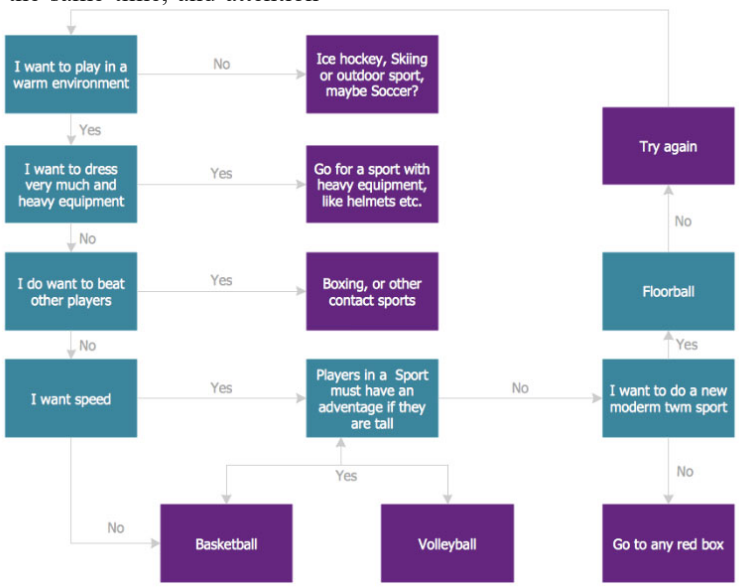

Figure 1. The flow chart of the data packaging analysis in sports

2. The Research Status of DEA in the Field of Sports

2.1. The Apparent Research Hotspots of DEA In the Field of Sports

The research status of data envelopment analysis in sports is mainly concentrated in four aspects: competitive sports, mass sports, sports industry, and school sports. In competitive sports, the CCR model and the BCC model in the data envelopment analysis method analyze the input and output of the training of reserve talents for competitive sports in 31 provinces (cities, districts) in China in 2020. Some scholars evaluate the relevant efficiency of the Olympic Games and the relative efficiency of the top ten countries in the Olympic medallist[5]. In mass sports, the Tobit regression model in the data envelopment analysis method is used to judge the correlation between the factors affecting the social environment and the efficiency value of public sports services and to explore relevant measures. Some scholars have also used the Tobit model to analyze the input-output benefits and factors of Chinese mass sports. In the field of the sports industry, by collecting and arranging the financial data published in the annual reports of 15 Chinese and foreign listed sporting goods companies, using the data envelopment analysis method to analyze the operating benefits of these 15 companies in order to find the differences between these 15 listed sporting goods companies, Enhance the core competitiveness of local brands[6]. By revising the classic DEA (Data Envelope Analysis) model, the economic benefits of China's sporting goods manufacturing industry are evaluated and analyzed. In the field of school sports, there is much literature on the evaluation of school sports. The analysis of the effectiveness of sports management in colleges and universities has clarified the existing deficiencies and adopted targeted improvement measures. Using the data envelopment analysis (DEA) method, combined with traditional methods such as expert evaluation, this paper comprehensively analyzes the operational benefits and scale benefits of sports work in colleges and universities.

2.2. Potential Research Hotspots of DEA In the Field of Sports

Teaching is a complex process, and the teaching evaluation methods are different. Since the implementation of the new curriculum reform in China, many scholars have continued to develop and innovate in teaching and physical education evaluation methods. Based on data envelopment analysis (DEA) and the concept of developmental evaluation in the West, the teaching process of college teachers is regarded as an input-output system. Taking teachers as the foundation, some scholars put forward the DEA developmental teaching evaluation method and conducted empirical research. Scholars believe that the effectiveness of DEA's developmental teaching evaluation mainly manifests in five aspects: First, the practical application is more feasible. That is, DEA can handle the evaluation of multiple inputs and outputs without prior knowledge of the form of the production function, Estimating function parameters, etc. The second is to analyze the ineffective input indicators and their degree, which provides convenience for further analysis of improvement measures. The third is to follow the law of talent growth, making management decisions more scientific, objective, and accurate. The fourth is to take timely and appropriate training measures for teachers. The fifth is "reduction." The effectiveness analysis is based on data processing based on the model built in advance, avoiding the heavy manual calculation process, see Figure 2.

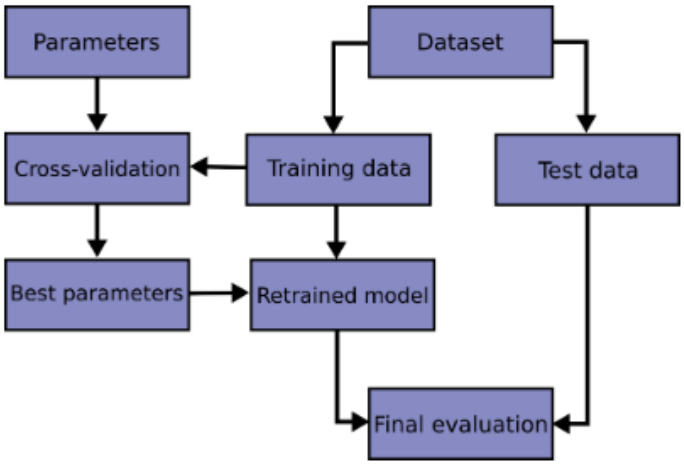

Figure 2. Physical exercise evaluation index selection principle

Based on data envelopment analysis (DEA) and relative evaluation, some scholars have used DEA to conduct method research on teachers' teaching effects and introduced the DEA secondary relative benefit value method, which is used to evaluate management effectiveness, into the evaluation of teaching effects. The difference in initial conditions is eliminated through empirical demonstration, and a new teaching management evaluation method is established. When establishing the DEA data model, the scholar first used the Analytic Hierarchy Process (AHP) to budget the past conditions of each evaluation object and called this index the reference index; using the same method to evaluate the current situation, called this index as a current index. The array is composed of the reference index, and the current index is the index status of the evaluation object. The secondary relative benefit evaluation is carried out based on the DEA model. The test results depend on the growth rate of the test index. This method effectively eliminates the impact of differences in objective primary conditions on performance evaluation.

The research on teaching evaluation based on data envelopment analysis (DEA) has already started on the teaching quality of English, mathematics, and medical colleges. Through the reasonable selection of evaluation indicators (input indicators are workload, professional title, teaching age, and output indicators are CET-4 pass rate, expert evaluation of teaching, and student satisfaction) to collect and sort out relevant evaluation data, an English language system for military academic education colleges has been established. The DEA model of the teaching quality of teachers, after calculation and analysis, objectively evaluates each teacher and puts forward corresponding improvement suggestions for students whose DEA is in an invalid state. The scholar constructed an evaluation index system from three aspects: teachers, students, and the teaching environment, and finally selected nine input indicators and three output indicators (students are both input indicators and output indicators), and the mathematics of a school is Data research was conducted on the teaching quality, and the BCC and CCR efficiency values of 10 classes were calculated, and the classes with relatively good and poor teaching quality were obtained.

3. Principles of Selection of Physical Exercise Evaluation Indicators Based on Data Envelopment Analysis

The input and output of physical exercise show the characteristics of diversity and complexity, which determines that the indicators and methods of physical exercise performance evaluation are also diverse. Therefore, certain principles must be followed to select representative indicators from many indicators. According to the scholars' discussion on performance evaluation principles, this study believes that the performance evaluation indicators of physical exercise should also follow scientific, systematic, and operability. And the principle of comparability.

3.1. Scientific Principles

The scientific nature of indicators is the basis for ensuring good evaluation results. Whether an evaluation activity is scientific depends primarily on whether its indicators, standards, procedures, and other methods are scientific. It can produce a series of chain reactions of performance results. If there are no scientific evaluation indicators, the index system will not be established, and the scientific nature will be lost, then the final performance evaluation results will be meaningless. Therefore, the evaluation index system must be non-overlapping, non-conflicting, coordinated, and unified. The index system's structure and level should be clear and unambiguous, and it should conform to the logical thinking of the design of physical exercise performance evaluation indicators.

3.2. Systematic Principles

As an organic whole, the physical exercise performance evaluation index system should be able to reflect and measure the main characteristics and conditions of the object being evaluated and fully reflect the various elements of physical exercise input and output. Therefore, to adhere to the systematic principle, it must be clear that the physical exercise performance evaluation index system is an organic whole, and the evaluation object is regarded as a system. The exercise performance evaluation index system can highlight the key points and reasonably and comprehensively reflect the development level of national fitness.

3.3. The Principle of Operability

The physical exercise performance evaluation index system must adhere to the principle of operability because the selection of indicators must consider the availability of data and the observability of the indicators. Data availability is the basis of ensuring the performance evaluation of the physical exercise. The measurement of the index value is an essential means of physical exercise performance evaluation. That is, the purpose of performance evaluation is achieved through statistical analysis of relevant data. Furthermore, in the observation of objective indicators and subjective indicators, the available objective indicators should be used as much as possible to reduce the subjective indicators and design new indicators, thereby improving the operability of the evaluation indicators.

4. DEA Model Analysis

4.1. CCR Model (C2R Model)

The CCR model assumes that there are n departments or units (DMUs), where each DMU has m kinds of "inputs" (i.e., the consumption of "resources" by the department) and s kinds of "outputs" (i.e., the consumption of "resources" by the department Subsequent "effectiveness" information). As follows.

$$
\begin{aligned}
&v_{1,}1\rightarrow x_{11}\ \ x_{12}\cdots x_{1j}\cdots x_{1n}\\
&v_{2,}1\rightarrow x_{21}\ \ x_{22}\cdots x_{2j}\cdots x_{2n}\\
&\cdots\quad\ \ \cdots\quad\ \ \cdots\quad\ \ \cdots\\
&v_{m,}1\rightarrow x_{m1}\ \ x_{m2}\cdots x_{mj}\cdots x_{mn}
\end{aligned}
$$

$$
\begin{aligned}
&y_{11}\ \ y_{12}\cdots y_{1j}\cdots y_{1n}\rightarrow 1,u_1\\
&\qquad y_{21}\ \ y_{22}\cdots y_{2j}\cdots y_{2n}\rightarrow 2,u_2\\
&\qquad\cdots\quad\ \ \cdots\quad\ \ \cdots\quad\ \ \cdots\\
&\qquad y_{s1}\ \ y_{s2}\cdots y_{sj}\cdots y_{sn}\rightarrow s,u_2
\end{aligned}
$$

A measure (or "weight") for the ith input; = the input of the jth DMU to the ith input,>0;=the output of the jth DMU to the rth output,> 0;=A measure (or "weight") for the rth output.;, is known data, which can be obtained from historical data or predicted data; is a variable. Corresponding to a set of weight coefficients, each decision-making unit has a corresponding efficiency evaluation index:

$$h_j = \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i y_{ij}, j = 1,2,\ldots,n \qquad (1)$$

To satisfy ≤1, we select the corresponding weight coefficients v and you. For example, to evaluate the efficiency of the the decision-making unit (1≤≤), the weight coefficients v and u are used as variables, and the efficiency index of all decision-making units (including the the decision-making unit) is hj≤1, j= , as constraints, the following optimization model is formed (denoted =, =)

$$\begin{cases} \max \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i y_{ij} = h_j^*{}_0 \\ \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i y_{ij} = h_j^*{}_0 \le 1, j = 1,2,\ldots,n \\ v = (v_1, v_2, \ldots, v_m)^T \ge 0 \end{cases} \quad (2)$$

It can be seen that the use of formula (2) to evaluate the effectiveness of decision-making units is relative to all other decision-making units. Moreover, the above problem is fractional programming. Using the Thames-Cooper transformation, it can be transformed into an equivalent linear programming problem. Let can be transformed into the following linear programming problem and its dual programming.

$$P_{C2R} \begin{cases} \max \mu^T Y_0 = h_j^* \\ \omega^T X_j - u^T Y_j \ge 0, j = 1,2,\ldots,n \\ \omega^T X_0 = 1 \end{cases} \quad (3)$$

$$D_{C2R} \begin{cases} \min \theta \\ \sum_{j=1}^{n} X_j \lambda_j \le \theta X_0 \\ \sum_{j=1}^{n} X_j \lambda_j \le Y_0 \ \lambda_j \ge 0, j = 1,2,\ldots,n, \end{cases} \quad (4)$$

4.2. After Adding Slack Variables

The dual programming can become:

$$\begin{cases} \min \theta \\ \sum_{j=1}^{n} + S_i^- = \theta X_0 \\ \sum_{j=1}^{n} y_j \lambda_j + S_r^+ = Y_0 \ \lambda_j \ge 0, j = 1,2,\ldots,n, \end{cases} \quad (5)$$

In Equation (5), it is a slack variable, and non-zero ones represent the ineffective input of resources in the i-th and the insufficient output in the jth, respectively. θ is the relative efficiency value of the decision-making unit (0≤≤1), which directly reflects the rationality of resource allocation. The larger the θ, the more reasonable the resource allocation. Depending on the value, the decision unit has three outcomes, see Figure 2:

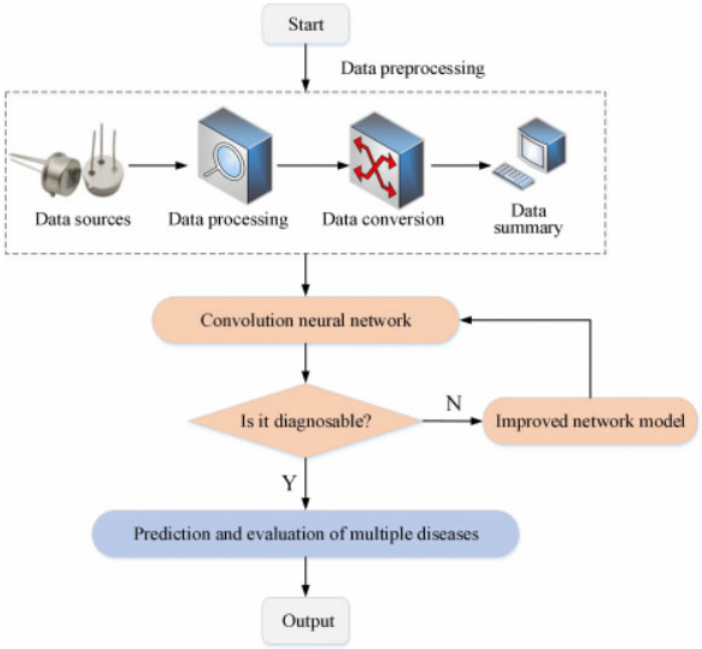

Figure 3. Physical exercise evaluation CCR model

1) When = 1 and when, DEA is valid, indicating that in this system, the resource allocation is reasonable, the effective use is achieved, the input combination is better, and the maximum output performance is obtained simultaneously.

2) It is weakly valid for DEA when = 1 and at least one or one. Explain that in this system, if the utilization efficiency of the i-th resource is; if so, consider the gap between the r-the output and the maximum output value.

3) When <1, it is non-DEA effective, indicating that the input can be reduced while keeping the original output unchanged. In this way, each effective DMU is connected to form an efficiency boundary. This boundary is used as a criterion to judge the "redundant input" and "insufficient output" of each non-DEA effective unit and conduct a practical resource allocation analysis for each decision-making unit. Conducive to the development of space and goals for physical exercise improvement.

5. Conclusion

The research uses the DEA method to evaluate physical exercise performance, revise the traditional CCR model, and construct the C2R model. Combined with the evolution of China's sports management system, the number of full-time

coaches, the amount of investment, the total number of international medals, and the number of people participating in physical exercise are used to evaluate the input and output of the system's performance. It can be seen that after the Beijing Olympics, Various problems with China's sports system have gradually become prominent, so the value of sports efficiency has declined, and we need an innovative sports management system. The analysis and suggestion of the innovation path of the sports system: the change mode of the sports management system should be transformed into a quasi-demand-induced system change actively promoted by the system demanders to accelerate the pace of the market-oriented sports system. The future sports management system should be dominated by association management and supplemented by government management. That is, it is required that the sports training organization system relies on each other between amateur and professional to form a club-based unit for the joint development of amateur sports training organizations and professional sports—Association management system.

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