AHP/ANP IN SPORTS: A COMPREHENSIVE LITERATURE REVIEW

Seyhan Nisel
School of Business, Istanbul University
Turkey
sipahi@istanbul.edu.tr

Muhlis Özdemir
School of Business, Istanbul University
Turkey
muhlisozdemir@istanbul.edu.tr

ABSTRACT

Since the invention of AHP/ANP, several literature review studies have been presented to summarize theoretical developments and different application areas of its techniques. The purpose of this study is to present a comprehensive literature review of AHP and ANP applications in the field of sports. A total of 62 sports related AHP and ANP articles were selected, categorized and analyzed in this study. The findings show that AHP and ANP techniques have successfully been used for performance evaluation of teams, player selection and ranking, team or club performance ranking and coach evaluation in many sport branches.

Keywords: AHP; ANP; sport applications; literature review

1. Introduction

The Analytic Hierarchy Process (AHP) technique, developed by Thomas L. Saaty in the 1970s, is a multi-criteria decision making technique that can incorporate both objective and subjective judgments in the decision making process. It can deal with complex decision problems by decomposing the problem into a hierarchical structure, and it has been widely used in many areas of science, engineering, business and management in the last four decades. The Analytic Network Process (ANP) technique, which is a generalization of AHP and developed by Saaty in the late 1990's, can deal with dependencies and feedback in the hierarchy that looks more like a network (Saaty, 2001). Although its methodological structure is more complex than the AHP algorithm, there are numerous real world applications of ANP in many fields and it has been used as an accurate decision making tool in the last 20 years.

Since its inception, AHP has been studied extensively and has become a prominently used technique in the literature. As a result, several literature review studies have been conducted to summarize theoretical developments and different application areas of AHP and ANP techniques. Firstly, Shim (1989) provided a comprehensive bibliographical survey of studies on AHP. The study used the DIALOG online information retrieval

service and 141 references of methodological and applied papers as well as 21 dissertation studies on AHP for the period from 1979–1988 were categorized. Vargas (1990) presented a literature review study of AHP and its applications. This study stated that AHP was a relatively young theory and was finding more advocates in both the theoretical and the applied sciences day by day. It also allocated and classified AHP related papers by area such as economic/management problems, political problems, social problems, technological problems and books of applications. In another study, Apostolou and Hassell (1993) reviewed AHP papers in accounting literature, and presented a discussion of the AHP and its applications in accounting throughout the years. Vaidya and Kumar (2006) grouped the references regionally and yearly in order to track the increase of applications of AHP. Liberatore and Nydick (2008) presented a literature review of the application of the AHP in medical and health care decision making since 1997. In this study, 50 papers were classified by diagnosis, patient participation, therapy/treatment, organ transplantation, project and technology evaluation and selection, human resource planning, and health care evaluation and policy (Liberatore & Nydick, 2008). Ho (2008) gathered related articles that appeared in international journals from 1997 -2006 and reviewed the literature of the applications of the integrated AHPs. This paper stated that mathematical programming, quality function deployment, meta-heuristics, SWOT analysis and Data Envelopment Analysis (DEA) were commonly combined with the AHP in integrated studies.

Sipahi and Timor (2010) presented a comprehensive literature review of applications of AHP as well as ANP for the years 2005-2009. The paper also covers fuzzy AHP and fuzzy ANP applications (Sipahi & Timor, 2010). Ishizaka and Labib (2011) theoretically reviewed AHP articles rather than classifying them by application areas. In their study, they discussed problem modelling, pairwise comparisons, judgment scales, derivation methods, consistency indices, incomplete matrix, synthesis of the weights, sensitivity analysis and group decisions issues (Ishizaka & Labib, 2011). Subramanian and Ramanathan (2012) reviewed and methodologically analyzed applications of AHP in operations management between the years 1990-2009. They categorized 291 application papers of AHP into operations strategy, process and product design, planning and scheduling resources, project management, managing the supply chain (Subramanian & Ramanathan, 2012). AHP based approaches for supplier evaluation were studied by Bruno et al (2012). In their study, they highlighted the weak and strong points emerging from the implementation of the AHP in a supply chain (Bruno et al., 2012). Finally, Russo and Camanho (2015) presented a systematic review of the literature on real cases that applied AHP to evaluate how the criteria were being defined and measured. Here, 33 cases used in the literature to build the criteria and calculate the weights in AHP or Fuzzy AHP contrary to other techniques which were used to evaluate alternatives were reviewed (Russo & Camanho, 2015).

Since the 1980's, the AHP methodology has been widely used in the field of sports. In the last two decades, ANP has also been utilized as a decision making tool in several branches of sports. However, a literature analysis about the use of AHP and ANP techniques in the area of sports has not been presented until now. The purpose of this study is to present a comprehensive literature review of AHP and ANP applications in several sports branches. The paper is organized as follows. The process of the research methodology is described in the next section. Analysis and classifications of the literature

are presented in section 3. In this section, articles are categorized and discussed by purpose of study and by sports branch. The last section is devoted to conclusions, remarks and suggestions for future research.

2. Research methodology

To conduct a comprehensive literature search on sports applications of AHP and ANP, peer reviewed journal articles written in the English language from 1980-2016 were carefully retrieved from the ISI Web of Science, ScienceDirect, EbscoHost (Academic Source Premier and Business Source Complete), Emerald, Taylor and Francis, Proquest ABI Inform, Ingenta, Ovid, Medline and InderScience academic databases. Books, book chapters, conference proceedings, and Master's and Doctoral theses were excluded from the study. The *International Journal of the Analytic Hierarchy Process* was also included in the study. During the literature search, studies in all areas of sports including physical activity (competitive or non-competitive) were considered. Four keywords ("Analytic Hierarchy Process", "AHP", "Analytic Network Process", "ANP") combined with "sport" were used in the first searching phase. The second searching phase was broadened, and the AHP and ANP keywords were combined with many sports related descriptors (football (soccer), basketball, baseball, volleyball, Olympic, national games, hockey, tennis, racing, swimming, handball, rugby, American football, cycling, riding, cricket, badminton, archery, chess, polo, golf, gymnastic, physical training and stadium in order to obtain a comprehensive list of articles. A total of 62 articles were identified for the literature review, and all articles were meticulously analyzed in terms of sports relation and in terms of technique(s) used in the study.

Information about 62 articles were coded and recorded in MS Excel under the following categories:

- Publication title
- Source title (Journal name)
- Author(s)
- Affiliation of Author(s)
- Publication year
- Branch(es) of sport
- Methodology or methodologies used (AHP, ANP and other integrated techniques)
- Problem definition
- Number of citations in Google Scholar (As of November 19, 2016)

Articles were categorized and analyzed according to several questions. Section 3 presents the classifications and analysis of the literature.

3. Classifications and analysis

3.1 Number of publications by AHP and ANP

As presented in Table 1 and Figure 1 the AHP method was used significantly in the studies. Out of 62 articles, 32 directly used AHP for the decision-making problem, while

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19 integrated AHP with some other techniques. The technique that was most often integrated with AHP was TOPSIS, followed by DEA, Delphi method and ANP respectively (Figure 1). In Table 1 and Figure 1, some studies were counted more than once for collaborative techniques (for instance, a study which integrated AHP and ANP was counted as AHP integrated study and also ANP integrated study).

Table 1
Number of publications of AHP and ANP

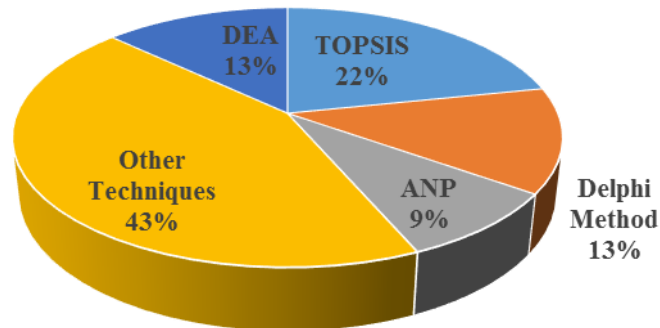| Method	Number of Publications
AHP studies	32
AHP integrated Studies	19
ANP	3
ANP integrated Studies	2
Fuzzy AHP	5
Fuzzy AHP integrated Studies	3
Total	**64**

Figure 1. Percentages of integrated methods with AHP

In Figure 1, other techniques (43%) integrated with AHP were input output analysis, SAW, entropy method, regression tree, decision tree, DEMATEL, grey systems, ANOVA, GIS and causality diagram. The publications that integrated AHP and these techniques in the field of sports were classified and are presented in the following sections.

3.2 Percentage of publications by different period of time
Figure 2 shows the percentage of publications by the period of time they were published. As can be seen, only 10% of the publications were published before the year 2000. Between the years 2000-2009, the number of papers increased with 22% of the papers belonging to that time period. However, between the years 2010-2016, the number of publications increased significantly with 68% of the publications published in the last

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seven years. This figure demonstrates a significant increase in the number of publications of AHP in the field of sports in recent years.
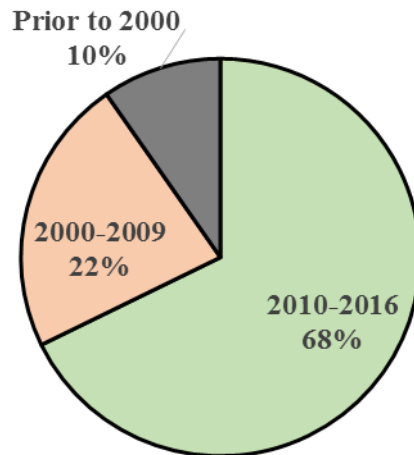

Figure 2. Percentages of number of publications by different time period

3.3 Classification by country (author affiliation)

Table 2 presents the frequency distribution of papers by author affiliation. As shown in the Table 2, China has the largest number of publications in the field with 17 papers followed by the US (14 papers) and Iran (6 papers). Korea (5), Taiwan (5), Croatia (4), and Turkey (4) are other significant contributing countries in the field with a number of papers. India, Israel and Japan are the other countries that have contributions. Switzerland, Finland, Georgia, Kenya, and Poland are countries that have at least one paper contributed to the field. As can be seen from the table, authors from 15 different countries used AHP or ANP techniques in the sports field in their studies. Four publications were counted more than once for collaborative studies.

Table 2
Number of publications by country (author affiliations)

Country Name (Affiliation of Authors)	Number of Publications	Country Name (Affiliation of Authors)	Number of Publications
China	17	Israel	2
US	14	Japan	2
Iran	6	Switzerland	1
Korea	5	Finland	1
Taiwan	5	Georgia	1
Croatia	4	Kenya	1
Turkey	4	Poland	1
India	2		
Total			**66**

3.4 Classification by journal

According to literature search results, six papers out of sixty-two were published in the journal entitled *Advanced Materials Research* (see Table 3). Table 3 also indicates that *Applied Mechanics and Materials* and *Collegium Antropologicum* made contributions to the field with four and three papers respectively.

Table 3
Top journals by number of publications

Journal Name	Number of publications
Advanced Materials Research	6
Applied Mechanics and Materials	4
Collegium Antropologicum	3
Interfaces	2
International Journal of Analytic Hierarchy Process	2
Mathematical and Computer Modeling	2
Other Journals	43
Total	**62**

Interfaces, *International Journal of Analytic Hierarchy Process* and *Mathematical and Computer Modeling* are also significant journals with two publications each. Forty-three different journals contributed at least one publication to the sports field with AHP or ANP models.

Journals were also classified by the total number of citations of the publications in the literature search. Table 4 shows the top fifteen journals with the highest number of citations. The number of citations of the publications was obtained from Google Scholar on November 19, 2016. When the number of citations is considered, *European Journal of Operational Research* has the highest number of citations (216) with just one paper followed by *Interfaces* (107) and *Collegium Antropologicum* (89) respectively. In Table 5, the top ten most highly cited papers have also been presented.

Table 4
Top journals by number of citations

Journal Name	Number of Citations of Publications
European Journal of Operational Research	216
Interfaces	107
Collegium Antropologicum	89
Sport Management Review	61
Journal of the Operational Research Society	35
Journal of the operations research Society of Japan	29
Sport, Business and Management: An International Journal	25
Computers & Operations Research	24
Management Decision	22
Mathematical Modelling	21
Mathematical and Computer Modelling	13
American Journal of Operations Research	12
Expert Systems with Applications	12
Journal of Multi-Criteria Decision Analysis	12
Journal of Systems Science and Systems Engineering	10

Table 5
Top 10 most highly cited papers (Google Scholar, November 19, 2016)

Publication Name	Methodology Used	Branches of Sport	Number of Citations (11/19/2016)
Partovi, F. Y., & Corredoira, R. A. (2002). Quality function deployment for the good of soccer. *European journal of operational research*, *137*(3), 642-656.	AHP & QFD & ANP	Football	216
Carlsson, C., & Walden, P. (1995). AHP in political group decisions: A study in the art of possibilities. *Interfaces*, *25*(4), 14-29.	AHP	Ice hockey	97
Trninić, S., & Dizdar, D. (2000). System of the performance evaluation criteria weighted per positions in the basketball game. *Collegium antropologicum*, *24*(1), 217-234.	AHP	Basketball	79
Lee, S., & Walsh, P. (2011). SWOT and AHP hybrid model for sport marketing outsourcing using a case of intercollegiate sport. *Sport Management Review*, *14*(4), 361-369.	AHP & SWOT	General	61
Sinuany-Stern, Z. (1988). Ranking of sports teams via the AHP. *Journal of the Operational Research Society*, *39*(7), 661-667.	AHP	Football	35
Nishizawa, K. (1995). A consistency improving method in binary AHP. *Journal of the operations research Society of Japan*, *38*(1), 21-33.	AHP	Baseball, Tennis	29
Lee, S., & Ross, S. D. (2012). Sport sponsorship decision making in a global market: An approach of Analytic Hierarchy Process (AHP). *Sport, Business and Management: An International Journal*, *2*(2), 156-168.	AHP	General	25
Bodin, L., & Epstein, E. (2000). Who's on first–with probability 0.4. *Computers & Operations Research*, *27*(3), 205-215.	AHP	Baseball	24
Liao, S. K., & Chang, K. L. (2009). Select televised sportscasters for Olympic Games by analytic network process. *Management Decision*, *47*(1), 14-23.	ANP	Olympic Games	22
Vachnadze, R. G., & Markozashvili, N. I. (1987). Some applications of the analytic hierarchy process. *Mathematical Modelling*, *9*(3-5), 185-191.	AHP	Relay race	21

3.5 General classification by branches of sports

Football (or soccer in US originated studies) was found to be the most popular sport in AHP or ANP studies during the literature search. Table 6 shows a large amount of papers were related to football (13 publications). Basketball is the second most popular sport with nine publications, followed by baseball and the Olympic Games with seven publications each. Athletics, hockey and tennis were also found to be significant sports in the literature. American football, badminton, cricket, and physical education branches can also be considered significant with two publications each. In the literature, AHP was

used in many other branches of sports. Moreover, several studies that were not directly related to any specific branch of sports, but related to the sports field in general were also found in the literature. These studies were categorized as "other sports or general studies" in Table 6, and they are mentioned in more detail in the Section 3.10 and also presented in Table 11. Studies that discussed more than one sports branch were counted more than once.

Table 6
Top 10 highly cited papers (Google Scholar, November 19, 2016)

Sport Branches	Number of Publications	Sport Branches	Number of Publications	Sport Branches	Number of Publications
Football	13	Athletics	4	Badminton	2
Basketball	9	Hockey	4	Cricket	2
Baseball	7	Tennis	3	Physical education	2
Olympic and National Games	7	American Football	2	Other sports and general studies	16
TOTAL: 71					

3.6 Football studies

As mentioned in the previous section, football has a dominant place among AHP studies in the field of sports. Thirteen out of sixty-two articles applied AHP to the football field, and TOPSIS was the technique mainly integrated with AHP in football related studies. As can be seen in the Table 7, since the year 1987, the AHP technique has been used for performance evaluation of football teams, player selection, selection of Golden Ball winners, trainer and coach evaluation, ranking teams and clubs, world cup football tournament evaluation, factor evaluation of rules, measuring football performance and comparing the great records.

3.7 Basketball studies

Basketball was found to be the second most popular sport among AHP studies. As presented in the Table 8, a large portion of the studies were carried out after the year 2000, and five studies out of nine were performed in 2014. Tang and Dong (2014) presented an AHP-DEA integrated model for selecting the best coaches in basketball, baseball and hockey. Cao (2014) also used AHP for coach evaluation in basketball. In another study, Balli and Korukoglu (2014) utilized Fuzzy AHP and TOPSIS for developing a decision support framework for the selection of player candidates in basketball. Also, Wan et al. (2014) used AHP and Input-Output Analysis for coach evaluation in basketball, American football and baseball, whereas Xiong et al. (2014) used AHP, fuzzy synthetic evaluation and entropy method for coach evaluation in basketball. Table 8 shows that the AHP technique was also used in basketball for performance evaluation of players, evaluation of basketball teams, performance evaluation in the game , and for selecting and comparing a number of great records in basketball, baseball, football and hockey (Yu et al.; Sinuany-Stern, 2006; Trninić and Dizdar, 2000; Golden and Wasil, 1987).

3.8 Baseball studies

In the literature search, baseball was also found to be a popular sport in AHP studies. Table 9 shows seven studies out of sixty-two were related to baseball. Table 9 also shows that some other multi-criteria decision-making techniques such as DEA, TOPSIS and input output analysis were integrated with AHP in the studies conducted in 2014. Coach evaluation, pitcher selection, player and team ranking, and performance evaluation of players were popular subjects in AHP related studies in the baseball field.

Table 7
Football studies

Publication Name	Authors	Year	Method	Problem Definition
A mathematical model using AHP priorities for soccer player selection: a case study	Ozceylan, E	2016	AHP	Soccer player selection
Who really won the FIFA 2014 Golden Ball Award?: What sports can learn from multi-criteria decision analysis	Mu, E.	2016	AHP	Selecting the Golden Ball winner
Privatization priorities of Iranian football clubs from the perspective of experts	Shahlaee, J., Ghorbanalizadeh Ghaziani, F.	2015	AHP, TOPSIS, SAW	Measuring privatization priorities of Iranian football clubs
Data processing and modelling with information technology in choosing college best trainer	Li, P. L	2014	Delphi method, AHP	Choosing a good college trainer
An MCDM reflection on the FIFA 2014 World Cup	Mu, E.	2014	AHP	Selecting the Golden Ball award winner
Prioritization of the factors effecting privatization in sport clubs: with AHP & TOPSIS methods-emphasis in football	Salimi, M. et al.	2012	AHP, TOPSIS	Prioritization of the factors effecting privatization in sport clubs
Ranking football teams with AHP and TOPSIS methods	Kiani Mavi, R. et al.	2012	AHP, TOPSIS	Ranking football teams
Evaluating the performance of Iranian football teams utilizing linear programming	Hamidi, M. et al.	2011	DEA, AHP	Evaluating the performance of Iranian football teams utilizing linear programming
FARSJUM, a fuzzy system for ranking sparse judgment matrices: a case study in soccer tournaments.	Gholamian, M. R. et al.	2007	AHP	World Cup soccer tournament evaluation
Importance of hierarchical structure determining tennis performance for modern defensive baseliner	Yun, Y. K.	2005	AHP	Prioritizing psychological factors determining football performance
Quality function deployment for the good of soccer	Fariborz Y. Partovi, Rafael A. Corredoira	2002	AHP,QFD, ANP	Prioritizing and designing rule changes for the game of soccer
Ranking of sports teams via the AHP	Sinuany-Stern, Z.	1988	AHP	Predicting the ranking of the 16 soccer teams of the Israeli National League
Ranking outstanding sports records	Golden, B. L., Wasil, E. A.	1987	AHP	Selecting and comparing a number of great records

Table 8
Basketball studies

Publication Name	Authors	Year	Method	Problem Definition
Assessment of coaches using Data Envelopment Analysis and Analytical Hierarchy Process	Tang, H. C., Dong, Y. A.	2014	AHP, DEA	Selecting the best coaches
Coach evaluation method based on AHP	Cao, X.	2014	AHP	Coach evaluation
Development of a fuzzy decision support framework for complex multi-attribute decision problems: A case study for the selection of skilful basketball players.	Ballı, S., Korukoğlu, S.	2014	Fuzzy AHP, TOPSIS	Developing a decision support framework for player selection
Evaluation of College Coach Capacity in USA	Wan, F. X., Hu, D., Tian,	2014	AHP, Input Output Analysis	Coach evaluation
Evaluation system for college coaching legends	Xiong, F. et al.	2014	AHP, Fuzzy Synthetic Evaluation, Entropy Method	Coach evaluation
An exploratory study of long-term performance evaluation for elite basketball players	Kun-Tzu Yu, Zhong-Xin Su, Rui-Chen	2008	AHP	Long-term technical performance evaluation method for elite basketball players
Application of the analytic hierarchy process for the evaluation of basketball teams	Zilla Sinuany-Stern	2006	AHP	Evaluation of basketball teams
System of the performance evaluation criteria weighted per positions in the basketball game	S. Trnini, and D. Dizdar	2000	AHP	Performance evaluation criteria weighted per positions in the basketball
Ranking outstanding sports records	Golden, B. L., Wasil, E.	1987	AHP	Selecting and comparing a number of great records

Table 9
Baseball Studies

Publication Name	Authors	Year	Branch of Sport	Method	Problem Definition
Assessment of coaches using Data Envelopment Analysis and Analytical Hierarchy Process	Tang, H. C., Dong, Y. A.	2014	Baseball, Hockey, basketball	AHP, DEA	Selecting the best coaches
Professional baseball team starting pitcher selection using AHP and TOPSIS methods.	Chen, C. C., Lee, Y. T., Tsai, C. M.	2014	Baseball	AHP & TOPSIS	Selecting starting pitchers
Evaluation of college coach capacity in USA	Wan, F. X., Hu, D., Tian, J.	2014	Basketball, American football, baseball	AHP, Input Output Analysis	Coach evaluation
Who's on first–with probability 0.4.	Bodin, L., Epstein, E.	2000	Baseball	AHP	Ranking players of a baseball team
A consistency improving method in binary AHP	Nishizawa, K.	1995	Baseball, Tennis	AHP	Ranking teams in league
An analytic hierarchy approach to major league baseball offensive performance ratings	Lanoue, M. R., & Revetta, J. J.	1993	Baseball	AHP	Performance evaluation of major league players
Ranking outstanding sports records	Golden, B. L., Wasil, E. A.	1987	Baseball, basketball, football,hockey	AHP	Selecting and comparing a number of great records

Table 10
Studies about Olympic or National games

Publication Name	Authors	Year	Branch of Sport	Method	Problem Definition
Ranking countries more reliably in the Summer Olympics	Sagir, M., Saaty, T. L	2015	Olympic Games	ANP	Evaluating the medals won and the country scores in the 2012 London Olympics
Ranking countries by medal priorities won in the 2014 Sochi Winter Olympics.	Saaty, T. L. et al.	2014	Olympic Games	AHP	Ranking countries
Rankings in sport by pairwise comparison and league table	Sitarz, S.	2013	Olympic Games	AHP	Describing a method of creating rankings in sport (medal tables).
On emergency of large scale engineering sports events	Junying, A.	2012	National Games	Fuzzy AHP	Emergency assessment
Who won the Winter 2010 Olympics? A quest into priorities and rankings.	Saaty, T. L.	2010	Olympic Games	AHP	Assigning appropriate weights to each type of medal
Select televised sportscasters for Olympic Games by analytic by network process	Sen-Kuei Liao, Kuei-Lun Chang	2009	Olympic Games	ANP	Selecting televised sportscasters for Olympic Games
Who won the 2008 Olympics? A multicriteria decision of measuring intangibles	Saaty, T. L.	2008	Olympic Games	AHP	Country ranking in 2008 Olympic Games

3.9 Studies about Olympic games or national games

The literature search revealed that AHP and ANP methodologies have also been used in several studies as decision-making tools in the field of Olympic Games or National Games. Seven studies have been conducted since 2008, and Table 10 shows that Thomas L. Saaty was the author that contributed the most AHP studies in the field of Olympic Games. Sagir and Saaty (2015) presented an ANP model for evaluating the medals won and the country scores in the 2012 London Olympics. Saaty et al. (2014) utilized AHP for ranking countries by medal priorities in the 2014 Sochi Winter Olympics. In another study, Sitarz (2013) described a method for obtaining ranking of medal tables in the Olympic Games using AHP. Junying (2012) presented a fuzzy AHP model for emergency assessment in national games. Saaty (2010) used AHP again for assigning appropriate weights to each type of medal in the Winter 2010 Olympics. Liao and Chang (2009) used the ANP technique for selecting televised sportscasters for the Olympic Games. In the earliest study, Saaty (2008) used AHP for obtaining a country ranking in the 2008 Olympic Games. The studies reviewed and shown in Table 10 conclude that AHP and ANP techniques can be successfully applied to obtain and develop a medal or country ranking system in the Olympic Games.

3.10 Other sports and general studies

Besides football, basketball, baseball and the Olympic Games, AHP and ANP techniques have also been used in many other areas of sports in the last 25 years. These sport branches are athletics, hockey, tennis, American football, badminton, cricket, physical training, archery, golf, judo, leisure sports, relay race, running, swimming, volleyball and water polo. Table 11 summarizes the studies in these branches of sport. During the literature search, it became apparent that some studies were not directly related to any branch of sports. In these general studies, the AHP technique was used for performance evaluation of sport centers, assessing performance of sports buildings, risk evaluation for stadium construction, and factor evaluation for sport marketing outsourcing decision.

Table 11
Studies about other sports and general studies

Publication Name	Authors	Year	Branch of Sport	Method	Problem Definition
Study on the influencing factors of applying nanotechnology in sport injury repair based on Analytic Hierarchy Process	Ding, L.	2016	Athletics	AHP	Analyzing main factors influencing the application of nanotechnology in athletes injury repair
Importance of hierarchical structure determining tennis performance for modern defensive baseliner	Đurović, N., Dizdar, D., Zagorac, N.	2015	Tennis	AHP	Analyzing offensive and defensive tennis priorities for counterpunchers
The relative importance of performance factors in Korean archery	Kim, H. B., Kim, S. H., So, W. Y	2015	Archery	Delphi method, AHP	Evaluating factors affecting archery performance
AHP-neural network based player price estimation in IPL	Dey, P. K. et all.	2014	Cricket	AHP, ANP	Player price estimation
Choose the best coach based on the rheory of grey system	Zhao, J.	2014	Athletics	Grey system, AHP	Selecting the best college coaches
Coaches ranking: A time-irrelevant data mining solution with flexibility and objectivity	Chen, Y. Y. et all.	2014	Athletics	Regression tree, decision tree (CART), AHP	Ranking of coaches
Establishment on comprehensive evaluation indication system for leisure sports development level	Zhang, L., Wang, Z. L.	2014	Leisure sports	AHP	Evaluating the present situation of leisure sports development level
Evaluation of sports center performance using a fuzzy multi-criteria decision-making model	Wang, C. Y	2014	General	Fuzzy AHP	Evaluate the performance of sports centers
Evaluation research on competitive ability of volleyball player based on fuzzy set of evaluation index and weight	Kai, G.	2014	Volleyball	AHP	Evaluating the competitive ability of volleyball player
Identifying the best Coach by an improved AHP model	Xing, J. et all.	2014	American Football	AHP	Evaluation of coaches in college ball game
Selection and concentration strategy in the sports exchange between North and South Korea.	Yu, K. G., Park, S. Y.	2014	General	Delphi method, AHP	Strategy selection and concentration in inter-Korean sports exchange
The practice of two-phase recommender system for sporting goods	Lo, W. T. et all.	2014	Badminton	AHP	Developing a recommendation technique to improve the selling of sporting goods specialty stores
Why do some elite players accomplish their Grand Slam goals while others fail?	Djurovic, N. et all.	2014	Tennis	AHP	Accelerating the player's development
Constructing Taipei city sports centre performance evaluation model with fuzzy MCDM approach based on views of managers	Wang, C. Y. et all.	2013	General	FAHP, FANP, Dematel	Recognizing the influential indicators of sport centre business management in Taipei city's sports centre

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Table 11
Studies about other sports and general studies (Continued)

Publication Name	Authors	Year	Branch of Sport	Method	Problem Definition
Research on the preventive measures of sports injury based on causality diagram and analytic hierarchy process	Zhou, Z. X	2013	Physical education	Causality diagram, AHP	Analyzing the factors of injury accident in physical education teaching process
The green energy-saving design of stadium	Chen, X. J.	2013	General	AHP	Assessing environmental performance of green sports building
Efficiency analysis of provincial departments of physical education in Iran	Soleimani-Damaneh J. et all.	2012	Physical education	DEA, AHP	Analyzing the performance of physical education organizations in Iran.
Forecasting rounds of golf	Parrott, S. et all.	2012	Golf	AHP	Making adjustments to statistical forecasts of golf demand at a course
Sport sponsorship decision making in a global market: An approach of Analytic Hierarchy Process (AHP).	Lee, S., Ross, S. D.	2012	General	AHP	Identifying the decision making factors of sport sponsorship in the global market context
Statistical based multi-criteria decision making analysis for performance measurement of batsmen in Indian Premier League	Dey, P. K., et all.	2012	Cricket	TOPSIS, AHP, ANOVA	Measuring the performance of batsmen
Fuzzy Analytic Hierarchy in project risk management-New stadium construction project in Weifang City	Zhang, Y., Liu, C. J	2011	General	Fuzzy AHP	Construction project risk assessment
SWOT and AHP hybrid model for sport marketing outsourcing using a case of intercollegiate sport	Lee, S., Walsh, P.	2011	General	AHP, SWOT	Examining sport marketing outsourcing decision-making factors using a SWOT and AHP combined model
Evaluation of individual and team judo strengths using AHP technique and team competition data	Hirose, N. et al.	2010	Judo	AHP	Evaluating individual and team judo strengths
Developing computer aided model for selecting talent players in badminton	Ali Agilonu, Serkan Balli	2009	Badminton	Fuzzy AHP	Selecting talent players in badminton
Efficient management design for swimming exercise treatment	Kim, K. et al.	2009	Swimming	Fuzzy AHP	Design a swimming-based exercise treatment management system
Experts opinion about system of the performance evaluation criteria weighted per positons in the water polo game	Hraste, M., Dizdar, D., Trninić, V.	2008	Water polo	AHP	Water polo players' actual quality evaluation
Should a new arena be built in the city of Pittsburgh?	Stacy Monarkoa, et all.	2007	Hockey	ANP	Eecision analysis for building a new arena
Using geoinformatics to identify suitable middle to long distance Athletics' rraining sites in Kenya	John Kiema et al.	2007	Running	GIS, AHP	Selecting suitable training sites for endurance running
AHP in political group decisions: A study in the art of possibilities	Carlsson, C., Walden, P.	1995	Ice hockey	AHP	Finding the optimal location for a new ice-hockey arena
Some applications of the analytic hierarchy process	Vachnadze, R. G., Markozashvili, N. I.	1987	Relay race	AHP	Electing team members and their distribution for relay-race stages

4. Conclusion

Sporting has become one of the fastest growing areas of industry and entertainment worldwide. In almost all competitive sports branches, it is obligatory to consider all success factors in order to be successful or to win the game. Developing tactical strategies and kicking styles, managing time wisely during a game, changing players in the proper period, tactical movements, making decisions quickly, selecting proper players for positions, and building a technical game structure, all require professional decision making abilities. Therefore, since the 1970's, managers, professionals and fans have applied many statistical tools and models in order to analyze sports data systematically in many areas of sports.

As a result of the comprehensive literature analysis, it was concluded that AHP and also ANP techniques were successfully used in many areas of sport such as football (or soccer), basketball, baseball, the Olympic Games, athletics, hockey, tennis, American football, badminton, cricket, physical training, archery, golf, judo, leisure sports, relay race, running, swimming, volleyball and water polo. The methods were used mainly for performance measurement, team or player evaluation and ranking, prediction of failure, coach evaluation, rule evaluation in a game, measuring technical efficiency, and for sports marketing. There has also been a significant increase in the number of AHP studies in the sports field especially in the last five years, and it is estimated that this trend will continue as more statistical data will be available for researchers, and the worldwide popularity of many sports branches will continue to grow. We hope that this literature review will guide researchers towards the advancement of AHP and ANP applications in many sport fields.

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