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Designing a model for optimal locating of sports facilities based on the urban planning criteria

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Abstract

Background: Sports facilities are one of the most commonly used services in the city with a significant role in improving the physical and mental health condition of citizens thus a proper procedure is required to locate and distribute them.

Aim: The purpose of this study is to design a comprehensive model for the optimal location of sports facilities.

Materials and Methods: The research method is descriptive-analytic based on information gathering and is applied research based on objectives. The opinions of 20 experts have been used to design the model using the Delphi method, and weighting the effective criteria in the sports facilities location. The weight of each criterion has been obtained as population density (0.47), access (0.31), development potential (0.14), and adjacency (0.08); furthermore, the Kendall coefficient of concordance (0.74) in the third step of the Delphi method shows the strong agreement between the experts, regarding the proposed model. The proposed model consisted of six steps: 1. Aim; 2. Verification of the functional area of the existing sport facilities and specific restrictions of the area; 3. Introducing and weighting the important criteria in the sports facilities location; 4. Identifying the most suitable locations for constructing the sports facilities; 5. Evaluating the needs of users; 6. Selecting the best spaces and prioritizing them.

Results: The results of the model showed that the most important criteria for locating sport facilities are population density, access, development potential, and adjacency. Additionally, it was indicated that the agreement between the experts increased over time.

Conclusion: According to the proposed model, it is possible to identify the points that are suitable for constructing the new sports facilities.

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1. Introduction

The belief that sport, exercise and other forms of physical activity can be healthy is as old as recorded history [1]. Many prior works have highlighted the benefits of sports to mental and social health by decreasing social isolation, mitigating depression, and increasing self-esteem and overall life satisfaction [2]. However, global trends indicate that one-third of adults and four-fifths of children are not accomplishing the minimum level of physical activity recommended by general public health principles [3]. Positive effects of sport participation have attracted the interest of the inhabitants of metropolitan areas. Recently, despite the growing need for sports activities, the problem of a lack of space in metropolitan areas makes it difficult to meet the requirements [4]. Space, for developing the facilities, is also more limited in metropolitan areas. This condition results in a relatively low per-capita sport facility provision [5].

One of the main problems of sport is inappropriate and unfair distribution of sports facilities; so that many people in a community cannot use them properly due to inaccessibility. The diversity and proper distribution of the sports equipment make them available for everyone and increases users' choice and ultimately improves the efficiency of these places [6, 7].

Fail in optimal location causes big problems like increasing the need for travel over long distances, using energy for transportation, wasting time, athletes' exhaustion, etc.; therefore, finding the proper location is one of the most important requirements of planning for sports facilities [6].

On the other hand, nowadays due to the big increase in the number of variables effective on the location process and complexity of the urban issues, using traditional methods for location analysis is not possible and it is necessary to apply appropriate analytical tools such as Geographical Information System (GIS) in location [8]. Scientific developments make it much easier to use advanced methods in the process of decision making. Multi-criteria decision-making technic is one of these new methods in which decision-maker needs to scrutinize several different criteria. This technic is a practical way to increase the precision of the space/ location related decisions in urban planning and reduce the costs and time of the process.

There are several different methods available for multi-criteria technic. The most well-known one is the Analytic Hierarchy Process (AHP) which can be used for weighting the effective criteria in the sports facilities' optimal locating process [6].

The results of McCormac et al. (2004) [9] and Panter and Jones (2008) [10] show availability of the sports facilities, recreational facilities and parks in addition to their quality have a significant role in increasing the amount of physical activity. These researchers insist that the groups of the respondents who have access to a high or average level of facilities in their area, are more likely to be physically active and doing walking. In these studies, GIS software has been used for estimating the distance of individuals from clubs, sports facilities and green areas.

Oh and Jeong (2007), in a study about the dispersion of recreational facilities in Seoul South Korea, which was done with the aid of GIS software, found although the amount of per capita green areas and recreational facilities in Seoul is fairly high, because of inadequate distribution, they don't have an acceptable efficiency rate for the citizens [11]. GIS system has been used for estimating the distance between houses and sports facilities in another study in Canada which aims in determining the role of accessibility of the local facilities in the individuals' participation in physical activities. The results show the rate of local welfare facilities has a direct relationship with the level of physical activities; Also, it indicates that local sports facilities can be important especially for women who are more willing to use the sports facilities in the nearby area [12].

The results of Norozi et al. (2014) about the locational analysis of the sports facilities with the aid of GIS indicate sports facilities in the district one of the Tehran City don't meet the standard criteria and also per capita sports facility of this district is less than the standard per capita space [7].

Higgs et al. (2015) study about the accessibility of sports facilities in Wales using GIS-based analysis of socio-economic variations in the provision. They show that association with the private sports facilities is inversely proportional to the level of social deprivation although the public sports facilities might be potentially more accessible in some of those areas. Researches indicate that variations in access to sporting facilities can be identified through GIS-based analysis as part of wider studies about the investigation of sport participation rates and levels of physical activity [13].

Zohrevandian et al. (2016) applied AHP to prioritize the sports facilities' locating criteria. The results showed that four criteria of population density, accessibility, development potential, and adjacency are respectively of the highest importance [14].

In Eslami Marzankalaye et al. (2018) study, about the analysis and locating the sports facilities in the city of Gorgan, five indicators of operation radius, population density, building density, distance from the road, and distance from the sports facility have been used. After determining the layers and indicators weight, prioritizing the information layers using AHP, and layers overlap in GIS, five locations were offered to build the new sports facilities [15].

Vich et al. (2019) study about the level of physical activity in the city of Barcelona with the aid of smart phones' GIS and GPS indicates that the existence of big spaces like coasts, parks and big green areas is the most effective factor in the walking time of the participants [16].

Salimi and Khodaparst (2021) investigated the capabilities of the GIS analytic functions and suggested a new method, based on it, for the sports facilities locating. At first, a study database is provided, containing the applications and urban elements, sports facilities' locations, population density of the region, and drawings. This database is prepared in separated layers with the aid of GIS. In the next step, the determining factors of the sports facilities' locating process are combined to form a final map through the layers' shared overlapping [17].

Sports facilities are one of the most commonly used services in the city with a significant role in improving the physical and mental health condition of citizens thus a proper procedure is required to locate and distribute them. The current study tries to identify and weigh the crucial criteria based on the available resources. Then, proposes a model for the optimal locating of sports facilities.

2. Materials and Methods

The current study is applied research in terms of the aim, and descriptive-analytic in terms of the data collection method. At the very first step, a comprehensive literature review was done on the existing studies and theories on the location of the service applications; then, the initial theoretical model was prepared. After that, the proper model was developed with the aid of the Delphi method in survey research at three stages basedg on thef experts'd opinionsdd Opinions and judgments of 20 experts have been used for designing the model and weighting predefined criteria for sports facilities location. This group of experts is selected purposefully and consists of four university professors in the field of management and planning in physical education, four experts of the Development and Maintenance of Sports Facilities Company, four experts of Urban Management and Planning Organization, four experts of the Ministry of Housing and Urban Development and four managers of the sports facilities.

Analytic Hierarchy Process (AHP), one of the most efficient multi-criteria decision-making technics is the analytic hierarchy process which was introduced by Saaty for the first time in 1980 and is based on the paired comparison. This technique allows managers to investigate different scenarios. Whenever agreeing about the importance of the criteria is difficult, the AHP method can simplify and accelerate the decision-making processes and enables us to make effective decisions about complicated cases [18, 19, 20]. The first step in analytic hierarchy process is to make a graphical depiction of the problem in which, aims, criteria and options are shown (Figure 1).

Level one of the hierarchy shows aim. Level two sets the criteria of the case and in the last level, options are displayed.

In analytic hierarchy process, the elements of each level are compared to their respective element at the higher level in pairs and their weights are calculated; these weights are called relative weight. Then, the final weight of each option will be determined by combining the relative weights; this weight is called absolute weight. All comparisons in analytic hierarchy process are done in pairs. When element "i" is compared to element "j", the decision-maker says the importance of i over j is one of the following (Table 1).

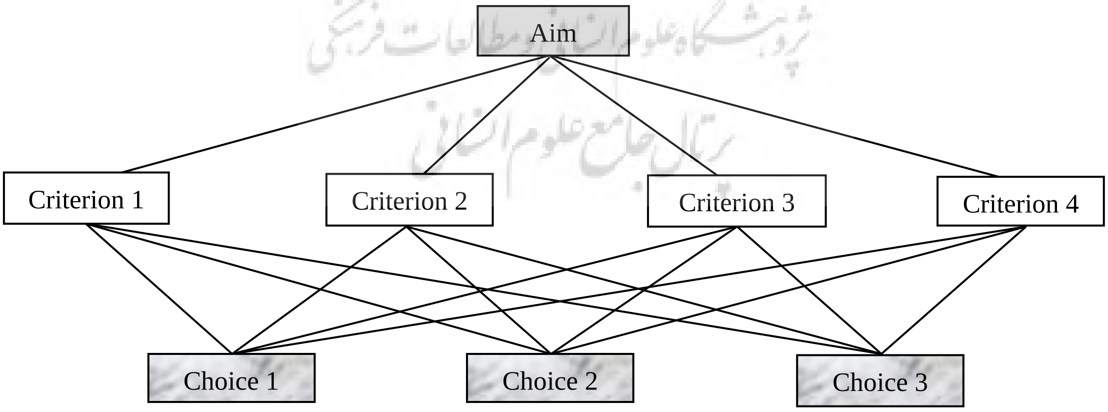

Figure 1. A hypothetical hierarchy

Table 1. Numerical preference values for paired comparisons

A	Equally preferred	Moderately preferred	Strongly preferred	Very strongly preferred	Extremely preferred	Preference between intervals
Numerical value	1	3	5	7	9	2, 4, 6, 8

One of the benefits of the analytic hierarchy process is to control the compatibility of the decision. In other words, in the process of hierarchical analysis, the degree of decision-makings compatibility can be always calculated and then one can decide whether it is good or bad, acceptable or not. The acceptable range of incompatibility in each system depends on the decision-maker but in general, Saaty suggested that if the decision mismatch is bigger than 0.1, it would be better for the decision-maker to reconsider its judgment.

3. Results

The group of experts included 16 men (80%) and 4 women (20%); education-wise, the most populous category was PhD/Doctorate with 8 experts (40%); considering the work experience, the densest population belonged in the group of “more than 20 years of experience” with 7 participants (35%). The initial theoretical model was prepared after a thorough investigation of the existing studies and theories about the service applications location. Then it was scrutinized in survey research based on the experts opinions at several stages and eventually, the proper model was developed after analyzing the information and data.

In other words, experts expressed their detailed opinions about all parts of the theoretical model. After analyzing the ideas, we retained the accepted parts and changed or improved the rest. The questionnaires were distributed in three stages based on the Delphi method. The parts with an average grade of 4 and above were kept and repeated in the next questionnaire and the rest was eliminated. Tables 2 and 3 presents the descriptive analyses and the results of Delphi panel data collections, in brief.

Table 2. The results of three-stage Delphi; steps of the locating process of the sport facilities

Step	Activities in each step of the locating process of the sport facilities	First stage		Second stage		Third stage	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
1	Investigation of the operation radius of the existing sport facilities	4.57	0.73	4.65	0.68	4.82	0.51
2	Investigation of the special restrictions (earthquake channel, riverside, sea, HV electrical network, …)	4.62	0.85	4.64	0.77	4.73	0.66
3	Introducing the crucial criteria	4.58	0.46	4.61	0.41	4.65	0.39
4	Weighting the crucial criteria	4.43	0.83	4.46	0.75	4.51	0.54
5	Preparing the layers of criteria, operation radius of the existing sport facilities, and restrictions by the aid of GIS	4.21	0.75	4.31	0.69	4.46	0.61
6	Overlaying through GIS to find the proper locations	4.38	0.84	4.45	0.72	4.52	0.64
The standard deviation of opinions			0.85		0.76		0.58

Table 3. The results of Kendall coefficient of concordance for Delphi

Delphi stage	Kendall coefficient of concordance	Level of significance	Result
First	0.63	0.002	Mediocre
Second	0.71	0.006	Strong
Third	0.74	0.001	Strong

Based on Table 2, the standard deviation of the panel's members about the steps of the locating process of the sports facilities, in the first, second, and third stages are respectively 0.85, 0.76, and 0.58.

Kendall coefficient of concordance has been calculated in the first Delphi stage to measure the level of agreement between the experts about the steps of the locating process. The resultant coefficient of 0.63 implies a mediocre agreement level. This coefficient increases to 0.71 and 0.74 in stages 2 and 3, respectively. That means the agreement increases between the experts. Because the number of the panel's members is more than 10, the resultant Kendall coefficient is meaningful ($P \leq 0.05$). Based on the results of the three-stage Delphi method, we can see the agreement has been reached between the panel's members and no further repetition is required. The following reasons can be listed for this conclusion: The standard deviation of the experts responses decreases from 0.85 at the first stage to 0.76 at the second one and finally to 0.58 at the third stage. The Kendall coefficient grows 0.03 in the third stage, with respect to the second one; it means the agreement between the experts does not improve significantly anymore thus the Delphi repetitions can end.

The proposed model includes the basic steps in Figure 2.

Step 1. Aim

According to the title of the research, the main purpose is to design a model to find the optimal location of the sports facilities.

Step 2. Verifying the catchment area of the current sports facilities and the area's specific restrictions

To identify the most suitable locations for new sports facilities, it is assumed construction of new sports facilities inside the catchment area of the current ones or in some specific constrained regions (such as earthquake fault, riverside, seashore, close to high voltage electricity, etc.) are not allowed; therefore with the aid of overlapping functions of GIS, all layers related to the catchment area will be superimposed based on their level of operation and also the specific restrictions of the area; ultimately, those points which are not recommended for construction are obtained.

Step 3. Introducing and weighting the important criteria in sports facilities location

Identification of the crucial criteria of sports facilities location is one of the most important steps of the process of finding the suitable points for constructing the new sports facilities. To obtain the aim of this research which is "designing a model to finding the optimal location of the sports facilities", a set of criteria needs to be considered.

The most important criteria are listed below [6].

1. Population density: Places with higher population density have higher priority to construct new sports facilities.
2. Development potential: Lack of open spaces in the urban fabric creates restrictions for the planners and urban decision-makers. Therefore, it is suggested to select areas with high intervention potential.

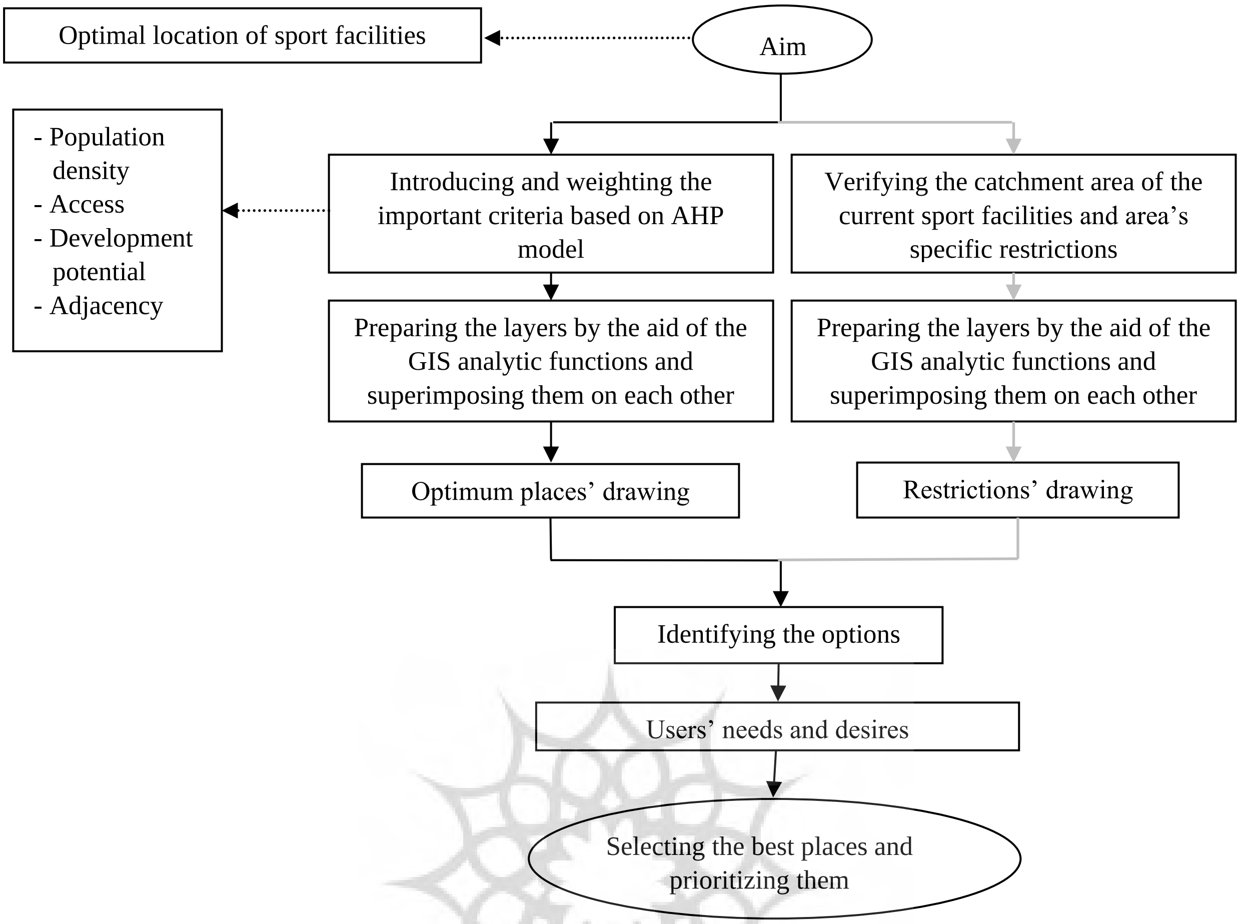

Figure 2. The proposed model for optimal location of sport facilities

3. Access: This criterion is used as a measure that indicates how easy is to reach a location. The way of access is evaluated by distance and travel time from one location to another.
4. Adjacency: It means compatible applications need to be placed together and incompatible ones should be separated from each other.

The weights of the criteria of the sports facilities location is one of the most crucial tasks in the implementation of the proposed model in an area required in step four is to find the weight and importance of each criterion. To weigh the criteria presented in this study, a matrix questionnaire was designed using AHP. The questionnaire was distributed between twenty experts and sport's managers. Following equivalent matrix was created from the results.

In Table 4, the importance rate of each criterion is identified with respect to another one. Expert Choice 11 software has been used for weighing the criteria and determining the importance of each one. Accordingly, the weight of the criteria is given in Figure 3.

Table 4. Paired table of criteria of sports facilities location

	Population density	Access	Development potential	Adjacent
Population density	1	2	3	5
Access	0.50	1	3	4
Development potential	0.34	0.34	1	2
Adjacent	0.20	0.25	0.50	1

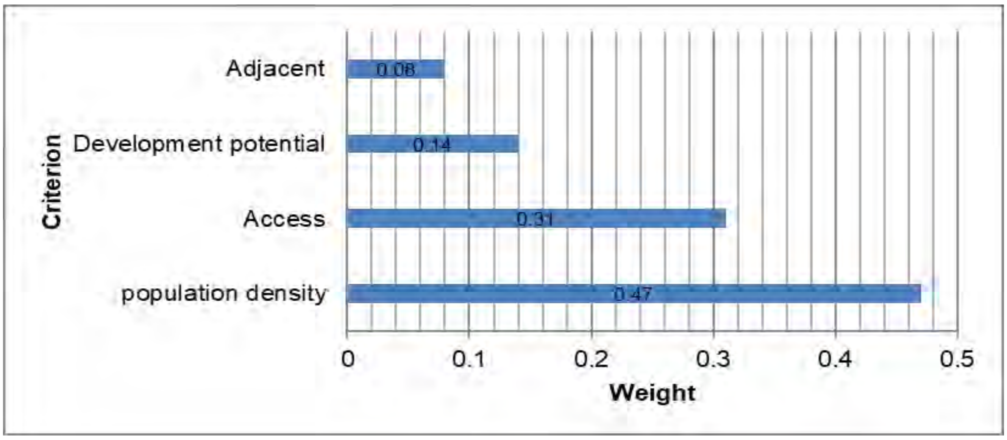

Figure 3. Weight rate of each criterion in sports facilities location

The results show higher priorities are population density (0.47), access (0.31), development potential (0.14) and adjacency (0.08), respectively. The compatibility factor of this comparison is also 0.0557 which is an acceptable value considering the compatibility coefficient should be less than or equal to 0.1.

At the next step, with the help of GIS analytic functions, all layers related to these criteria are prepared and each class is scored according to its obtained score in the AHP model; then with the aid of overlapping functions of GIS, the layers will be superimposed and ultimately the most suitable places for new sports facilities will be obtained regardless of the current facilities location and specific restrictions of the region.

Step 4. Identifying the most suitable points to construct sport facilities

After studying the functional areas of the existing sport facilities and specific restrictions of the region and according to the results of step 2, now it is possible to propose the new sports facilities' location for covering other parts of the area.

Step 5. Verification of the users' needs and desires

Interaction between managers and planners of the new sports facilities and the community is important to comply with the customer orientation and increase the efficiency of these facilities.

Step 6. Selecting the best spaces and prioritizing them

At this stage, some points are proposed for the construction of the sports facilities considering the comprehensive plan, current needs and the population of the studying area; then according to the plans, the allocated budget will be prioritized.

Based on the designed model for the construction of the new sports facilities in the studying area, at first, the condition of the current sports facilities of the area in terms of per capita space and distribution must be completely studied; then with the aid of the GIS analytical functions and based on the important identified criteria and their relevant weights, the respective layer (for each criterion) will be provided and each class will be scored according to its obtained score in AHP. Then, that layers will be superimposed on each other with the overlapping functions of GIS. Finally, after reviewing the functional areas of the existing sport facilities and the specific restrictions of the area, the most suitable places will be determined.

4. Discussion

Nowadays, due to the complexity of urban issues, numerous variables affect the location of facilities, and large databases make it almost impossible to apply the traditional methods for analysing the locating the facilities. Therefore, the current study uses powerful analysing tools such as GIS and AHP to prepare a model for sports facilities' optimal locating. The opinions of 20 experts have been used to design the model using the Delphi method (in three stages) and weighting the effective criteria.

The current study follows the approach of Riva et al. (2007) [12], Oh and Jeong (2007) [11], Panter and Jones (2008) [10], Norozi Seyed Hoseini et al. (2014) [7], Higgs et al. (2015) [13], Zohrevandian et al. (2016) [14], Ahmadi et al. (2017) [6], Eslami Marzankalaye et al. (2019) [15], Vich et al. (2019) [16], Salimi and Khodaparst (2021) [17] who were persistence of using GIS as a powerful tool for studying the distribution and dispersion of sports facilities in their research area.

The present work introduces four crucial criteria to locate the sports facilities including population density, accessibility, developmental potential, and adjacency. The highest priority would be the population density as is indicated in Zohrevandian et al. (2016) [14], Ahmadi et al. (2017) [6] and Eslami Marzankalaye et al. (2019) [15] as well. It means the area with a higher population density needs more sports facilities to achieve the standard space per capita.

The second criterion is the accessibility of the facilities for which the access level to the public and private transportations must be studied. Our results are compatible with the works of McCormack et al. (2004) [9], Riva et al. (2007) [12], Oh and Jeong (2007) [11], Panter and Jones (2008) [10], Norozi Seyed Hoseini et al. (2014) [7], Higgs et al. (2015) [13], Zohrevandian et al. (2016) [14], Ahmadi et al. (2017) [6], Eslami Marzankalaye et al. (2019) [15], Vich et al. (2019) [16]. They all name the accessibility of the sports facilities as an effective factor in the users participation in physical activities.

The third criterion is developmental potential. The lack of available spaces in cities creates restrictions for the urban planners and decision-makers. Thus, to increase the possibility of the plan and avoid heavy probable compensations and fines, it is recommended to select locations with a high potential of interfering. The results of the works of Zohrevandian et al. (2016) [14], Ahmadi et al. (2017) [6] and Eslami Marzankalaye et al. (2019) [15] show that locations with higher potential for interference would be in the higher priorities in the planning procedure.

The fourth criterion is adjacency to the compatible spaces (like parks, culture centres) and incompatible spaces (like a hospital, polluted area) that need to be considered. The location must be chosen considering the compatibility of the vicinity to the sports activities. It requires a deep knowledge of the structural and operational features of the adjacent activities. Studies by Norozi Seyed Hoseini et al. (2014) [7], Zohrevandian et al. (2016) [14] and Ahmadi et al. (2017) [6] show the importance of this criterion.

Using AHP in a GIS environment is an effective tool in finding the location of the sports facilities; it allows the planners to compare and evaluate different sites and select the most suitable place based on the accepted criteria. The proposed model is capable of use in different areas. The only requirement would be updating the criteria based on the local area's features which do not affect the efficiency.

5. Conclusion

The theoretical model has been developed using the Delphi method in three stages based on experts opinions. It contains 6 steps: 1. Aim; 2. Verification of the functional area of the existing sport facilities and specific restrictions of the area; 3. Introducing and weighting the important criteria in the sports facilities location; 4. Identifying the most suitable locations for constructing the sports facilities; 5. Evaluating the needs of users; 6. Selecting the best spaces and prioritizing them.

The suitable locations for the new sports facilities can be identified and compared based on the proposed model. We suggest that the bodies responsible for providing the new sports facilities investigate the dispersion and per-capita space of the existing facilities then build the new ones considering the crucial criteria and following the mentioned steps; furthermore, the findings of the present work can be effectively used for improving the quality and quantity of these facilities.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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