

## Research Article

# Performance Optimization Method of Community Sports Facilities Configuration Based on Linear Planning Model

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The conventional community sports facility allocation methods have high minimum costs, and a new community sports facility allocation performance optimization method is designed based on a linear programming model in order to reduce the performance capital investment. The standardized community sports facility allocation performance objective function is established, and a pairwise model is built to divide the feasible and optimal solutions, and the feasible solutions and their constraints are found out. Establish a community sports facility configuration performance optimization model, delineate the boundaries of the optimal solution by bifurcation, and set the feasible domain of the performance optimization model. The performance optimization algorithm is designed to improve the speed of community sports facility allocation performance optimization. In the experiment, the method is compared with data-driven method, digital management method, and evolutionary game algorithm, which requires less capital investment in spring, autumn, and winter than digital management method and evolutionary game algorithm, and the minimum capital investment in summer is less than the other three methods. From the above experimental data, it is clear that the performance optimization method has the smallest minimum capital investment and achieves the purpose of reducing the input cost.

## 1. Introduction

China has made great achievements in the construction of public infrastructure. The construction of public infrastructure includes community public fitness service facilities. In the context of national fitness, the role of community public construction service facilities is particularly important, and its improvement provides residents with convenient exercise sites. In the context of better overall development, it is necessary to pursue issues such as the performance of facility configuration [1]. For example, Figure 1 shows the distribution of community fitness service facilities in the main urban areas of Beijing (Dongcheng District, Xicheng District, Haidian District, Fengtai District, Shijingshan, Chaoyang District, and the jurisdiction of the Capital Airport). It can be seen from the figure that the distribution of community fitness service facilities in the main urban area of Beijing is relatively even and comprehensive, indicating that the construction of fitness facilities in the main urban area of Beijing is good, but it is worth

thinking about whether the cost of community public fitness facilities allocation is reasonable. How to maximize the coverage of community public fitness facilities and improve the utilization rate, while reducing the configuration cost is the way to achieve better performance. In the future planning, how to save the configuration cost and improve the performance is the issue to be considered, which is also the embodiment of reasonable resource allocation.

Some studies have optimized the facility configuration performance in the digital library through the data-driven mechanism, constructed the formation mechanism model of the data through the simulation analysis method through the system dynamics, and provided a feasible design scheme for the optimization through particle calculation [2]. However, this approach requires very complex parameters and realistic data when applied to the optimization of community sports facility configuration performance and requires extensive calculations, otherwise the desired results are not achieved; a predictive energy management strategy for plug-in hybrid vehicles is proposed in this

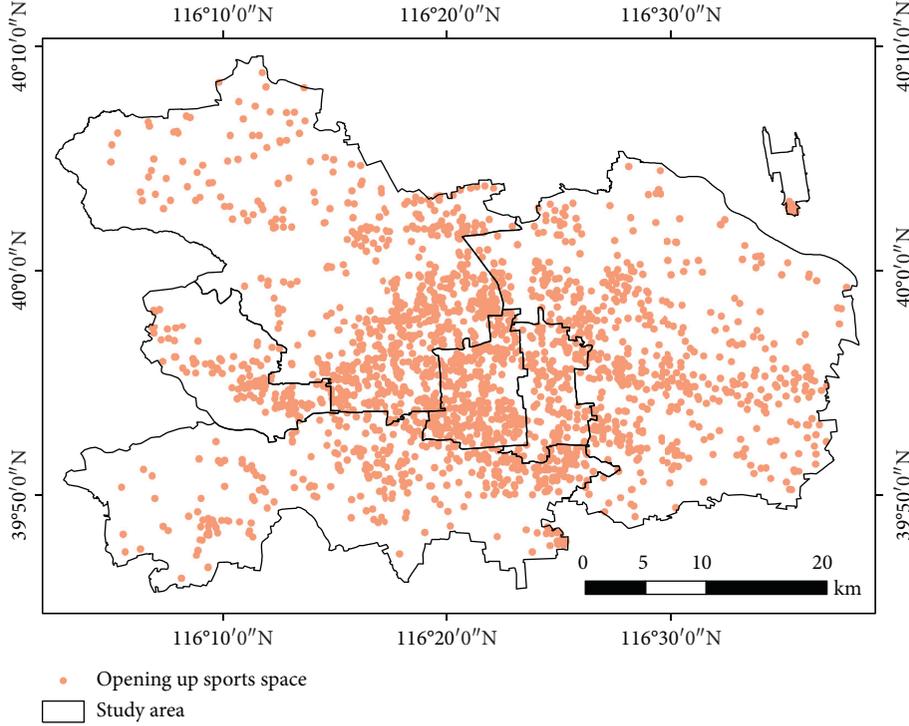


FIGURE 1: Distribution of community fitness service facilities.

literature using calibration through real-time optimization and data-driven calibration [3]. The literature [4] achieves performance optimization of urban infrastructure configurations by setting up a digital urban infrastructure performance structure, establishing a unified optimization model, and combining it with a parametric statistical testing algorithm that is objectively and rationally applied to a big data application domain. If this method is applied to community sports facilities configuration, only a feasible solution, not an optimal solution, can be obtained, so the performance optimization method obtained using this algorithm model is less effective. In the literature [5], a simulation model was developed through evolutionary game algorithm theory as well as system dynamics to analyze the stable equilibrium strategies between performance and projects, respectively, and an effective performance optimization method was designed through two unstable and three stable strategies. The accuracy of the model is verified by examples in this literature, and sensitivity studies are conducted to assess the impact of model parameter changes on dynamic response characteristics [6]. These performance optimization methods, when applied to the field of community sports facility configuration performance optimization, are closely coupled with the results of data obtained from surveys, creating a decentralized collection of information that possesses a high standard and is very dependent on the evaluation of sports facility configuration by the residents of the local community, with very unstable results. In this paper, we synthesize the above literature and design a new method for optimizing the performance of community sports facility allocation using a linear programming model.

## 2. Design Performance Optimization Method of Community Sports Facilities Based on Linear Planning Model

*2.1. Linear Analysis of Community Sports Facility Configuration Data Mining.* Through the joint parameter identification, the endogenous integration and parameter control of community sports facility configuration data mining  $\gamma$  are realized, and the similarity calculation formula of community sports facility configuration data mining can be defined as follows:

$$\text{Sim}(y_1, y_2) = |y_1 \cap y_2|. \quad (1)$$

Using the linear integration method of community sports facility configuration data mining, the statistical characteristics of community sports facility configuration data mining is, and the linear planning model of community sports facility configuration is further satisfied:

$$U = \sum_i \sum_{k=1} \ln \left( \frac{1}{\gamma} \frac{\text{Sim}_y(y_1, y_2)}{\sigma_i(k)^2} - 1 \right). \quad (2)$$

Using the information fusion and feature clustering method of community sports facility configuration data mining, the decision function of community sports facility configuration data is  $\varphi$ . An information entropy fusion model for the mining data evaluation, when  $1/\chi > 1/\chi$  satisfied where the threshold function  $1/\chi$  is represented, obtains the linear fitting feature  $\kappa$  output of the data mining of the community sports facility configuration. When the two attribute values satisfy the convergence, the optimal strategy

for obtaining the community sports facility configuration data is:

$$Y = \kappa U \times \varphi. \quad (3)$$

We adaptive scheduling functions of community sports facility configuration data mining is obtained based on the fuzziness of the two concept maps:

$$q_{ri}(k) = p_{rj}(k) \sum_{k=1} \ln \left( \frac{1}{\gamma} \frac{\text{Sim}_y(y_1, y_2)}{\sigma_i(k)^2} - 1 \right) + Y. \quad (4)$$

Semantic ontology feature quantities of community sports facility configuration data were extracted, and fuzzy threshold control parameters of community sports facility configuration data mining  $i$  were obtained. According to the semantic similarity distributions of the two concepts, nodes are obtained to use the maximum expansion of the compatibility distribution to concepts and linear analyze the community sports facility configuration data mining according to the endogenous fusion control.

**2.2. Standardized Community Sports Facilities Configuration Performance Objective Function.** Based on the results of the above analysis, it is clear that the construction of community sports facility configuration needs to be associated with the cost of construction, and in addition to this [7–9], it is also closely related to the cost, quality, population, number of equipment, instructors, and the quality of infrastructure construction in the community itself; therefore, while standardizing the objective function of community sports facility configuration performance, it is also necessary to establish a pairwise model that substitutes the three into the model so that they can be transformed into each other.

$$\begin{cases} \min M_t = \xi^u N_t, \\ \min M_t = \xi^v K_t. \end{cases} \quad (5)$$

Denotes the standardized objective function  $M_t$  represents the configuration performance of the community sports facilities;  $N_t$  is the construction cost of the community sports facilities;  $K_t$  is the infrastructure construction quality standardization objective function of the community itself;  $\xi^u$  is the optimal solution of the sports facilities configuration performance and the sports facilities construction cost;  $\xi^v$  is the optimal solution of the sports facilities configuration performance and the infrastructure construction quality dual model of the community itself [10] where the parameter constraints for the dual model are as follows:

$$\text{s.t.} \begin{cases} N^u K^u \xi^u \geq \mu_i, \\ \xi^u \geq 0, \\ \xi^v \geq 0, \end{cases} \quad (6)$$

$\mu_i$  denotes the combined feasible solution of the two dyadic models. This constraint enables to obtain specific community sports facility allocation performance decision attributes, which in turn replace the objective function in the dyadic model [11]. The resulting model of the standardized

community sports facility allocation performance objective function can be obtained as follows:

$$\max \sum_{i=1}^N \frac{\mu_i a_i}{\xi^u N_t} + \frac{\mu_j b_j}{\xi^v K_t}, \quad (7)$$

$N$  represents the number of decisions in the dual model;  $\mu_j$  is the feasible solution of the dual model of the sports facility configuration performance and the infrastructure construction quality of the community itself;  $a_i$  is the parameter characteristics in the observation data; and  $b_i$  the parameter characteristics in the data to be tested [12, 13].

The feasible and optimal solutions in equation (7) are adopted to realize the nonlinear substitution of the model and solve the large difference between the optimal value and the dual model. At the same time, the solution of the above two function values can also verify the accuracy of subsequent data and make the configuration of performance target functions more standardized.

**2.3. Set the Feasible Domain of the Performance Optimization Model.** After obtaining the standardized objective function, the configuration performance optimization parameters of community sports facilities with nonnegative characteristics are set by estimating the linear planning model parameters [14]. First assuming that each performance parameter has a matrix capable of pointing to all parameters so that it can contain all objective functions, designing parallel estimation models of linear planning parameters requires to build the aggregation function and build the community sports facility configuration performance optimization model as follows:

$$\Psi_t = \max_{\mu_{xi=1}}^N \left( \sum_{i=1}^N \sqrt{\frac{\overline{a_i r_h}}{b_i}} \right). \quad (8)$$

where  $\Psi_t$  is the median value of the aggregation function,  $\mu_x$  is the construction element properties of the matrix in this paper and  $r_h$  is the singular value in the function. Among them, if you want to get the results of performance optimization quickly, you can deal with the feasible and infeasible solutions of the function by delimiting the feasible domain of the performance optimization model [15], and the specific delimitation process is shown in Figure 2.

As can be seen from Figure 2, when the optimal solution is obtained in the function model, many branches of non-optimal solutions appear [16, 17], and these nonoptimal solutions will reduce the computational speed of the algorithmic model and pull down the performance of the whole model [18]. Therefore, the upper and lower bounds of the optimal solutions in the model can be distinguished by setting the feasible domain.

$$\begin{cases} H_t: \max x_i = x_a y_b, \\ H_t: \min x_i = x_b y_a, \end{cases} \quad (9)$$

where  $H_t$  represents the community sports facility configuration performance optimization model,  $x_i$  represents the

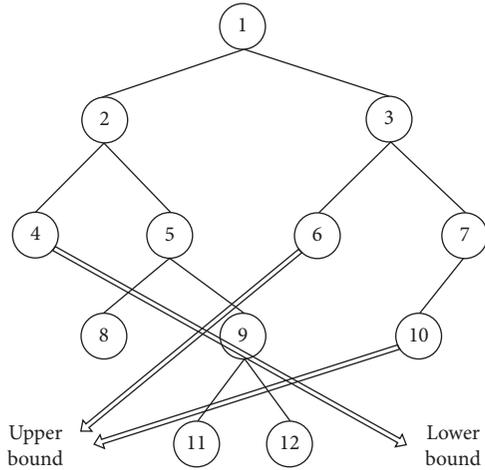


FIGURE 2: Brief plot of binary bounds.

optimal solution in the model,  $x_a$  represents the order of the upper boundary in the binary tree,  $x_b$  is the lower boundary in the binary tree;  $y_b$  the order of the upper boundary in the binary tree,  $y_a$  is the lower boundary in the binary tree [19, 20].

The upper and lower bounds of the function model can be determined by the binary tree delimitation above, but it is also necessary to delimit the feasible domain according to Figure 3.

In the process of delimiting feasible domains, a large number of inequality constraints should be added as a spatial solution set to reduce unnecessary nonoptimal solutions, so as to greatly reduce the solution time, narrow the target range of the optimal solution, and reduce the iterative nodes of the optimized solution in the functional model. Thus, the simplified evaluation of the optimal solution is applied to practice.

*2.4. Design the Performance Optimization Algorithm for Community Sports Facilities Configuration.* By setting the target function above, the optimized community sports facility configuration performance function model is obtained, and then the binary tree is constructed in the performance optimization model, which separates the upper and lower bounds of the optimal solution in the model. The upper and lower bounds of the optimal solution can delimit the feasible domains of the functional model [21, 22], Thus to obtain a more efficient performance optimization algorithm, the algorithm implementation process is shown in Figure 4.

In the performance optimization algorithm shown in Figure 4, to simplify the algorithm structure, it needs to maintain the maximum output while traversal the nodes in the binary tree. Almost all traversal methods at this stage start from the far right, but in this paper, the direction of the traversal can be set manually, by solving the optimal solution. If the optimal solution is near the right end, it can be solved from the right, but if the optimal solution is near the left end, then starting from the left end.

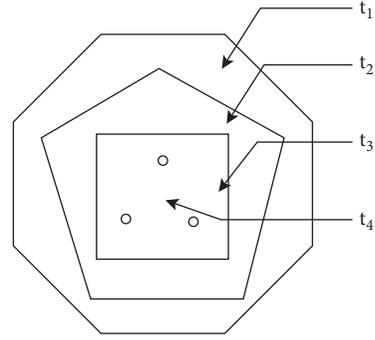


FIGURE 3: A functional model for feasible domain delineation.

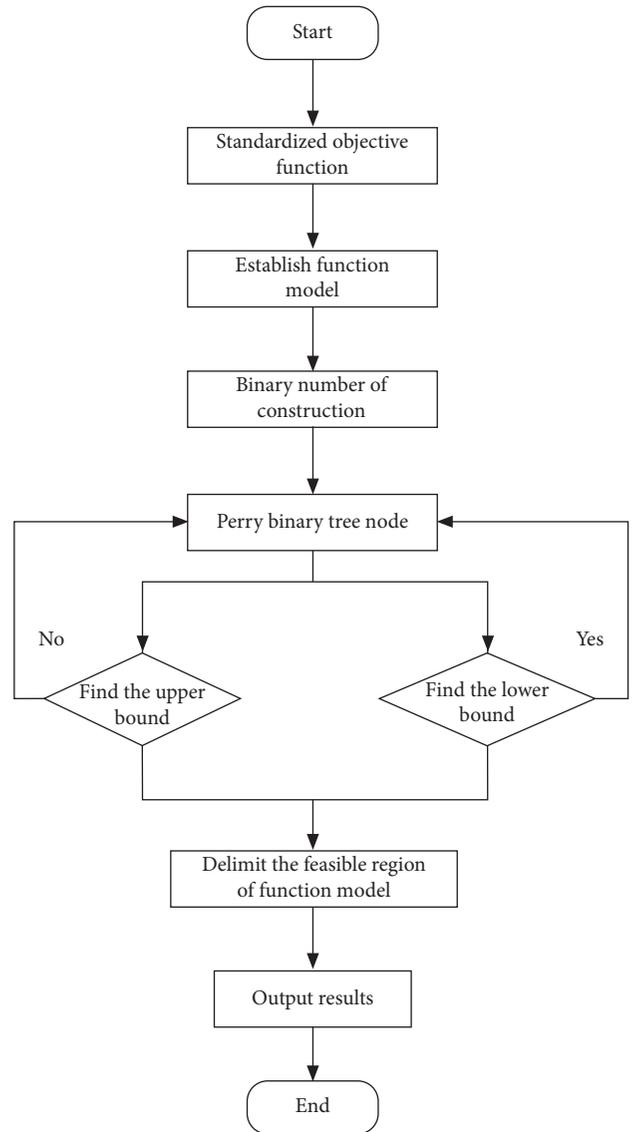


FIGURE 4: Design of the performance optimization algorithm.

### 3. Experimental Study

*3.1. Preparation.* A performance optimization method of community sports facilities configuration based on a linear planning model was designed above, which was tested by

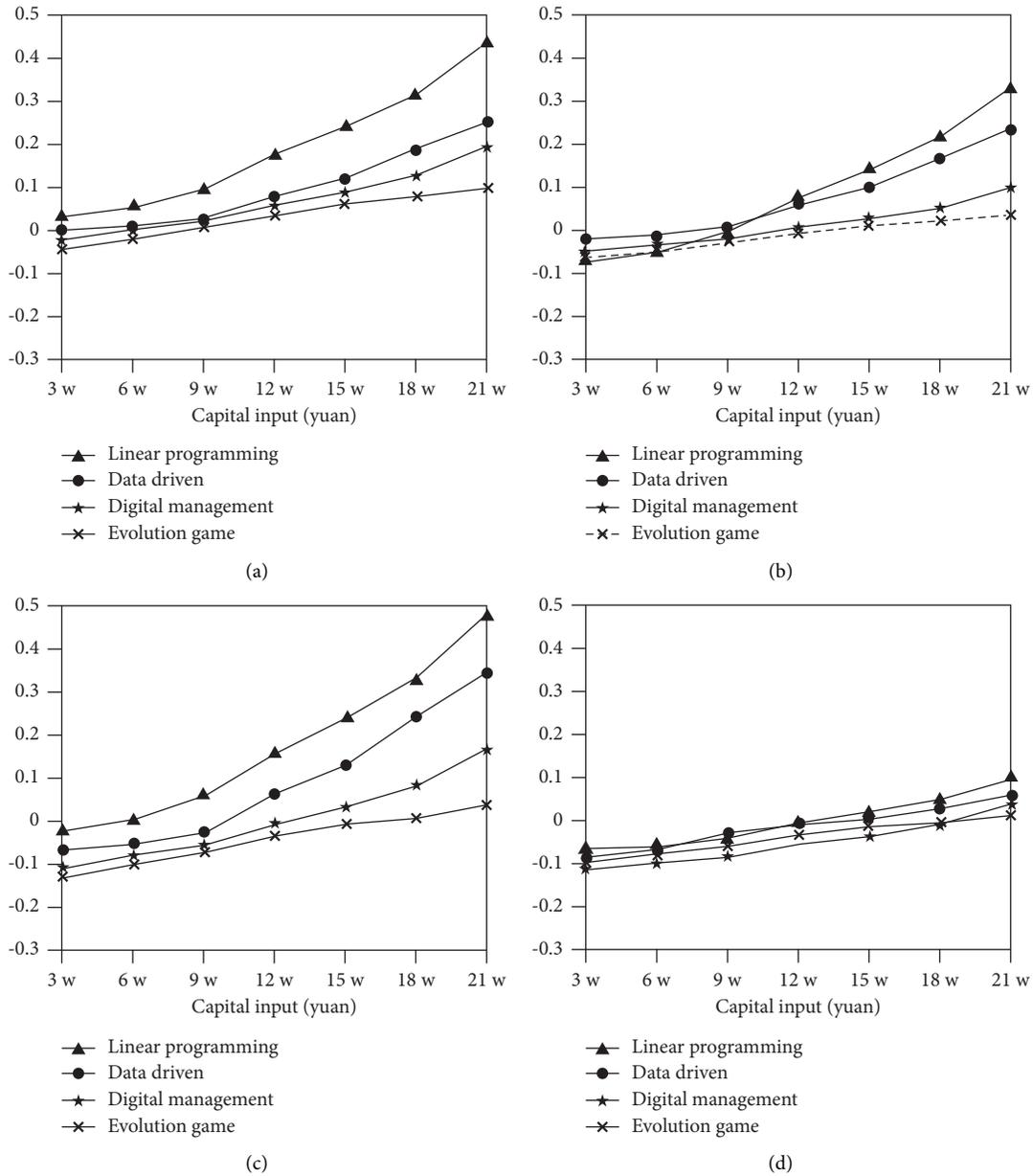


FIGURE 5: Model optimization effect test. Note: won the horizontal axis means 10000 yuan. (a) The community sports facilities configuration for spring performance. (b) Provide community sports facilities for summer performance. (c) Autumn performance of community sports facilities configuration. (d) The sports facilities in the community configure winter performance.

TABLE 1: The performance optimization coefficient is zero capital investment comparison.

Season	Linear planning model	Data driven mechanism	Digital urban management	Evolution game algorithm
Spring	0 ¥-30,000 ¥	0 ¥-30,000 ¥	30,000 ¥-60,000 ¥	60000 ¥-90000 ¥
Summer	60000¥-90000 ¥	\$90000-\$120000	90000 ¥-120000 ¥	120,000 ¥-150,000 ¥
Autumn	0 ¥-30,000 ¥	0¥-30,000 ¥	30,000 ¥-60,000 ¥	60000 ¥-90000 ¥
Winter	120,000 ¥-150,000 ¥	120,000¥-150,000 ¥	180,000 ¥-210,000 ¥	180,000 ¥-210,000 ¥

data envelope analysis to test for performance optimization. Compared with the data-driven method [2], digital management method [4] and evolution game algorithm mentioned in the introduction [5], the comparison results described below were obtained.

In the experiment, the data selected the investment and results achieved in a community sports facilities from 2010 to 2015. Generally speaking, the more money invested in community sports facilities, the better the effect can be achieved. Therefore, this experiment takes capital

investment as a different independent variable, and increases the number of users after the improved allocation of community sports facilities as the test standard. Establish the solution model of linear planning:

$$\left\{ \begin{array}{l} \min e_{\lambda}(x) = \mu_x - \delta_{n*m} \left( \sum_{i=1}^n a^{-} + \sum_{j=1}^m a^{+} \right), \\ \text{s.t.}, \\ \sum_{i=1}^n p_i q_i + a^{-} = \delta_{n*m} p_i, \\ \sum_{i=1}^n p_i q_i - a^{+} = q_i, \\ a^{+} \geq 0, a^{-} \geq 0, \end{array} \right. \quad (10)$$

where  $e_{\lambda}(x)$  is the optimization effect of the community sports facility configuration planned through the above model,  $\mu_x$  is the overall performance effect index of the frequency,  $\delta_{n*m}$  is the minimum,  $a^{-}$  and  $a^{+}$  are the input and output matrix constants after the independent variable change respectively;  $p_i$  is the  $i_{th}$  input vector in the decision unit, and  $q_i$  is the  $i_{th}$  result display vector in the result unit. If the four performance optimization methods tested in this experiment can improve the use effect, then the value  $e_{\lambda}(x)$  will be greater than 0, otherwise it will be less than 0, and the higher the value  $e_{\lambda}(x)$ , the better the performance optimization effect. The characteristic parameters in the experiment were calculated by equation (10) and then brought into the input of public service funds of 30,000, 60,000, 90,000, 120,000, 150,000, and 180,000, respectively, and the experimental results were calculated by mathematical model. The value of  $\mu_x$  varies from 0 to 0.850, and the values of  $\delta_{n*m}$ ,  $a^{-}$ ,  $a^{+}$ ,  $p_i$ ,  $q_i$  and  $n$  are 0.002, 0.845, 0.108, 0.272, 0.890, and 10, respectively.

**3.2. Model Optimization Effect Test.** Comparing the performance optimization method based on linear programming model designed in the paper, as well as the performance optimization method based on data-driven mechanism, evolutionary game algorithm, we examine the growth of the frequency of sports facility use in this community in each of the four seasons after the configuration optimization, and calculate the experimental results by Matlab and plot them as the image shown in Figure 5.

As shown in Figure 4, with the increase of public service funds, the performance optimization effect of the model optimizing the allocation of community sports facilities is also constantly improving. Of the four seasons, overall performance optimization was better in spring and autumn, followed in summer and the worst in winter. As shown in equation (10), when  $\mu_x$  is greater than 0, the performance optimization method improves the use frequency of community sports facilities, and optimizes the configuration performance in the field of mathematical models. Therefore, the number of capital input when the performance optimization effect  $\mu_x$  is equal to 0 is shown in Table 1 and judges the performance optimization effect of the above four models.

As shown in Table 1, the performance optimization method based on the linear planning model requires less than 30,000 yuan than 0,60,000–90,000 yuan in winter; the data-driven mechanism is similar to the design method, but the expenditure in summer is slightly higher than the linear planning model. The performance optimization model based on digital urban management needs 30,000–60,000 yuan in spring and autumn to significantly improve the use performance. It needs 90,000–120,000 yuan in summer, and 180,000–210,000 yuan in winter, and such data is significantly greater than the linear planning model method. The final evolutionary game algorithm requires 60,000–90,000 yuan in spring and autumn, 120,000–150,000 yuan in summer, and 180,000–210,000 yuan in winter, with the largest investment in the four performance optimization methods. To sum up, in the test of this paper, when the performance of community sports facilities configuration has a certain optimization effect, the performance optimization method of community sports facilities configuration based on linear planning model costs less. Through the comparison of capital investment in four seasons of a year, this method has the lowest cost of the four optimization methods.

## 4. Conclusion

This paper establishes a new performance optimization model for community sports facility configuration based on a linear programming model, which simplifies the algorithm structure, improves the effect of model optimization, and reduces the capital investment required to achieve performance optimization by delineating the feasible domain of the function. The experimental data showed that the residents mostly used the community sports facilities in spring and autumn, and the frequency of using the sports facilities increased in spring and autumn after the optimization of the facility configuration. Relatively speaking, the performance optimization of community sports facilities in winter was not satisfactory regardless of the amount of investment. Therefore, improving the performance of community sports facility configurations in summer and winter to achieve an overall performance improvement can be considered in the further study. Moreover, although comparing the proposed model with data-driven mechanisms, digital city management, and evolutionary game algorithms, the proposed model is found to be more effective. Additionally, it may also be affected by biases resulting from the sample and still needs to be tested for subsequent studies.

## Data Availability

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Authors' Contributions

Pu Sun provided research direction, Xuefeng Tan, Chenggen Guo, and Shaojie Zhang collected data, Xuefeng Tan, Chenggen Guo, and Shaojie Zhang wrote the article, Pu Sun provided funding, Xuefeng Tan, Chenggen Guo, and Shaojie Zhang took part in data calculation, Pu Sun corrected the article.

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