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The satisfaction of ecological environment in sports public services by artificial intelligence and big data

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In order to gain a more accurate understanding and enhance the relationship between the fitness ecological environment and artificial intelligence (AI)-driven sports public services, this study combines a Convolutional Neural Network (CNN) approach based on residual modules and attention mechanisms with the SERVQUAL evaluation model. The method employed involves the analysis of big data collected from questionnaire surveys, literature reviews, and interviews. This study critically examines the impact of advanced AI technologies on residents' satisfaction with the fitness ecological environment in sports public services and conducts theoretical analysis of the obtained data. The results show that the quality of sports public services empowered by AI significantly influences residents' satisfaction with the fitness ecological environment, such as running, swimming, ball games and other sports with high requirements for sports service quality and ecological environment. Only the good public sports service quality matching with them can meet the needs of the ecological environment for fitness, and stimulate the enthusiasm of the people for fitness. The study also shows that swimming, running and all kinds of ball games account for the largest proportion of all sports. To sum up, the satisfaction of residents' fitness ecological environment is greatly affected by the quality of public sports services, which is mainly reflected in the good and perfect sports environment and facilities that can provide residents with a wealth of fitness options, greatly improving the sports ecological environment. This study is helpful to realize the relationship between sports public service and sports ecological environment. It contributes to understanding the role of AI and deep learning in enhancing the correlation between sports public service and the ecological environment of sports.

Keywords Ecological environment, Sports, Service, Satisfaction, Enthusiasm, Deep learning, Artificial intelligence, Big data

With the development of society and economy, public service has been greatly developed and improved[1]. The improvement and development of public service is a symbol of social progress and the government's service to the people[2]. There is a close relationship between public services and the improvement of social economy. The improvement of economy is the foundation of the improvement of public service, and the improvement of public service will also promote the development and progress of economy[3]. The scope of public services is very large. Among them, the very important public sports service system has also been rapid development and progress. However, as far as the actual situation in China is concerned[4], public sports services cannot be fully developed to every corner to meet the needs of every region[5]. Generally speaking, the level of public sports service in China is still in a relatively basic stage and level[6], so it is very important to arrange and plan sports resources reasonably and efficiently. Due to the large population and shortage of resources, it is necessary to arrange the public resources reasonably[7]. From the analysis of the actual situation of China's national conditions, public sports can improve people's health, strengthen socialist civilization, improve national cohesion, and strengthen national and international influence and other aspects[8]. In the modern digital age, the rapid development of artificial intelligence (AI) technologies, such as deep learning (DL), along with big data analytics, has brought unprecedented opportunities and challenges to various industries. As an integral component of societal health and well-being, the quality of sports public service profoundly impacts residents' satisfaction with the ecological environment of fitness. With the ongoing proliferation of big data and AI, utilizing these advanced technologies

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to enhance sports public service and consequently improve residents' fitness experiences has become a crucial topic requiring in-depth exploration[9].

It is necessary to study the satisfaction of sports public service. Research on satisfaction can clearly grasp the current level of urban public sports[10], and then make reasonable arrangements to improve the level of public sports service in China. With the gradual structural improvement of Chinese society, the role of a city's public sports service is becoming more and more important. To solve the problem of public service[11], it is very important and necessary to realize the satisfaction of the people, and it plays a very important role in building a socialist harmonious society. The change and improvement of a good public sports environment is of great significance and value to the improvement of the ecological environment[12]. Therefore, public sports services have a very important impact on the development of the ecological environment for people's fitness.

To sum up, there is a close relationship between the satisfaction of residents' fitness ecological environment and the quality of public sports services, mainly reflected in the rich and comprehensive public sports environment and facilities that can provide residents' fitness needs, greatly improving the ecological environment of sports. The study motivation is to gain a deeper understanding of how these advanced technologies facilitate innovation in sports public service and their positive impacts on residents' satisfaction with the fitness ecological environment. The aim is to provide robust theoretical support for the future development of community sports services. This study seeks to explore how DL-based big data and AI function in sports public service and the specific mechanisms through which they positively influence residents' satisfaction with the fitness ecological environment. Through a comprehensive analysis of existing research and practices, this study aims to establish a comprehensive framework, revealing how these advanced technologies optimize sports services and enhance residents' satisfaction with the fitness environment.

This study has the following research significance:

(1) Theoretical significance: At present, governments and people all over the world have important planning and research on public sports service, and each country has different understanding and planning on public sports services. Combined with the existing research, almost all of the research focuses on the internal operation method and supply level of public sports services, and there is almost no research on public satisfaction with public sports services. Therefore, in this study, SERVQUAL model is used to study the public demand for public sports.
(2) Practical significance: Public sports service includes two levels of meaning. On the one hand, it has both service components and sports colors. Therefore, it is a combination of service and sports. It is of great significance and value for the national policy research and project planning to conduct in-depth and thorough research on public sports services. Therefore, the research based on public sports service is inevitable, which can provide reference for the overall development and design of the country.

Literature review

The application of DL-based big data and AI in sports public service and its impact on residents' satisfaction with the fitness ecological environment has garnered widespread attention in the academic community. In the research on the application of AI technologies such as DL in sports public services, Tanisawa et al. (2020) explored the application of big data analytics in recognizing patterns of fitness behavior[13]. Through DL analysis of residents' fitness data, they revealed the significant potential of AI in identifying individual exercise habits and needs, laying the foundation for personalized sports services. Yang et al. (2022) developed an evaluation model for public sports services based on fuzzy integrals and convolutional neural network (CNN). The results showed that this model outperformed both the unoptimized model and the noise-integrated model in terms of evaluation accuracy and runtime[14]. Teng et al. (2024) assessed and managed the risks in the sports service supply chain using fuzzy comprehensive evaluation and AI technologies. They proposed that government service capacity had the highest weight in the sports service supply chain, providing guidance for adjustments in management strategies and enhancing market competitiveness[15].

In terms of residents' satisfaction with public sports services, Venkatachalam et al. (2022) proposed an optimization method for sports venue operations by applying DL algorithms to analyze data on venue usage[16]. They focused on optimizing the services of public sports venues using DL to increase residents' satisfaction with these facilities. Zhang et al. (2021) highlighted the application of AI in managing public fitness facilities. By employing big data analysis and DL technology, they proposed a user-demand-based model for managing public fitness facilities to enhance service efficiency and satisfaction[17]. Luo et al. (2021) investigated the impact of different sports activities on the ecological environment by integrating big data and DL. The results emphasized the differences in environmental requirements among various sports activities, providing crucial theoretical support for this study[18]. Dergaa et al. (2023) focused on using AI to improve sports public service. Through big data analysis and DL, they proposed an intelligent sports venue management system to enhance the efficiency of public venues and residents' satisfaction[19].

The studies of these scholars contribute valuable theoretical foundations and methodological experiences to this study, offering feasible approaches and empirical support for the application of DL, AI, and big data in sports public service. However, much of the existing literature focuses on the application of single technologies or the management optimization of specific sports facilities. In contrast, this study explores the relationship between big data-driven public sports service quality and resident satisfaction by combining DL with the SERVQUAL evaluation model, thus filling the gap in existing research regarding comprehensive evaluation methods for the quality of public sports services. Furthermore, while previous studies have explored the relationship between the sports ecological environment and public sports services, most of these studies are limited to the analysis of a single sport or a specific dimension. This study, however, employs big data analysis in conjunction with DL to comprehensively assess the impact of multiple sports on the sports ecological environment, revealing

the complex interactions between different sports and residents' satisfaction as well as ecological environment needs. Finally, this study adopts a broad data collection approach, utilizing extensive surveys, literature reviews, and interviews, combining both quantitative and qualitative analyses. This provides a richer and more comprehensive empirical basis for understanding the interaction between public sports services and the ecological environment. Therefore, this study not only offers methodological innovation but also provides a new perspective for optimizing public sports services through integrated analysis and interdisciplinary approaches, contributing both theoretical insights and practical guidance to research in related fields.

Method

Theoretical foundation

The theoretical framework of this study revolves around the following core concepts: AI and DL, big data, resident satisfaction and enthusiasm, and the relationship between public sports services and the sports ecological environment. In constructing the theoretical framework, multiple literatures and theoretical models were referenced to comprehensively analyze the key variables in the study and their interactions.

AI is a broad field within computer science, encompassing subfields such as machine learning and natural language processing. DL, as a significant branch of AI, primarily employs neural network models (e.g., CNN) to perform data processing and pattern recognition. DL models process data through multiple layers, allowing for the extraction of valuable features from complex sports data, thereby providing precise support for optimizing public sports services. The application of DL in public sports services is significant because it can optimize the supply of sports facilities and service quality in real-time through big data analysis. For example, by analyzing user behavior data, DL can help predict residents' exercise needs during specific time periods, enabling the efficient allocation of resources. Furthermore, DL applications in image recognition, speech recognition, and other fields can improve interactive experiences in sports services, such as smart fitness devices and intelligent sports analytics. Big data refers to the vast and complex sports data collected through digital technologies and smart devices. This data includes not only residents' exercise behavior data but also information on the use of sports facilities, environmental data, and social interaction data. The application of big data technologies allows for a comprehensive understanding of residents' needs, preferences, and behavior patterns, thereby providing precise support for public sports services. The combination of big data and DL offers strong support for the precise optimization of public sports services. By collecting and analyzing big data, combined with the predictive and decision-making capabilities of DL algorithms, public sports services can improve service quality while more accurately meeting residents' needs, thereby enhancing their satisfaction and enthusiasm.

Satisfaction is defined as residents' overall perception of the sports ecological environment and service quality after participating in public sports services (such as running, swimming, ball games, etc.). According to the SERVQUAL model, customer satisfaction is primarily influenced by service quality, which includes five dimensions: reliability, responsiveness, assurance, empathy, and tangibles. In the context of public sports services, residents' perceptions of sports facilities, the environment, and service quality directly determine their satisfaction. Enthusiasm, on the other hand, refers to the degree of active participation and intrinsic motivation that residents have for fitness activities. According to Self-Determination Theory (SDT), enthusiasm is influenced not only by external rewards but also by strong intrinsic motivations, such as interest in fitness and the pursuit of a healthy lifestyle. Therefore, the quality of public sports services not only affects residents' satisfaction but also stimulates their enthusiasm to engage in fitness activities, thereby promoting a healthier social ecological environment.

The quality of public sports services directly affects residents' exercise experiences and satisfaction, while a good sports ecological environment forms the foundation for stimulating residents' enthusiasm for fitness. The sports ecological environment includes not only the quality of sports venues and facilities but also natural environmental factors such as air quality and green coverage. The tangibles dimension in the SERVQUAL model emphasizes the external quality of facilities and equipment, which significantly influences the choice of sports activities and resident participation. The application of DL and AI technologies offers new possibilities for improving the sports ecological environment. For example, through big data monitoring and AI analysis, the usage status of sports venues can be assessed in real-time, optimizing management decisions and ensuring the quality of public sports services. Additionally, AI-based predictive models can help plan sports facility layouts that better meet residents' needs, thereby enhancing their satisfaction and enthusiasm for participation.

This study combines satisfaction theory, big data, and the application of DL technologies to provide a solid theoretical foundation for exploring the relationship between public sports services and the sports ecological environment. This framework offers a better understanding of how AI-driven public sports services influence residents' participation in sports and their overall perception of the sports ecological environment.

Research method

Literature method: The first step is to find materials and books related to public sports. The next step is to combine key words such as satisfaction, sports and service, and find articles and materials that meet the needs in China National Knowledge Infrastructure (CNKI). Then, combined with the content of the information, the national public sports system is analyzed and studied.

Interview method: The first step is to design and study the interview questions in public sports service, and to search for the experts and scholars in public sports service and social research who meet the requirements to conduct the interview and Research on relevant questions. Under the current social conditions, the level of public sports service needs of ordinary people is studied, and how to improve the satisfaction of public sports service under the current conditions is also discussed.

Questionnaire survey method: It is necessary to combine the research direction, find the relevant articles and materials for reference and research, and design and study the framework of the questionnaire survey.

Combined with the opinions of experts in the field of public sports, and then in accordance with scientific and positive methods to design and plan the questionnaire, a questionnaire that meets the requirements and can highlight the theme is designed, and then relevant experts and scholars is found for verification and analysis.

Questionnaire design and distribution

According to the previous research results and the guidance of experts and scholars, this study is mainly divided into two aspects. On the one hand, it mainly analyzes and studies the personal data and information of the objects to be investigated. On the other hand, it mainly studies and analyzes the current recognition degree of people for the quality of urban public services. The research indicators are divided into three levels. The first level is public sports service, and the second level is mainly based on the understanding and research of scholars and experts and combined with the national system documents, mainly divided into information service, organization service, guidance service, facility service and testing service. The third level is mainly based on the actual situation of the city and the previous data to develop analysis indicators and methods.

Under the guidance of experts and scholars, the questionnaire design not only referenced the latest research findings in the field of public sports services both domestically and internationally[20–22], but also aligned with the requirements of relevant domestic policy documents, such as the *Opinions on Building a Higher-Level National Fitness Public Service System*. To ensure the scientific and effective design of the questionnaire, this study also gathered substantial theoretical and practical support through expert interviews. The experts involved in the interviews included senior scholars from fields such as sports management, public services and social policies, data analysis, as well as relevant officials from local sports administrative departments. These experts provided the following specific recommendations during the questionnaire design phase: First, from a theoretical framework perspective, they suggested combining the dimensions of the SERVQUAL model with residents' satisfaction in the fitness ecological environment to ensure that the questionnaire covers the five dimensions of service quality: reliability, responsiveness, assurance, empathy, and tangibles. Second, based on local policy contexts, they recommended optimizing questions related to residents' needs, such as the convenience of fitness facilities and the timeliness of services. Third, on an operational level, they advised using simpler and clearer language to describe the questions, while avoiding overly complex technical terms, ensuring that ordinary residents could accurately understand and complete the questionnaire.

After the initial questionnaire design, it was further optimized through multiple rounds of revision to improve its scientific accuracy and validity. Specifically, the questionnaire underwent two rounds of expert review, with the experts providing further suggestions on its logical coherence, relevance, and language clarity. For example, after the first round of reviews, adjustments were made to the scale design of certain questions, and a 7-point Likert scale was introduced to more accurately capture subtle differences in residents' satisfaction. After the second round of reviews, some redundant or less relevant questions were removed, ensuring that the questionnaire remained concise and focused on the research objectives. Additionally, a small-scale pilot survey was conducted, involving 50 residents from a pilot region. Based on the preliminary analysis of the pilot survey data, it was found that some questions might cause ambiguity, such as unclear descriptions of fitness facility maintenance. As a result, relevant statements were adjusted in the final version of the questionnaire. Furthermore, the pilot survey helped validate the clarity of the questionnaire's logic and led to optimizations in the order and categorization of the questions.

In selecting the survey areas, this study fully considered the representativeness and diversity of the regions. The selected areas were based on the "*National Fitness Activity Status Survey Bulletin*" issued by the General Administration of Sport of China, as well as relevant statistical data from local governments, ensuring coverage of typical areas with varying levels of economic development, fitness facility accessibility, and resident population density. Among the 12 valid ranges in XXX area, 4 ranges were randomly selected. Then, in each range, three streets were selected randomly. In each street, 80 people were chosen to conduct effective questionnaire research and investigation. 960 people were selected to conduct an effective questionnaire study. The survey participants covered residents from different age groups, genders, occupations, and income levels to ensure the diversity and representativeness of the sample. By employing random sampling, each resident in the street had an equal chance of participating in the survey, thus avoiding sample selection bias. A total of 960 questionnaires were distributed, with 912 valid questionnaires returned, yielding a response rate of 95%. However, some respondents did not fully complete the relevant sections of the questionnaire or there were logical inconsistencies in their responses. Therefore, questionnaires with missing answers to key questions, as well as those with apparent response biases or inconsistencies, were excluded. In total, 8 invalid questionnaires were discarded. Ultimately, the data analysis was based on 904 valid questionnaires.

Model design

The impact of advanced AI technology on residents' satisfaction with the fitness ecological environment in sports public service

Advanced AI technology has a widespread and profound impact on residents' satisfaction with the fitness ecological environment in sports public service. On the one hand, AI technology can analyze large-scale fitness data through DL algorithms to better understand residents' exercise behaviors and habits. Through such analysis, providers of sports public service can more accurately grasp the needs of different levels and groups, thereby targetedly improving the quality of services. For example, AI can identify users' preferred sports activities, activity time preferences, and expectations for the ecological environment, optimizing the arrangement and design of fitness facilities accordingly.

On the other hand, AI can provide personalized fitness advice and plans for residents based on individual physical conditions, health goals, and preferences. By analyzing big data, AI systems can predict residents' exercise trends and provide tailored exercise recommendations based on individual differences. This personalized service

enhances residents' satisfaction with sports public service and encourages them to actively participate in fitness activities, fostering a healthier lifestyle.

In terms of the ecological environment, AI technology can also monitor and manage the usage of sports venues and public fitness facilities in real time. Through sensing devices, cameras, and other technologies, AI systems can promptly detect equipment damage or overcrowding in venues, enabling proactive maintenance or adjustments to venue usage plans. This helps improve the overall quality of the fitness environment and provides safer and more comfortable sports facilities, thereby enhancing residents' overall satisfaction with sports public service.

Overall, through DL and big data analysis, advanced AI technology in sports public service achieves comprehensive optimization of residents' satisfaction with the fitness ecological environment. The application of this technology makes sports services more personalized and intelligent, improving the precision and efficiency of services, and ultimately providing residents with a more satisfying fitness experience.

Research on evaluation index and model of sports public service based on SERVQUAL

In this study, SERVQUAL evaluation concept is applied to the process of sports public service quality management. The purpose is to improve the quality of sports public service and the satisfaction of the public. SERVQUAL's five elements of tangibility, reliability, responsiveness, assurance and empathy are the core of his theory[23–25]. Based on the above five aspects, service quality is evaluated. In the past decade, this model has been widely used. Therefore, the SERVQUAL model is also an effective tool to evaluate the public service quality of sports. At the same time, with the help of the evaluation results, the quality of public services is improved, in order to meet the growing needs of people's sports services.

SERVQUAL's sports public service evaluation index is shown in Fig. 1. The evaluation indicators are divided into seven main dimensions, including basic sports infrastructure indicators, sports management indicators, venue indicators, mass sports indicators, competitive sports indicators, sports industry indicators, and other indicators. Basic sports infrastructure indicators refer to the infrastructure and services required to ensure the accessibility of sports services, including the availability and convenience of sports venues, facilities, and related equipment. Sports management indicators primarily focus on the operational efficiency and management level of sports services, involving the effectiveness of administrative processes, strategic planning, and the rational allocation of resources. Venue indicators assess the condition, capacity, and usage of sports venues, including the cleanliness of the environment, the completeness of directional signage, and the implementation of safety measures. Mass sports indicators emphasize public participation in sports activities and their accessibility, highlighting the inclusiveness of sports services and community involvement. Competitive sports indicators mainly evaluate the quality and availability of facilities and services provided for the training of high-level athletes and the development of competitive sports. Sports industry indicators analyze the role of the sports industry in promoting economic and social development, including job creation and the catalytic effect on related industries. Other indicators encompass additional important factors affecting public satisfaction that are not explicitly covered in the main dimensions.

Tangibility refers to the attraction of sports public service facilities, instructor appearance and sports events. Reliability refers to the provision of accurate and reliable services. Responsiveness refers to the willingness of sports public service instructors to provide convenient services for the public. Assurance refers to the attitude, professional knowledge and ability of the sports public service instructor. Empathy refers to the care and personalized service given to the public. Finally, Likert scale 5 scale is used for each dimension index, and the perceived service quality is set with five grades: very good, good, general, bad and very bad by using progressive degree selection method. The scores of each item correspond to 5, 4, 3, 2 and 1 respectively.

Based on the overall investigation of the actual situation of sports public service and the scientific understanding and grasp of SERVQUAL evaluation model, five dimensions of sports public service are preliminarily constructed by referring to the existing research results. Then, on the basis of interviewing 40 government sports department managers, social sports instructors, and the public, the preliminary indicators in five dimensions is constructed. Finally, 15 experts and scholars of sports public service are invited to evaluate

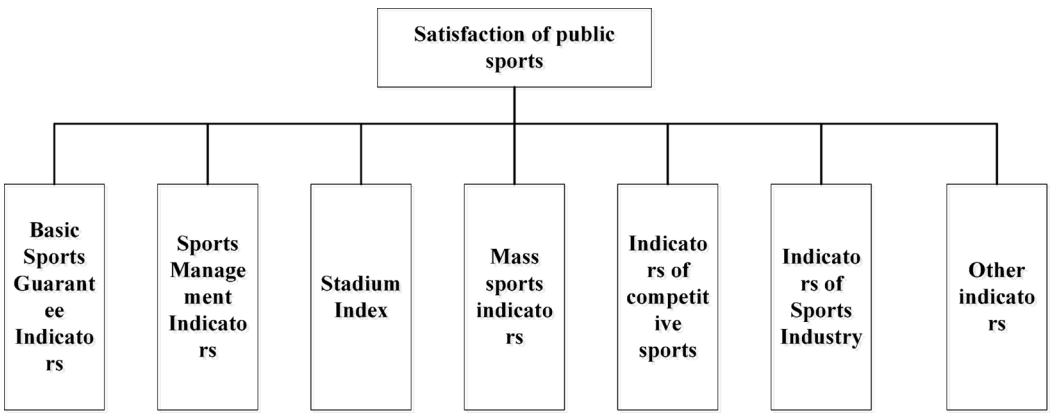

Fig. 1. SERVQUAL's evaluation index of sports public service.

and grade the primary indexes, including 7 professors of universities, 3 managers of sports bureau, 3 managers of community work and 2 managers of fitness service industry. After scoring, adjusting and modifying the two rounds of primary indexes, the five dimensions and 22 indexes of public service quality evaluation of sports are finally established, as follows:

Tangible dimension: The supply and layout of public sports facilities, the appearance, dress, speech and behavior of social sports instructors and fitness coaches in fitness venues, and the attractiveness of supplied sports items are evaluated by the following four indicators. The first is to provide the public with modern sports facilities to meet the fitness needs. The second is that the gymnasium is equipped with perfect guide signs. The third is the clean environment inside and outside the gymnasium. The fourth is the fitness venues social sports instructor clothing, appearance neat, and wear work permits.

Reliability dimension: Sports public service staff fulfill their service commitments and provide accurate and reliable services for the public. These are evaluated by the following three indicators. The first is that social sports instructors can complete their work within the promised time. The second is that when the public encounter fitness problems, social sports instructors will try their best to help solve them. Third, social sports instructors can correct service errors in time.

Response dimension: Sports public service staff are evaluated by the following three indicators. First, the fitness venues timely and accurately carry out fitness service information publicity. Second, social sports instructors actively help the public to participate in fitness activities. Third, the fitness stadium can quickly and effectively solve user complaints.

Assurance dimension: Sports public service staff's attitude is mainly reflected by the following six indicators. The first is that the social sports instructor does not neglect the fitness personnel due to his own reasons. The second is that the behavior of the staff in the gymnasium can stimulate the confidence of the gymnasts. Third, social sports instructors are polite and friendly. The fourth is the social sports instructor to listen to the inquiry patiently. Fifth, social sports instructors have enough professional knowledge to guide the public to exercise. The sixth is that the fitness venues can take into account the specific needs of customers to arrange services.

Empathy dimension: For the personnel engaged in public sports services, they need to change and redesign their own services in combination with various personnel requirements and ideas in social groups to meet the needs and development. The most important thing is to use the following six aspects to show. The first is the transportation situation of the people to the fitness venues. The second is the opening and closing time of the stadium. The third is whether the environment in the public gymnasium meets the needs. The fourth is whether the gymnasium has comprehensive guidance and publicity for people's fitness. The fifth is the most critical safety protection and emergency measures. The sixth is the maintenance intensity and realization of public sports service gymnasium for venues and facilities.

Research on the influence of sports service on sports ecological environment

Building on the aforementioned indicators and the relationship between the dimensions of sports public service quality and residents' satisfaction, this study evaluates the quality of public sports services from the perspective of "residents' satisfaction." The SERVQUAL demand analysis of public sports services, as shown in Fig. 2, is employed to further investigate the quality of public sports services through the lens of residents' satisfaction.

Figure 2 categorizes service attributes into four distinct types: reverse attributes, expected attributes, attractive attributes, and basic attributes. Basic attributes refer to the essential requirements that must be met in the service, such as the provision of facilities, site safety, and service standards. These attributes represent the minimum expectations of the public for sports services; failure to meet them leads to significant dissatisfaction. Expected attributes pertain to services that the public holds higher expectations for, though they are not strictly necessary, such as the enthusiasm of service staff or the aesthetic quality of the venue environment. When these attributes exceed the public's expectations during service delivery, they can contribute to increased satisfaction.

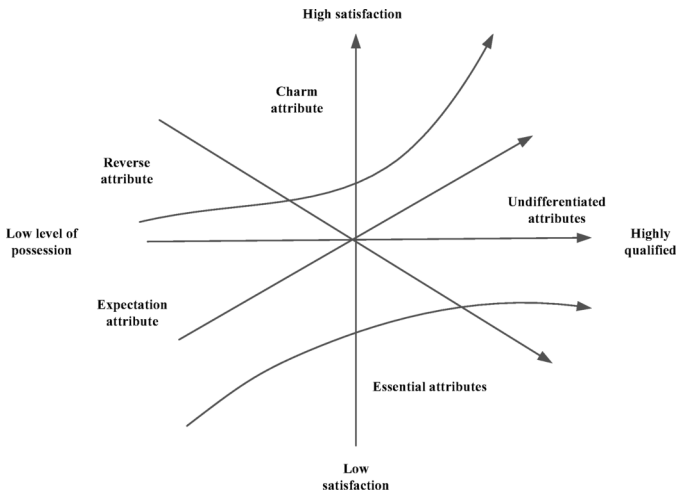

Fig. 2. Public sports service SERVQUAL demand analysis chart.

Attractive attributes refer to services that the public does not explicitly anticipate but are provided beyond expectations, such as innovative activities or personalized services. These attributes can significantly enhance public satisfaction. Reverse attributes are those that the public perceives as unnecessary or even potentially harmful, with the provision of such services likely to decrease satisfaction. By categorizing the different service attributes, this approach assists managers in accurately identifying areas that require improvement. Through the questionnaire, the expected value (P) and the actual feeling value (E) of the public to the quality of sports public service are measured respectively, and then the difference between them is obtained. The difference is taken as the evaluation of the public on the public service quality of sports, i.e. service quality (Q), as shown in the figure above. The calculation equation is:

$$Q = \sum_{i=1} (E_i - P_i)$$

The process of integrating a CNN model based on residual modules and attention mechanisms with the SERVQUAL evaluation model

A CNN model based on residual modules and attention mechanisms is employed to comprehensively analyze residents' satisfaction with the fitness ecological environment. The residual module is a special neural network structure that, by introducing skip connections, can more effectively train deep neural networks. In CNN, the residual module adds residual blocks, allowing the network to learn residuals (the difference between actual output and expected output) and better capture features in the data. This helps avoid the vanishing gradient problem, making the network converge more easily during training. The attention mechanism enables the network to focus on different parts of the input when processing information, allowing the model to concentrate on crucial features. In CNN, introducing the attention mechanism allows the model to learn which features are more critical in specific contexts. This flexibility enables the network to pay attention to different dimensions when processing data related to residents' fitness ecological environments, enhancing the model's expressive power and predictive accuracy.

This study combined a CNN model based on residual modules and attention mechanisms with the SERVQUAL evaluation model to comprehensively and accurately analyze the impact of sports public service on residents' satisfaction with the fitness ecological environment. It provided robust data support for service improvement. First, based on the extensive data collected on residents' fitness ecological environment, these data were input into the CNN model to extract multi-dimensional features. During the data collection phase, a diverse sample of residents was surveyed, including individuals of various ages, genders, occupations, and fitness habits. The data included residents' subjective ratings of different dimensions of public sports services (such as tangibles, reliability, responsiveness, assurance, and empathy), along with objective data on venue distribution, facility utilization rates, service complaint rates, and residents' health indicators. The questionnaire utilized a 5-point Likert scale, capturing both expected and perceived service quality to calculate the service quality gap. In the data preprocessing stage, standardization, normalization, and missing value treatment were applied to ensure the quality and consistency of the data. The model design incorporated multiple residual modules, with each module introducing skip connections to directly pass inputs to subsequent layers, enabling the model to learn the discrepancies between input and output features. This design allows the network to capture both low-level features in the data and effectively learn high-level complex patterns. Simultaneously, the attention mechanism enables the model to dynamically adjust the focus weights on different parts of the input features. For instance, when processing data related to public sports services, the model can automatically identify certain dimensions (such as venue facility availability or the attitude of social sports instructors) that are relatively more important to satisfaction, thereby allocating more computational resources to these key features. During the training process, a stratified sampling method was employed to divide the data into training, validation, and test sets, ensuring fairness and robustness in model evaluation. The training phase used the cross-entropy loss function as the optimization objective, with backpropagation and the Adam optimizer updating the network weights. To accelerate model convergence and avoid overfitting, batch normalization and Dropout techniques were applied. Convergence was monitored by observing the loss function values for both the training and validation sets. The model was considered to have converged when the loss values stabilized and there was no significant drop in performance on the validation set. In terms of model evaluation, multiple metrics were used to thoroughly assess the model's performance, including accuracy and F1 score. These evaluation metrics ensured the reliability and stability of the model in predicting residents' satisfaction with the fitness ecological environment. Subsequently, the high-dimensional features extracted by the CNN model were integrated with the theoretical dimensions of the SERVQUAL evaluation model, forming a framework that combines both data-driven and theory-driven approaches.

The SERVQUAL model typically includes key service quality dimensions such as reliability, responsiveness, and assurance. These dimensions can be matched with the features extracted by the CNN model, establishing a more comprehensive model that considers the multifaceted impact of sports public service on residents' satisfaction with the fitness ecological environment. The fused model is trained, and model parameters are adjusted through optimization algorithms such as gradient descent to enhance model performance. During training, the residual module and attention mechanism enable the model to better adapt to the complex features of residents' fitness ecological environments. Combining these mechanisms with the SERVQUAL assessment model improves the model's overall accuracy. The trained model is then used to predict new data, yielding predictions for residents' satisfaction with the fitness ecological environment. By interpreting the model results, a deeper understanding of the contribution of each evaluation dimension to overall satisfaction can be gained, guiding the optimization of sports public service.

Results analysis

The relationship between public sports service and residents' fitness ecological environment is shown in Fig. 3. With the passage of time, between 2014 and 2018, with the improvement of the quality of public sports services in the city, residents' satisfaction with the fitness ecological environment will also increase. It can be seen that public sports services have a significant impact on the fitness ecological environment of residents. The improvement in residents' satisfaction is primarily reflected in the following aspects: First, with the advancement of urban infrastructure, the provision of modern fitness facilities has significantly increased. The coverage of high-demand venues, such as running tracks and swimming pools, has notably expanded, directly enhancing residents' fitness experiences. Second, the organizational and managerial standards of public sports services have improved, leading to more timely dissemination of service information and more efficient event organization, which in turn has made it easier for residents to participate in fitness activities. Third, progress has been made in the service attitude and professionalism of public sports services. For instance, the enhanced expertise of social sports instructors has allowed residents to receive better guidance and assistance during their fitness routines. These findings indicate that improving the quality of public sports services is an effective approach to enhancing residents' satisfaction with the fitness ecological environment.

The research of public sports residents' fitness sports is shown in Fig. 4. It can be seen clearly from the figure that the proportion of running is very high, followed by ball games, and the least proportion is dancing and swimming. This result reflects, to some extent, residents' preferences in fitness activity choices and the differing adaptability of the ecological environment to various sports. A deeper analysis reveals that running occupies the highest proportion due to its low requirements for space, its broad applicability to various populations, and its minimal reliance on equipment. Urban public sports services, by providing high-quality running tracks, green belts, and suitable exercise environments (such as improved air quality), create favorable ecological conditions for runners, which significantly contributes to the satisfaction of this activity. In contrast, the high participation rate in ball sports is related to the higher social and organizational demands of these activities. The provision of ball facilities (e.g., basketball courts, football fields) and the quality of management services in urban sports venues play a crucial role in enhancing satisfaction with these activities. However, the relatively low participation in dance and swimming may be attributed to several factors: First, swimming requires higher standards for facilities, including well-maintained pools and supporting infrastructure. In some cities, the insufficient provision or poor maintenance of public swimming pools limits residents' participation. Second, although dance is a low-space requirement activity, its lower degree of community engagement and insufficient guidance services have not attracted a larger number of residents. This reflects the need to improve the ecological compatibility and service coverage of public sports services for specific activities.

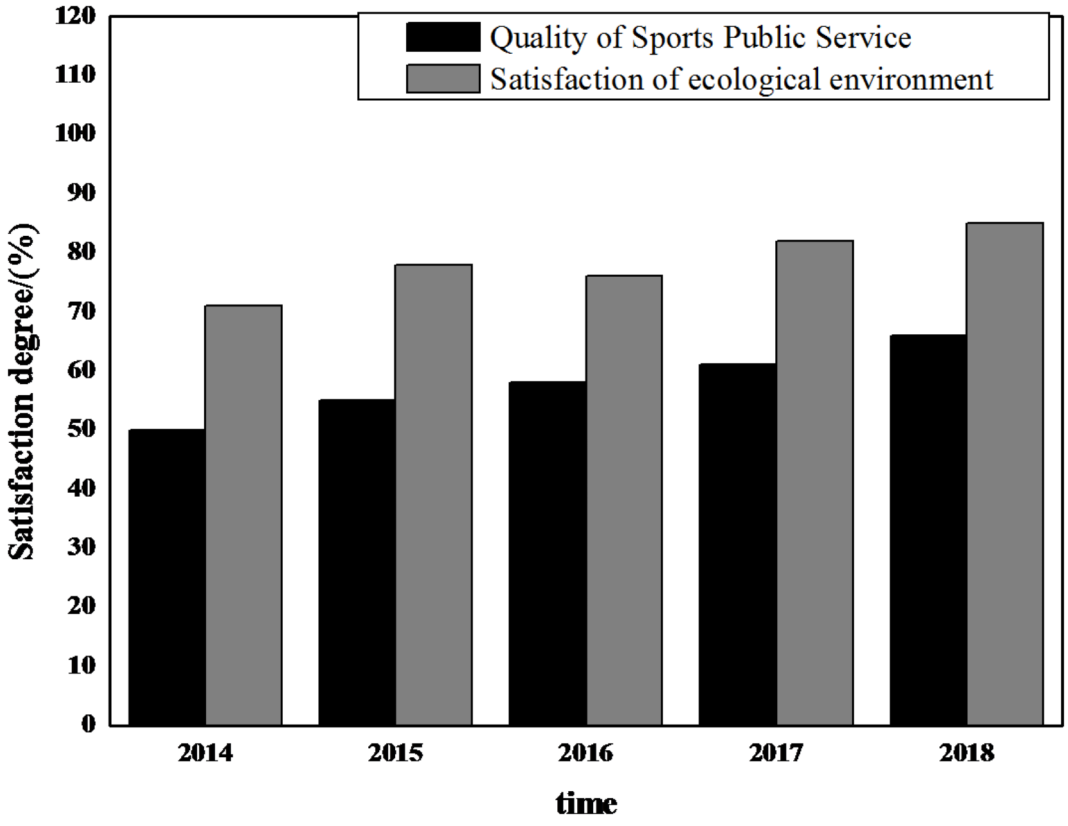

Fig. 3. Research on the relationship between public sports service and residents' fitness ecological environment.

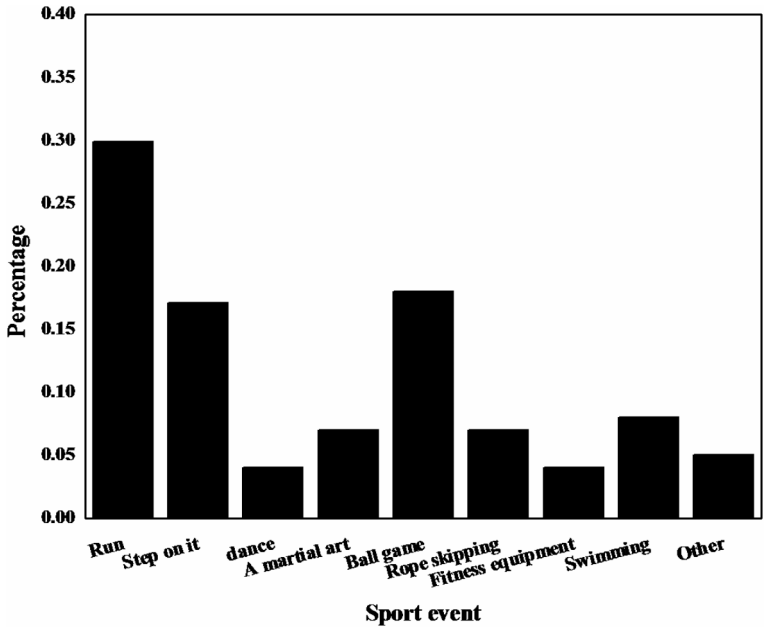

Fig. 4. Research on the fitness sports of public sports residents.

Overall, the study demonstrates that the quality of public sports services has a significant positive impact on residents' satisfaction with the fitness ecological environment. The variation in satisfaction across different sports activities reveals the complex interplay between the ecological environment and the provision of public services. The key to enhancing residents' satisfaction lies in the following areas:

(1) Targeted Facility Provision: The high satisfaction with running and ball sports is largely attributed to the prioritization of facility provision in these areas by urban public sports services. For activities with lower participation rates, such as dance and swimming, it is necessary to strengthen facility provision planning. This may include increasing the coverage of public swimming pools and improving the social design of dance venues to better balance the ecological compatibility of different sports.
(2) Personalized and Professional Services: The findings of this study also indicate a growing demand for specialized services. The quality of social sports instructors' services plays a key role in multiple sports activities. For example, providing swimming lessons or organizing dance classes can effectively increase participation and satisfaction in these sports.
(3) Optimizing Ecological Environment Compatibility: Different sports have distinct environmental needs. For instance, running is sensitive to air quality and green spaces, while swimming requires safe water quality and specialized facilities. This highlights the importance of urban public sports services not only optimizing the overall ecological environment but also addressing the specific needs of different sports activities with targeted strategies.

Public sports services can be optimized in terms of facility provision, service professionalization, and ecological environment to improve residents' satisfaction.

Conclusion

In this study, through the establishment of SERVQUAL evaluation model and the combination of questionnaire survey and literature review, the impact of sports public service on residents' fitness ecological environment satisfaction has been studied carefully. Simultaneously, it is proposed to enhance the analysis by introducing DL and AI technologies, specifically adopting an integrated CNN model that incorporates the residual module and attention mechanism. This approach aims to provide a more comprehensive understanding of this relationship. The results show that the quality of public sports service has a significant impact on the satisfaction of the residents' fitness ecological environment, such as running, swimming, ball games and other sports with high requirements for the quality of sports service and ecological environment. Only with the good public sports service quality matching with it, the ecological environment needed for fitness can be met and the enthusiasm of the people for fitness can be aroused. Therefore, the public sports service quality and the residents' fitness ecological environment satisfaction are in a positive proportion. By introducing DL and AI, this study deepens the understanding of the relationship between sports public service and residents' satisfaction with the fitness ecological environment and refines the analysis. The use of an integrated CNN model incorporating residual modules and attention mechanisms allows for a more precise analysis of different data dimensions, capturing complex patterns that traditional methods might overlook. This advanced analytical approach enhances people's ability to comprehend the multifaceted impact of public sports services on residents' satisfaction with the ecological environment of fitness. In conclusion, the residents' satisfaction of fitness ecological environment

is greatly affected by the quality of public sports service. This study also has some shortcomings, mainly in the relatively small scope of the questionnaire survey, and the results are relatively lack of persuasion. The scope of sports public service is very large. In this study, the satisfaction of specific sports items to the fitness ecological environment is mainly studied, and the impact of public sports services on the satisfaction of sports ecological environment is generally reflected.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author Wenxia Han on reasonable request via e-mail hanwenxia@xiyi.edu.cn.

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Author contributions

Ke Mu: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparationZhiling Wang: software, validation, formal analysisJinzhou Tang: investigation, resources, data curationJiarui Zhang: visualization, supervision, project administrationWenxia Han: writing—review and editing, visualization, supervision, project administration, funding acquisition.

Declarations

Competing interests
The authors declare no competing interests.

Ethical approval
The studies involving human participants were reviewed and approved by School of Health Management, Xi 'an Medical University Ethics Committee (Approval Number: 2022.5904856). The participants provided their written informed consent to participate in this study. All methods were performed in accordance with relevant guidelines and regulations.

Additional information
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