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EVALUATION OF THE EQUITY OF SCHOOL SPORTS RESOURCE ALLOCATION AND OPTIMIZATION SIMULATIO

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Abstract: This study focuses on the equity of school sports resource allocation and develops an analytical framework integrating evaluation, problem identification, and optimization simulation to examine the current conditions, major problems, and possible improvement pathways of school sports resource allocation. First, based on the core components of school sports resources, an equity evaluation system is constructed from multiple dimensions, including physical education teachers, sports facilities, equipment, financial support, and opportunities for sports participation, in order to assess the overall level and disparity characteristics of school sports resource allocation. Second, drawing on the evaluation results, the study identifies the major problems embedded in current allocation practices, showing that the existing system is characterized not only by inter-school and inter-regional disparities, but also by structural imbalance and the accumulation of shortages across multiple dimensions. Finally, by establishing different allocation scenarios, the study conducts a comparative simulation of optimization effects under alternative resource allocation strategies. The results indicate that although school sports resource allocation has reached a certain developmental baseline, there remains substantial room for improvement in balanced development. Simply maintaining the current allocation logic is insufficient to significantly reduce disparities. Compensatory allocation can effectively improve resource shortages in disadvantaged schools, whereas a coordinated optimization strategy that integrates equity and efficiency performs better in narrowing allocation gaps, improving overall performance, and promoting structural coordination. This study provides both theoretical reference and practical implications for the scientific allocation of school sports resources and for informed decision-making in educational governance.
Keywords: School sports resources; Resource allocation; Equity evaluation; Optimization simulation; Educational equity

1 INTRODUCTION

Against the backdrop of high-quality educational development and the ongoing implementation of the Healthy China initiative, school sports has received increasing attention as a vital component of promoting students' physical and mental well-being, enhancing holistic development, and fulfilling the fundamental task of fostering virtue through education[1-2]. School sports resources constitute the material and institutional foundation for physical education classes, extracurricular exercise, and campus sports activities[3-4]. Their level of allocation directly shapes the quality of school sports development and students' access to participation opportunities. However, due to differences in regional economic conditions, fiscal capacity, school operating conditions, and resource allocation mechanisms, disparities in sports resource allocation persist across regions, between urban and rural areas, and among schools. Such disparities not only undermine the equity of school sports public services, but also constrain the overall effectiveness of school sports in practice. Accordingly, a systematic evaluation of the equity of school sports resource allocation, together with an exploration of feasible optimization pathways, has become an important issue in both school sports research and educational governance.

Existing studies have generated valuable insights into educational resource equity, disparities in school sports development, and the equalization of public services, thereby providing an important foundation for the present study[5-6]. On the one hand, prior research has examined school sports resources from multiple dimensions, including teachers, funding, facilities, and opportunities for participation, and has revealed structural differences across regions and school types[7]. On the other hand, some studies have introduced quantitative approaches to assess the fairness and balance of resource allocation. Nevertheless, several limitations remain. First, the evaluation dimensions of school sports resources have not yet been fully unified, and a more comprehensive analytical framework is still needed. Second, much of the existing literature focuses primarily on static descriptions of disparities, with insufficient attention to the internal structure and underlying causes of resource imbalance. Third, relatively few studies integrate equity assessment with optimization simulation to generate policy-relevant and operational allocation strategies. Therefore, it is necessary to develop a more coherent framework that combines evaluation with practical application.

In response, this study takes school sports resource allocation as its research focus and is organized around the analytical logic of evaluation, diagnosis, and optimization. First, based on the core components of school sports resources, this paper develops an evaluation framework for allocation equity and examines the overall level and disparity characteristics of school sports resource distribution. Second, drawing on the evaluation results, it identifies the major problems in current resource allocation and highlights the most prominent manifestations and key

determinants of imbalance. Finally, through optimization simulation under different allocation scenarios, the study compares potential improvement effects and explores a feasible pathway that better balances equity and efficiency. This study aims to provide both a theoretical reference and practical evidence for the scientific allocation of school sports resources and for informed decision-making in educational governance.

2 EVALUATION OF SCHOOL SPORTS RESOURCE ALLOCATION EQUITY

2.1 Data Sources and Indicator Selection

This study focuses on the allocation of school sports resources. The relevant data are mainly drawn from educational statistical materials, annual school reports, publicly available data released by local education authorities, and survey materials on school sports resources. To ensure the comparability and representativeness of the analysis, this study selects indicators with strong data availability and explanatory value to evaluate the status of school sports resource allocation. Given the multidimensional nature of school sports resources, the indicator selection not only considers the total amount of resources, but also takes into account resource structure and the conditions for effective use, so as to more comprehensively reflect the actual disparities in sports resource allocation across schools and regions.

More specifically, the indicator system is constructed around several core dimensions, including physical education teachers, sports facilities, equipment, financial support, and opportunities for sports participation. These indicators capture the basic components of school sports resources and provide a sound basis for assessing both the actual level and the equity of resource allocation. To improve the scientific rigor of the evaluation, the original data were subject to necessary cleaning and standardization procedures. On this basis, an evaluation framework for the equity of school sports resource allocation was established to support the subsequent analyses of disparity identification, problem diagnosis, and optimization simulation.

2.2 Evaluation Framework for the Equity of School Sports Resource Allocation

A scientific assessment of the equity of school sports resource allocation is the prerequisite for identifying resource disparities, diagnosing allocation problems, and developing optimization strategies[8]. School sports resources should not be understood as a single form of input; rather, they constitute a multidimensional system composed of teaching staff, sports facilities, equipment, financial support, and opportunities for sports participation. Accordingly, the evaluation of allocation equity should go beyond a simple comparison of resource quantity and instead consider multiple dimensions, including resource structure, allocation level, and distributional disparity. Based on the practical needs of school sports development, this study categorizes school sports resources into several core dimensions and develops an evaluation framework to capture the actual conditions of sports resource allocation across schools or regions in a comprehensive manner.

More specifically, the present evaluation focuses on two aspects. The first is the overall level of school sports resource allocation, which reflects the extent to which schools or regions possess and provide sports-related resources. The second is the degree of allocation equity, which concerns whether substantial disparities exist in the distribution of such resources across different schools and regions. The former is intended to capture the quantity and quality of resource provision, whereas the latter emphasizes the fairness and coordination of resource distribution. Following this logic, this study constructs an indicator system covering physical education teachers, sports facilities, equipment, and financial support, and conducts a comprehensive evaluation of school sports resource allocation based on standardized indicator values. This provides the analytical foundation for the subsequent identification of major problems and the optimization simulation.

2.3 Evaluation Results of School Sports Resource Allocation Equity

The overall evaluation results suggest that school sports resource allocation has reached a certain developmental baseline, yet clear disparities remain across different resource dimensions. In relative terms, some schools have already secured the basic conditions necessary for physical education, while still facing notable deficiencies in high-quality facilities, dedicated financial investment, and access to well-qualified teaching staff. This indicates that the problem of school sports resource allocation is not merely one of insufficient total input; more importantly, it is characterized by an imbalanced internal structure and weak coordination among different categories of resources.

From the perspective of equity, disparities in school sports resource allocation remain evident across schools and regions. Schools with relatively abundant resources tend to hold simultaneous advantages in staffing, facilities, and funding, whereas schools in weaker positions often experience shortages across multiple dimensions, resulting in a cumulative pattern of disadvantage. At the same time, the degree of equity varies across resource types, and those more strongly shaped by fiscal capacity and locational conditions tend to exhibit more pronounced disparities. Overall, although school sports resource allocation has established a basic foundation, there remains considerable room for improvement in terms of balanced development. This also provides a practical basis for identifying the major problems of resource imbalance and for conducting optimization simulation in the following sections.

3 MAIN PROBLEMS OF SCHOOL SPORTS RESOURCE ALLOCATION

3.1 Main Manifestations of Imbalance in School Sports Resource Allocation

The most prominent problem in school sports resource allocation lies in the uneven distribution of resources. This imbalance is reflected not only in differences in resource possession across schools, but also in the lack of coordination among different categories of resources. From a cross-school perspective, some schools enjoy clear advantages in physical education teachers, sports facilities, and financial investment, allowing them to provide more comprehensive support for physical education and sports activities. By contrast, other schools face shortages across multiple dimensions at the same time, which constrains the quality of physical education and limits students' opportunities for participation. This suggests that disparities in school sports resource allocation are not confined to any single resource category, but instead exhibit a multidimensional and cumulative pattern of imbalance.

At the same time, another key problem is the irrational structure of resource allocation. Some schools may have accumulated a certain level of hardware resources, yet still remain weak in teaching staff, equipment renewal, and funding support, making it difficult to form a coordinated and mutually reinforcing resource system. In contrast, schools with better resource endowments are often able to improve hardware, staffing, and participation opportunities simultaneously, thereby further widening the gap between themselves and resource-constrained schools. It can therefore be seen that the main problem in current school sports resource allocation is not simply the insufficiency of total resources, but more fundamentally the hierarchical disparity in distribution and the imbalance in internal structure. These issues have become key constraints on the balanced development of school sports.

3.2 Major Causes of the Problems in School Sports Resource Allocation

The imbalance in school sports resource allocation is shaped not only by differences in external development conditions, but also by the limitations of the existing allocation mechanism itself. First, disparities in regional economic development and fiscal capacity are major external factors influencing school sports resource distribution. Regions with stronger economic foundations and greater fiscal support are generally more capable of providing schools with adequate facilities, equipment, and staffing, whereas less-developed areas are more likely to face resource constraints and insufficient foundations for school sports development. Second, variations in school size, locational conditions, and historical accumulation further reinforce allocation inequality. Schools with pre-existing advantages are often in a better position to attract qualified teachers, secure project support, and obtain financial preference, thereby generating a cumulative concentration of resources.

In addition, shortcomings in the precision and coordination of current allocation practices also contribute substantially to the problem. In practice, some forms of resource investment emphasize aggregate growth while paying insufficient attention to the actual needs, specific weaknesses, and developmental conditions of different schools, making it difficult for resource distribution to effectively address the core problems faced by disadvantaged schools. At the same time, school sports resource allocation tends to prioritize visible inputs such as venues and facilities, while giving relatively limited attention to teacher development, participation opportunities, and the long-term efficiency of resource utilization. This in turn leads to structural imbalance within the resource system. Overall, the combined effects of external disparities and internal allocation deficiencies constitute the main causes of the current problems in school sports resource allocation, and they also point directly to the need for the optimization simulation discussed in the next section.

4 OPTIMIZATION SIMULATION OF SCHOOL SPORTS RESOURCE ALLOCATION

4.1 Scenario Design for the Optimization Simulation of School Sports Resource Allocation

To identify a more effective pathway for improving school sports resource allocation, this study constructs three simulation scenarios based on the preceding equity evaluation and problem diagnosis. These scenarios are designed to examine how different allocation strategies affect the equity and overall performance of school sports resources. The baseline scenario follows the existing allocation logic and reflects the continuation of the current distribution pattern. The compensatory scenario gives priority to resource-constrained schools, with the aim of narrowing inter-school disparities and improving the minimum level of provision in disadvantaged schools. The coordinated optimization scenario, by contrast, not only prioritizes schools with evident shortages but also incorporates resource utilization efficiency and coverage, seeking a more balanced outcome between equity and efficiency.

Table 1 presents the overall results under the three simulation scenarios. Under the baseline scenario, the equity index remains low at 0.61, while the Gini coefficient reaches 0.31, indicating a substantial degree of inequality in the current allocation pattern. The compensatory scenario leads to a marked improvement in the equity index and a clear decline in the Gini coefficient, suggesting that targeted support can effectively alleviate allocation imbalance. In comparison, the coordinated optimization scenario performs best across the equity index, efficiency index, and overall performance, while further reducing the Gini coefficient to 0.18. This result indicates that the coordinated approach has a stronger comprehensive optimization effect.

Table 1 Overall Results of School Sports Resource Allocation Under Different Simulation Scenarios

Scenario	Equity Index	Efficiency Index	Overall Performance	Gini Coefficient
Baseline	0.61	0.72	0.66	0.31

Scenario	Equity Index	Efficiency Index	Overall Performance	Gini Coefficient
Compensatory	0.74	0.68	0.71	0.22
Coordinated Optimization	0.81	0.79	0.80	0.18

Figure 1 further compares the overall optimization performance across the three scenarios. The baseline scenario shows the lowest overall score, indicating that if the current allocation path is simply maintained, the potential for improving balanced development in school sports resources remains limited. The compensatory scenario improves overall performance, yet its effect is still weaker than that of the coordinated optimization scenario. The coordinated optimization scenario achieves the highest overall score, suggesting that although compensation-oriented intervention can enhance equity, a more stable and sustainable improvement in allocation outcomes requires the integration of equity and efficiency considerations.

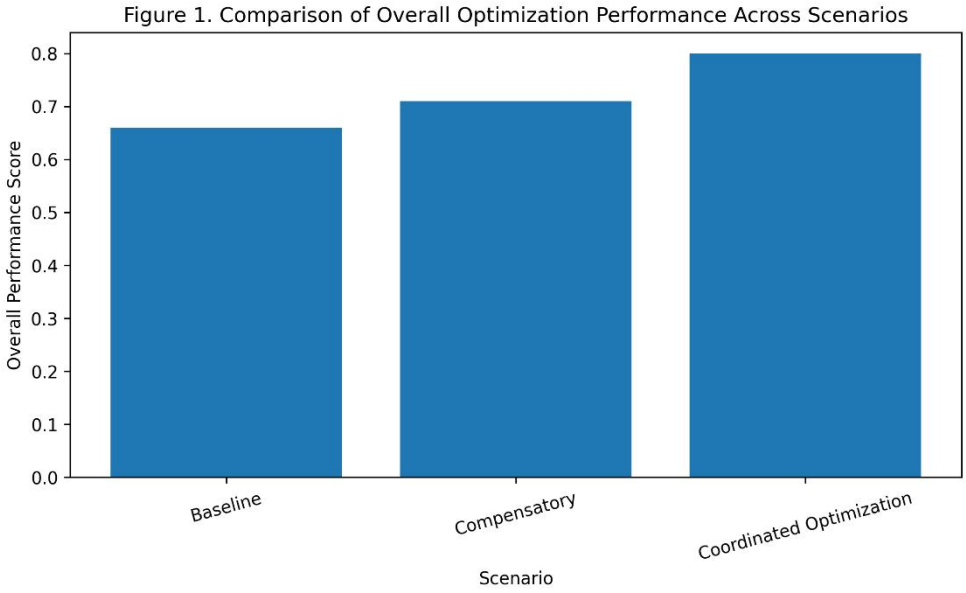

Figure 1 Comparison of Overall Optimization Performance Across Scenarios

4.2 Comparison of Simulation Results and Analysis of the Optimization Path

From the perspective of disparity reduction, Figure 2 shows the changes in the Gini coefficient across the three scenarios. The baseline scenario records the highest Gini coefficient, indicating that the existing allocation path largely reproduces the original structure of inequality and is unable to fundamentally reverse the uneven distribution of resources. The compensatory scenario reduces the Gini coefficient from 0.31 to 0.22, demonstrating that preferential support for disadvantaged schools can significantly compress inter-school disparities. More importantly, the coordinated optimization scenario lowers the Gini coefficient further to 0.18, indicating the strongest effect in reducing inequality. This finding suggests that equity and efficiency are not necessarily in opposition; rather, they can be jointly improved through a more rational allocation mechanism.

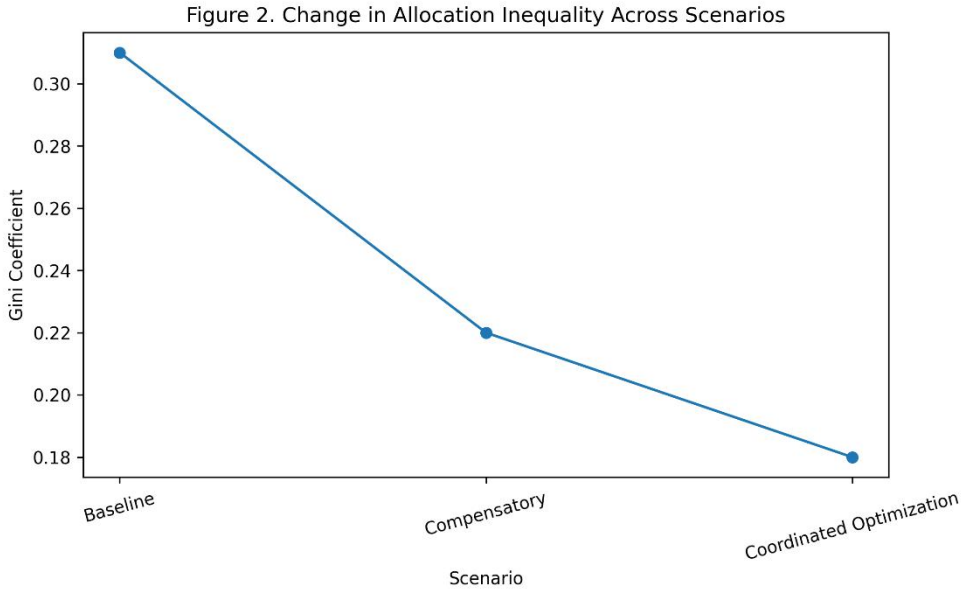

Figure 2 Change in Allocation Inequality Across Scenarios

To further assess improvement across resource dimensions, Table 2 and Figure 3 present the equity scores for five dimensions under the three scenarios: teachers, facilities, equipment, funding, and participation opportunities. As shown in Table 2, the baseline scenario produces relatively low scores across all dimensions, with funding and facilities performing particularly poorly. This indicates that these categories are more strongly constrained by local fiscal conditions and school capacity. The compensatory scenario improves all dimensions, especially funding, equipment, and facilities, suggesting that targeted investment can effectively address visible shortages in the short term. However, the coordinated optimization scenario not only achieves the highest scores across all five dimensions, but also demonstrates a stronger improvement effect in participation opportunities and staffing, implying that it is more conducive to structural coordination within the resource system.

Table 2 Equity Scores by Resource Dimension Under Different Simulation Scenarios

Dimension	Baseline	Compensatory	Coordinated Optimization
Teachers	0.64	0.73	0.80
Facilities	0.58	0.70	0.82
Equipment	0.60	0.72	0.79
Funding	0.55	0.69	0.78
Participation Opportunities	0.59	0.71	0.83

Figure 3 provides a more intuitive illustration of these differences. The coordinated optimization scenario maintains a consistently higher level of equity across all five dimensions, with particularly strong performance in facilities and participation opportunities. This result indicates that improving school sports resource allocation cannot rely solely on expanding one category of input. Instead, it requires a systematic strategy that advances hardware, staffing, funding, and opportunities for participation in a coordinated manner. If attention is given only to facilities while neglecting teachers and activity provision, structural problems may emerge, such as underutilized venues or insufficiently supported equipment. In contrast, the coordinated optimization scenario better reflects the systemic nature of school sports resource allocation and is more consistent with the practical goals of educational equity and high-quality development.

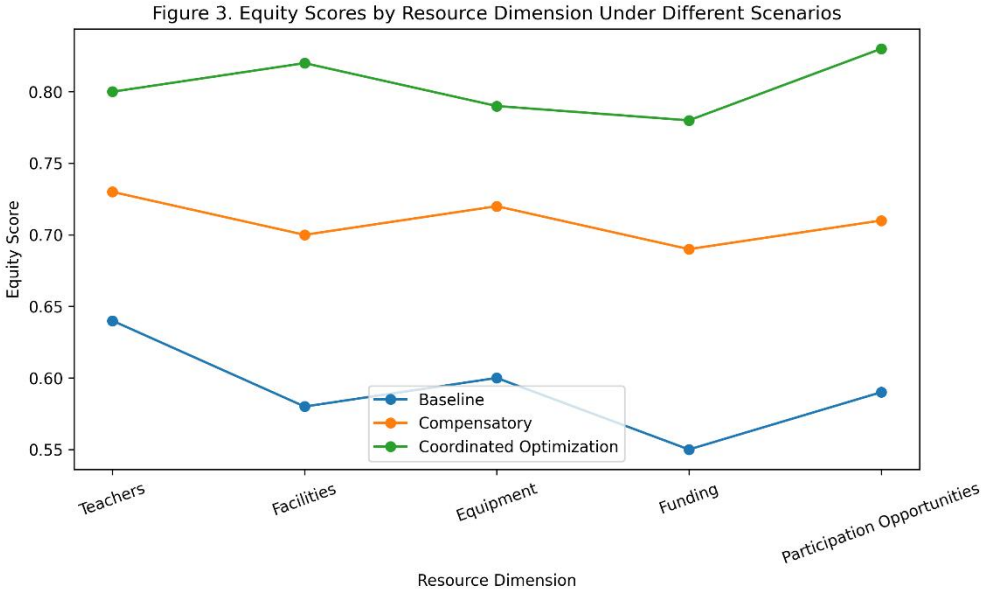

Figure 3 Equity Scores by Resource Dimension Under Different Scenarios

Taken together, these results show that optimizing school sports resource allocation does not mean simply distributing resources evenly. Rather, it requires differentiated intervention based on schools' resource foundations, major shortages, and actual needs. The baseline scenario preserves continuity but fails to effectively address existing disparities. The compensatory scenario can rapidly improve resource shortages in disadvantaged schools, but it shows certain limitations in overall efficiency. The coordinated optimization scenario, by contrast, achieves a better balance among equity enhancement, disparity reduction, and overall performance improvement. Therefore, future school sports resource allocation should place greater emphasis on combining targeted compensation with structural coordination. On the basis of guaranteeing basic conditions for resource-constrained schools, policymakers should promote coordinated improvements in teachers, facilities, funding, and participation opportunities, thereby gradually establishing a fairer, more efficient, and more sustainable allocation pattern.

5 CONCLUSION

This study examined the equity of school sports resource allocation through an analytical framework centered on evaluation, problem identification, and optimization simulation. It systematically explored the current conditions, major problems, and possible improvement pathways of school sports resource allocation. The findings show that although school sports resource provision has reached a certain developmental baseline, substantial disparities remain across schools and regions. These disparities are reflected not only in the total amount of resources, but more importantly in structural imbalance and the accumulation of shortages across multiple resource dimensions. Compared with better-resourced schools, disadvantaged schools tend to be in an unfavorable position simultaneously in terms of staffing, facilities, funding, and opportunities for participation, which constrains the balanced development of school sports and the realization of educational equity.

Further analysis suggests that the problems in school sports resource allocation are shaped not only by differences in regional economic development, fiscal capacity, and school conditions, but also by the limitations of current allocation mechanisms in terms of precision, coordination, and sustainability. Existing allocation practices tend to reproduce the original distribution pattern and therefore struggle to respond effectively to the core needs of resource-constrained schools. The scenario-based simulation further demonstrates that different optimization strategies produce markedly different effects. Simply maintaining the current allocation logic does not significantly reduce disparities, while compensatory allocation can improve resource shortages more quickly but still shows certain limitations in overall efficiency. By contrast, the coordinated optimization scenario, which integrates both equity and efficiency considerations, performs more effectively in reducing allocation gaps, improving overall performance, and promoting structural coordination.

Based on these findings, this study argues that future school sports resource allocation should place greater emphasis on combining targeted compensation with structural optimization. On the basis of ensuring basic provision for resource-constrained schools, policymakers should promote coordinated improvements in teachers, facilities, funding, and opportunities for sports participation. At the same time, greater efforts should be made to establish a dynamic monitoring system and a differentiated allocation mechanism so as to improve the precision and sustainability of resource investment. Overall, this study not only provides an analytical perspective for understanding imbalance in school sports resource allocation, but also offers theoretical reference and practical implications for policy improvement and educational governance.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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