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Original Article

The Applications of Artificial Intelligence in Performance Analysis to Obtain Data for Developing Training Programs for Handball Players

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Abstract

With the rapid and comprehensive scientific advancements across all fields, it has become essential to utilize various scientific disciplines to enhance athletic performance and akaeve desired excellence. Given that sports practice is interconnected with many other sciences, it is now critically important for sports professionals to recognize and understand scientific discoveries that can be adapted to improve athletic performance. This study aimed to examine the impact of AI applications in analyzing handball players' performance by assessing through the current use of AI in obtaining handball training data. As well, requirements for implementing AI in handball match analysis using a descriptive methodology, questionnaires were administered to technical/administrative staff and performance analysts (67) persons from Egyptian Handball League clubs. After pilot testing (11), the final sample comprised 56 participants. Key Findings were that AI enhances technical and administrative workflows in handball teams, Clubs must adopt AI to generate essential player performance metrics and Handball coakang requires modern technologies to align with global performance analysis trends.

Keywords:-*Artificial Intelligence, Training Programs, Handball*

Introduction

With the rapid and comprehensive scientific advancements across all fields, it has become essential to utilize various scientific disciplines to enhance athletic performance and akaeve desired excellence. Given that sports practice is interconnected with many other sciences, it is now critically important for sports professionals to recognize and understand scientific discoveries that can be adapted to improve athletic performance.

Abdul Sattar Al-Dammad (2019) notes that Artificial Intelligence (AI) has become one of the most effective technologies, making a strong and tangible impact capable of bringing about comprehensive changes in the business environment. AI aims to design makanes that can akaeve specific goals in ways similar to or even surpassing human capabilities. It consists of specific algorithmic "software" running on computers or computer networks that solve problems and make decisions logically and systematically, mimicking human thought

processes. AI enables makanes to assist users in managing tasks with minimal effort, reducing the need for additional human mental and physical exertion. Among its key benefits are: Eliminating repetitive tasks, saving time, enabling deeper specialization, Accelerating routine tasks, Conducting in-depth data analysis to produce highly accurate results (4:17).

The sports sector has long used statistics and data analytics, making it fertile ground for AI and makane learning applications. These technologies have significantly contributed to the rapid growth of sports, making them sought-after solutions for akaeving competitive superiority.

Faisal Al-Mulla (2019) highlights how AI technologies have begun widespread adoption across various sports domains, demonstrating multiple applications. Recent global experiments have proven AI's capability to enhance athlete performance by: (1) monitoring players' tactical adherence during matches, and (2) developing smart training programs that assess player skills, evaluate performance levels, and deliver customized training tailored to each athlete's capabilities (7:18).

The Executive Summary of AI in Sports (2022) identifies key benefits of AI applications in sports: Optimizing training investments based on player performance data, improving match outcome predictions and league strength assessments, Enhancing movement precision and result accuracy in athletic performance (3:1).

Mohamed El-Meligi (2023) emphasizes AI's potential to help teams: Reduce time/costs (e.g., automating video analysis), Create personalized training programs, Level the competitive field - small teams can access the same data tools as elite clubs Industry projections estimate the sports AI market will reach $19.2 billion by 2030.

Practical applications include Big data analysis to identify patterns (optimal training methods, player techniques), Strategic decision-making support, Deepened sport-specific understanding (9:310).

AI in Virtual Reality Training and Decision Support Systems Virtual Reality Training Applications: Artificial Intelligence is increasingly being utilized to develop virtual reality training environments that enhance athlete performance. Several major sports organizations have already implemented AI solutions: The National Football League (NFL) employs AI for comprehensive player performance video analysis, Major League Baseball (MLB) leverages AI to optimize player roster decisions, The National Basketball Association (NBA) utilizes AI to enhance talent scouting processes (9:54)

Fayza Al-Najjar (2010) identifies seven fundamental capabilities of AI systems: Incomplete Data Processing: Effective problem-solving despite missing information, Cognitive Processing: Ability to think, perceive, acquire, and apply knowledge, Experiential Learning:

Capacity to learn from historical data and past experiences, Knowledge Utilization: Adaptive application of prior knowledge to new situations, Complex Scenario Management: Competence in handling difficult and multifaceted cases, Visual Interpretation: Creative conceptualization and understanding of visual information, Decision Support: Generating actionable insights for administrative decisions (6:170)

Nahed Raheem (2014) confirms that artificial intelligence applications can be implemented in sports through Expert Systems - the foundational AI application that provides solutions to problems as they arise. These systems contain vast knowledge databases comparable to human expertise in specific domains (including particular sports). Many such programs have demonstrated remarkable effectiveness, confirming their high potential in this field, Expert Systems operate by: Acquiring knowledge from human experts, Structuring this knowledge for computational application, Processing specialized, input data through automated software, Generating expert-level responses that closely approximate human problem-solving capabilities for complex issues (12:47).

Caferra (2011) further identifies several key domains of artificial intelligence applications: Natural Language Processing (NLP), Enables computers to understand and process human language, Allows direct command input in natural language, Facilitates human-computer conversation, Speech Recognition, Processes human speech through:, Audio input reception, Sound reassembly, Voice pattern recognition, Appropriate response generation, Computer Vision, Equips computers with optical sensors, Enables identification of, Individuals, Objects, Visual patterns, Robotics, Electro-mechanical systems that, Execute specific commands from host computers, Incorporate AI capabilities for, Movement, Environmental understanding,Response to external stimuli, Makane Learning, Key applications include:, Automated reinforcement learning, Educational technology implementations, Human-makane interaction systems, Multi-talent systems, Neural network applications (14:41-42)

The General Organization for Technical and Vocational Training (2018), as cited by Samah Halawa (2020), emphasizes that artificial intelligence is poised to enter the world of sports. They stress the need to prepare by establishing a technological infrastructure that enables AI implementation and utilization within sports institutions (2:33).

Egyptian handball has emerged as a sport that has strongly entered global competitions, akaeving a presence marked by brilliance, prestige, and pride. As a sport requiring precise execution and diverse skills that often determine outcomes in world championships, Egyptian national handball players have demonstrated exceptional performance. This has led to their recruitment in top leagues across Europe and beyond, along with akaeving high rankings in international team competitions.

However, a significant paradox exists for this sport with its large fan base and global recognition: it lacks appropriate standing within Egypt itself. The sport suffers from insufficient

research, study, and development efforts needed to cultivate new generations of players who could shine in international handball.

Expert knowledge enables professionals to solve complex problems through various approaches, including empirical methods (like coakang) and the application of conceptual frameworks that guide problem-solving within their domain. Knowledge engineering in expert systems focuses on developing sophisticated computer systems that: Extract knowledge from human experts, systematically organize this knowledge, Transform it into tools for performance enhancement, This process deals not with general information, but rather with specialized, valuable expertise that benefits specific communities.

The role of a performance analyst in sports—particularly in handball—is one of the most vital positions, as it provides the head coach with essential data on opposing teams and key players before and during competitions. This enables the coach to develop tailored training strategies based on up-to-date and accurate performance metrics.

Artificial Intelligence (AI) is defined by Abdel Hamid Bassiouni (2015) as "the art of creating makanes capable of performing tasks that require intelligence when done by humans." (3:147)

Study by Mohamed El-Meligy (2023) (9) Titled: "Artificial Intelligence and the Sports Industry". The study aimed to explore the use of predictive modeling in AI for applications in the sports industry, Findings: Big data sources can directly confirm and focus more on physiological variables rather than the traditional emphasis on personal characteristics, Visual analytics are highly encouraged as a tool for data interpretation, as their presentation can be developed in an interdisciplinary manner to enable contributions from both sports scientists and computer experts,The computational aspect behind big data analysis in sports primarily stems from the expertise of computer scientists, as sports scientists typically lack the programming background required for such technologies.

Study by Issam Layaadi & Acheb Lakhdar (2021) (5) Titled "Models of Artificial Intelligence Applications in Sports Science" aimed to identify models of AI applications in sports science and highlight AI's role in sports training, equipment, and facilities.The study used a descriptive and analytical approach to examine AI application models in sports, with a questionnaire as the data collection tool, Key Findings: AI has significantly contributed to the development of sports training by creating virtual coaches, AI has improved sports equipment design, AI has enhanced the development of sports facilities.

Study by Mohamed Ghazi (2019) (11) titled "A Proposed Vision for Teakang Physical Education Classes Using Artificial Intelligence" aimed to explore the use of AI technologies in teakang physical education classes, The researcher employed a descriptive approach, with physical education teachers as the study sample. A questionnaire was used to analyze three key

criteria (knowledge of the educational aspect – the specialized curriculum to be delivered or learned) as a data collection tool, Key Findings:, The ka-square (χ^2) value reached 90.36%, a high percentage indicating consensus among the sample on the criteria in the first axis (knowledge of the educational aspect and the specialized curriculum), except for the criterion stating: "AI enhances cognitive processes related to developing the physical education curriculum."

4. Study by Mohamed Ismail & Osama Saoudi (2019) (11) titled “A Proposed Model for Implementing AI in Sports Injury Rehabilitation Centers at Premier League Football Clubs" aimed to propose a model for applying AI in sports injury rehabilitation centers within Premier League football clubs.The researchers used a descriptive approach (survey study), applying the research to medical devices at Premier League clubs with a sample size of 67 individuals. A questionnaire was used for data collection, Key Findings: The use of AI improves efficiency and accelerates task completion, The application of AI in sports clubs is well-received by top management, and this technology should be integrated across all sectors of sports institutions, Sports clubs implementing AI (e.g., intelligent agents, fifth-generation computing and modern neural network technologies) can significantly save time and effort.

The core issue addressed in this study revolves around the global prominence of AI technology, which has become one of the most transformative innovations across all sectors—including sports. Over the past two decades, AI models have deeply penetrated sports, contributing to: Enhancing player performance, supporting coaches and administrators in decision-making, Providing predictive analytics for future scenarios, Enabling numerous other applications where AI plays a pivotal role (13).

Moreover, processing a massive amount of data quickly and accurately is precisely what distinguishes "artificial intelligence." In the field of performance analysis in general, it is evident that accurately analyzing performance-related data helps game officials swiftly and precisely guide players toward correct performance, as opposed to relying on manual analyses that remain prone to errors. (8)

The research problem lies in the lack of accurate and necessary data among Egyptian handball coaches regarding the players they train, as well as other players. ** This hinders the ability to quickly adapt training strategies before, during, and after matches to obtain information swiftly and accurately. On one hand, this relates to the requirements of innovation, and on the other, to the applications of artificial intelligence.

The research aims to identify the impact of applying artificial intelligence in analyzing the performance level of handball players through searching the current state of AI applications in obtaining information for handball training, and the requirements for applying AI in analyzing handball matches.

Study Questions:

1- What is the current state of artificial intelligence in the field of handball training?
2- What are the requirements for applying artificial intelligence in analyzing handball matches?

Methods

The researcher used the descriptive approach (survey study) due to its suitability for the nature and procedures of this research.

Participants

The research population was purposively selected from technical and administrative staff, as well as performance analysts of Egyptian Handball League clubs, totaling (67) individuals. A preliminary study sample of (11) individuals was withdrawn, leaving the final research sample at (56) individuals. The following table illustrates the description of the research sample.

Table 1. Description of the participant groups

No.	Sample members	Pilot Study		Main Study	
		Number	%	Number	%
1.	Coaches	15	22,38	2	2,98
2.	Performance Analysts	20	29,85	3	4,47
3.	Administrative Staff	10	14,92	3	4,47
4.	Board Members	11	16,41	3	4,47
Total		56	100%	11	100%

The results of the table (1) indicate the number and percentage of the variables describing the main study participants and the Pilot study group in terms of (job - years of experience - governorate "sub-union").

Procedures

1. Forming the questionnaire

Scientific References and Research: The researcher conducted a literature review of studies, research papers, and scientific books related to this field to utilize them in preparing and designing the questionnaire that would be used for data collection.

Questionnaire Form: The researcher developed a questionnaire to survey the opinions of experts regarding the Axiss and statements of the questionnaire on the reality of applying artificial intelligence in analyzing handball players' performance. The main Axiss of this questionnaire can be outlined as follows: Axis 1: The current state of AI application in performance analysis in handball, Axis 2: The objectives and benefits of applying AI in performance analysis in handball, Axis 3: Challenges of implementing AI in sports clubs, Axis 4 Requirements for implementing AI in sports clubs.

2. Determining the phrases of the questionnaire

This questionnaire was presented to the experts in its preliminary form (see Appendix 1) to provide feedback on the prepared Axiss of the research questionnaire. The following table illustrates the percentage of experts' opinions on these Axes.

Table 2. Percentage Distribution of Experts' Opinions Regarding Questionnaire Axiss on Using Artificial Intelligence in Developing Performance and Training Programs for Handball Players

No.	Axis	Agreement	Agreemant Percentage
1.	Current Status of AI Implementation in Handball Team Training	10	%100
2.	Objectives and Benefits of AI Implementation in Handball Teams	10	%100
3.	Challenges of Implementing AI in Handball Teams	10	%100
4.	Requirements for AI Implementation in Handball Teams	10	%100

The table No. (2) clearly shows the percentage of experts' approval regarding the Axiss of the questionnaire on the actual implementation of artificial intelligence in analyzing handball players' performance. Approval rates for these Axiss reached 100% according to the experts' opinions. Consequently, these Axiss were adopted as the basis for developing relevant statements. The researcher identified a set of specific statements for each Axis, which were then presented to the experts for validation and to determine each statement's appropriateness to its respective Axis. The following table presents the percentage distribution of experts' opinions on the statements within each Axis.

Table 3. Experts' Evaluation of Questionnaire Axis Statements

Statement No	Axis	Agreement No	%
Axis 1: Current State of AI Implementation in Handball Team Training			
1.	AI contributes to activating predictive analytics in handball training.	4	%40
2.	Our team uses AI for handball player performance analysis.	8	%80
3.	Performance analysts utilize this technology in their work with the handball team.	8	%80
4.	Modern technology provides the necessary support for player development.	5	%50
5.	I have received training on how to use these technologies.	5	%50
6.	AI tools like "intelligent agents and fifth-generation computing" enable efficient handball performance analysis.	8	%80
7.	Reliance on modern neural network technologies significantly saves time and effort.	9	%90
8.	AI technology is employed for performance analysis in handball.	8	%80
9.	The club management desires to implement AI technology in the handball department.	8	%80
10.	The club administration seeks training on modern technological programs for handball.	8	%80
11.	Handball teams need modern technologies to keep pace with rapid developments in player performance analysis.	9	%90
12.	The club's computers are programmed to analyze player data.	8	%80
Axis 2: Objectives and Benefits of AI Implementation in Handball Teams			
13.	I believe our club keeps pace with modern technological developments.	8	%80
14.	Connecting players' smartphones to AI technology for sending performance analysis program notifications.	8	%80
15.	Internet of Things can be used to measure the duration of player performance analysis.	9	%90
16.	Using AI helps design customized training programs according to players' levels.	9	%90
17.	AI can establish player metrics and deliver immediate results using these modern technologies.	8	%80
18.	Through technologies, you can remotely control technical devices during performance.	9	%90
19.	Performance analysts using AI helps determine/measure player levels and design training programs.	8	%80
20.	Players having credit cards for this technology helps them access load planners' training programs.	8	%80
21.	This technology connects technical staff with training data to develop appropriate programs.	8	%80
22.	AI applications determine optimal timing/repetitions for equipment use based on age/competition type.	8	%80
Axis 3: Implementation Challenges			
23.	Shortage of AI-specialized personnel	10	%100
24.	Lack of infrastructure (wireless networks, computers, software)	9	%90
25.	Difficulty for analysts using Internet of Things and connecting with analysis devices	8	%80
26.	Players' difficulty understanding AI applications	8	%80
27.	Outdated analysis equipment incompatible with 5th-gen computing	9	%90

Table 3 Continued. Experts' Evaluation of Questionnaire Axis Statements

Statement No	Axis	Agreement No	%
28.	Challenges designing analytical applications/content for players	8	%80
29.	Existing club computer programming for player data analysis	8	%80
30.	Technical staff's difficulty designing smartphone-compatible training programs	8	%80
31.	Technical challenges connecting training halls with AI programs	6	%60
32.	No available applications suitable for handball teams	5	%50
33.	High AI implementation costs	5	%50
34.	Difficulty convincing club management to adopt AI for technical staff	8	%80
Axis 4: Implementation Requirements			
35.	Establishing dedicated AI technology units within sports clubs	9	%90
36.	Providing performance analysts with AI training courses and skill development	10	%100
37.	Club administrations should allocate budgets for purchasing server equipment and remote control devices for AI applications.	10	%100
38.	Developing a dedicated club application that connects players and technical staff.	9	%90
39.	Establishing electronic links between club management and training halls.	8	%80
40.	Creating player IDs with usernames/passwords linked to the club's database	8	%80
41.	Connecting training equipment with electronic codes activated by command.	8	%80
42.	Converting existing training equipment into coded systems linked with AFR IDs.	8	%80
43.	Installing sensors on rehabilitation devices (e.g., Orbiterack for physical fitness and leg muscle development) to receive technical staff instructions.	8	%80
44.	Providing specialized software for fitness assessment devices (e.g., "InBody" for measuring players' physical readiness).	8	%80
45.	Implementing systems to send training status reports by monitoring proper program execution.	9	%90
46.	Measuring players' rehabilitation progress from sports injuries.	8	%80

Content validity of the questionnaire

The tables No. (3) present the experts' evaluation percentages for each item across the questionnaire's thematic axes. Expert agreement rates ranged between 50-100%, with the researcher adopting only items scoring 80% or higher. Consequently, the following items were eliminated: From Axis 1: Items (1), (4), (5)**,** From Axis 3: Items (9), (10), (11) Resulting in a final questionnaire of 41 items (see Appendix).

Scoring Methodology: Experts unanimously approved a tripartite assessment scale: Agree, Neutral, Disagree

The researcher conducted a pilot study with a sample of 11 participants drawn from the research population to establish the questionnaire's psychometric properties (validity and reliability).

Psychometric Properties: Content Validity: The content validity was ensured by having the questionnaire form reviewed by expert judges. Additionally, the internal consistency validity of the questionnaire was verified by calculating the correlation coefficient between the score of each statement and the total score of the axis, as well as between the axis score and the overall questionnaire score. The following table illustrates this.

Table 4. Internal Consistency Validity of the Statements in the Questionnaire on the Reality of Applying Artificial Intelligence in Analyzing the Performance of Handball Players

statement	average	Deviation	Correlation Coefficient	statement	average	Deviation	Correlation Coefficient	statement	average	Deviation	Correlation Coefficient
Axis 1				5	1.82	0.750	*0.710	8	2.27	0.467	*0.720
1	1.52	0.687	*0.757	6	1.73	0.646	*0.756	9	2.54	0.687	*0.606
2	1.73	0.786	*0.782	7	2.73	0.467	*0.761	**Axis 4**			
3	1.90	0.831	*0.808	8	2.09	0.831	*0.481	1	2.64	0.764	*0.760
4	1.45	0.687	*0.850	9	2.27	0.909	0.900	2	2.45	0.687	*0.889
5	1.55	0.687	*0.891	10	2.36	0.809	*0.769	3	2.64	0.674	*0.760
6	1.64	0.809	*0.793	11	2.45	0.820	*0.831	4	2.64	0.674	*0.930
7	1.55	0.820	*0.780	**Axis 3**				5	2.45	0.687	*0.889
8	1.55	0.687	*0.811	1	2.63	0.504	*0.679	6	2.73	0.646	*0.893
9	1.64	0.674	*0.869	2	2.54	0.687	*0.606	7	2.64	0.504	*0.732
Axis 2				3	2.54	0.522	*0.711	8	2.45	0.683	*0.910
1	2.00	0.774	*0.822	4	2.63	0.674	*0.946	9	2.45	0.687	*0.827
2	2.09	0.831	*0.891	5	2.72	0.467	*0.720	10	2.64	0.809	*0.763
3	2.18	0.873	*0.898	6	2.63	0.674	*0.946	11	2.45	0.934	*0.773
4	2.18	0.837	*0.796	7	2.72	0.504	*0.724	12	2.55	0.687	*0.921

The tabulated (r) value at a significance level of 0.05 = 0.811

The table No. (4) shows that the correlation coefficients between the statement score and the total questionnaire score are statistically significant, ranging between (0.481 and 0.946), indicating the validity of the questionnaire.

The Reliability

To measure the reliability of the questionnaire, it was administered to the pilot sample, and Cronbach's Alpha coefficient was calculated. The following table illustrates this.

Table 5. Stability Coefficient of the Questionnaire Using Cronbach's Alpha

No	Axis	Average	Deviation	Cronbach's Alpha Coefficient
1.	The reality of applying artificial intelligence in training handball teams.	14.454	5.428	*0.618
2.	Objectives and benefits of applying artificial intelligence in handball teams.	24	6.752	*0.606
3.	Challenges of applying artificial intelligence in handball teams.	34.272	4.406	*0.627
4.	Requirements for applying artificial intelligence in handball teams.	30.454	6.960	*0.674

The tabulated (r) value at a significance level of 0.05 = 0.811.*

The table No. (5) shows that the reliability coefficients ranged between (0.606 – 0.674), indicating the stability of the questionnaire axes.

Main Study

The researcher conducted the main study by administering the questionnaire on the reality of applying artificial intelligence in analyzing the performance of handball players to 56 individuals, including coaches, performance analysts, administrators, and board members from (Local league clubs "Premier League"), during the period from 17/1/2024 to 27/1/2024.

Statistical Analysis

The authors used the following statistical treatments through the Statistical Packages Program (SPSS):

- Arithmetic Mean
- Standard Deviation
- Ka-Square Test (χ^2)
- Correlation Coefficient
- Cronbach’s Alpha Coefficient
- Percentage (%)

Results and Discussion

The tabular χ^2 (ka-square) value at a significance level of 0.05 with 2 degrees of freedom is 5.991, Table (6) reveals that the calculated χ^2 values range between 0.250 and 24.250, indicating statistically significant differences ($p < 0.05$) in all statements of Axis 1.

Table No. (7) shows calculated χ^2 values ranging from (0.893 to 30.464), indicating statistically significant differences ($p < 0.05$) in all statements of Axis 2.

Table 6. Frequencies, Percentages, Ka-Square Value (χ^2), Relative Weight, and Ranking of the Responses of the Selected Research Sample to the Statements of the First Axis (The Reality of Applying Artificial Intelligence in Training Handball Teams)

Statement	Agree		Neutral		Disagree		χ^2	Estimated Total	Percentage Weight	Ranking
	Frequence	%	Frequency	%	Frequency	%				
1	18	32.14	31	55.35	7	12.5	15.464	123	%72	3
2	7	12.5	17	30.35	32	57.14	16.964	87	%51.66	9
3	29	44.61	14	25	13	23.12	8.607	128	%76.16	2
4	10	33.92	16	28.57	21	37.5	0.679	110	%63.33	6
5	14	25	19	33.92	23	41.07	2.179	103	%61	7
6	20	35.71	17	30.35	19	33.92	0.250	113	%67	4
7	17	30.35	17	30.35	22	39.28	0.893	107	%63.66	5
8	36	64.28	11	19.64	9	16.07	24.250	139	%82.66	1
9	9	16.07	18	32.14	29	44.61	10.750	92	%54.66	8

Table 7. Frequencies, Percentages, χ^2 Value, Percentage Weight, and Ranking of Responses from the Selected Research Sample for Axis 2 Statements (Objectives and Benefits of AI Implementation in Handball Teams)

Statement	Agree		Neutral		Disagree		χ^2	Estimated Total	Weight Percentage%	Ranking
	Frequency	%	Frequency	%	Frequency	%				
1	18	32.14	37	66.07	1	1.78	25.750	129	76.78	4
2	37	66.07	8	14.28	11	19.64	24.571	138	82	1
3	18	32.14	37	66.07	1	1.78	26.393	129	76.66	5
4	31	55.35	10	17.85	15	26.78	14.286	128	76	6
5	29	44.61	20	35.71	7	57.41	14.393	134	79.76	2
6	31	55.35	10	17.85	15	26.78	12.893	128	76	6
7	18	32.14	37	66.07	1	1.78	25.750	129	76.66	5
8	20	35.71	19	33.92	17	30.35	0.893	113	67.26	7
9	37	66.07	8	14.28	11	19.64	24.571	138	82	1

*The tabular χ^2 value at significance level 0.05 with 2 degrees of freedom = 5.991

Table No. 8 reveals calculated χ^2 values ranging from 15.464 to 35.286, demonstrating statistically significant differences ($p < 0.05$) in all statements of Axis 3.

Table 8. Frequencies, Percentages, χ^2 Values, Relative Weights, and Response Rankings for Selected Sample Responses Regarding Axis 3 Statements (Challenges of Implementing AI in Handball Teams)

Statement	Agree		Neutral		Disagree		χ^2	Estimated Total	Weight Percentage%	Ranking
	Frequency	%	Frequency	%	Frequency	%				
1	38	76.85	16	28.57	2	3.57	35.286	146	86.66	5
2	38	67.85	14	25	4	7.14	32.714	146	86.66	4
3	30	53.57	22	39.21	4	7.14	19	138	82	8
4	38	67.85	16	28.57	2	3.57	35.286	148	88	1
5	34	60.71	18	32.14	4	7.14	24.143	142	84.33	7
6	31	55.35	18	32.14	7	12.5	15.464	136	80.66	9
7	35	62.5	20	35.71	1	1.78	31.107	146	86.90	2
8	36	28.64	16	18.57	4	7.14	28	144	85.70	6
9	36	64.28	18	32.14	2	3.57	31	146	86.66	3

*The tabular χ^2 value at 0.05 significance level with 2 degrees of freedom = 5.991

Table 9. Frequency Distribution, Percentages, χ^2 Values, Percentage Weights, and Response Rankings for Research Sample Responses Regarding Axis 4 Statements (Requirements for AI Implementation in Handball Teams)

Statement	Agree		Neutral		Disagree		χ^2	Estimated Total	Weight Percentage%	Ranking
	Frequency	%	Frequency	%	Frequency	%				
1	33	58.92	15	26.78	8	14.28	17.821	137	69	12
2	32	57.14	14	25	10	17.85	14.714	134	76.6	11
3	43	76.78	9	16.07	4	7.14	48.250	151	87.3	7
4	48	85.71	6	10.71	2	3.57	69.571	158	91	4
5	41	73.21	10	17.85	5	8.92	40.750	148	92.6	3
6	48	85.71	5	8.92	3	5.35	69.250	157	85.6	8
7	39	69.64	10	17.85	7	12.5	33.464	144	93.3	2
8	46	82.14	8	14.28	2	3.57	61	156	88	6
9	44	78.57	9	16.07	3	53.35	52.536	153	94	1
10	42	75	7	12.5	7	12.5	43.750	147	89.6	5
11	27	48.21	19	33.92	10	17.85	7.750	129	79.6	10
12	22	39.28	16	28.57	18	32.14	1	116	81.3	9

*The tabular ka-square (χ^2) value at a 0.05 significance level with 2 degrees of freedom = 5.991

Table (9) reveals calculated χ^2 values ranging from 15.464 to 35.286, demonstrating statistically significant differences ($p < 0.05$) in all statements of Axis 3.

The findings from Table (6), which pertains to the statements of Axis 1 (Current State of AI Implementation in Handball Team Training), reveal the following response distributions from the research sample (Agree) responses: Ranged between 12.5% and 64.28% (Neutral) responses: Ranged between 19.64% and 55.35% (Disagree) responses ranged between 12.5% and 57.14%. Additionally, the calculated ka-square (χ^2) values for these statements ranged from (0.250 to 24.250), all of which exceed the critical χ^2 value This confirms that all statements in Axis 1 exhibit statistically significant differences in responses.

The researcher attributes the "Agree" responses (items 3, 4, 6, 7, and 8) to several key factors regarding AI implementation in handball training: First, institutions must demonstrate willingness to adopt AI technologies. Second, they need to utilize diverse AI applications to accelerate operations. Third, performance analysts should employ modern neural network technologies to significantly save time and effort. Finally, management must pursue training programs to implement AI technologies effectively within handball teams.

The researcher notes that the "Neutral" responses for items 1 and 5 regarding AI implementation in handball training indicate that clubs are gradually adopting modern technologies in various activities to enhance and expedite their operations, with sports clubs showing interest in utilizing AI technology. However, the "Disagree" responses for items 2 and 9 reveal that performance analysts are not currently employing AI technologies in their work, and clubs lack comprehensive computer programs for analyzing player data.

The researcher notes that the "Neutral" responses for items 1 and 5 indicate that clubs are working to implement modern technologies in their various activities to develop and expedite operations, with sports clubs seeking to adopt AI technology.

The "Disagree" responses for items 2 and 9 reveal that performance analysts are not utilizing AI technologies in their work, and clubs lack comprehensive computer programs for analyzing player data.

These findings align with:

The study by Faisal Al-Mulla (2019)(7), which confirmed that AI methods enhance speed and accuracy in service delivery, facilitating ease and excellence, while being directly linked to beneficiaries and the services provided to them through faster player data analysis.

The study by Abdel Hamid Bassiouni (2005)(3), which concluded that AI applications accelerate task completion and that reliance on modern neural network technologies significantly saves time and effort.

The results from Table 7 show response percentages for Axis 2 ranged as follows: "Agree" (32.14% to 66.07%), "Neutral" (14.28% to 66.07%), and "Disagree" (1.78% to 57.41%). The calculated χ^2 values (0.893 to 30.464) exceeded the critical χ^2 value, confirming all Axis 2 statements were statistically significant.

The researcher attributes the "Agree" responses (items 2, 4, 6, 9, 10) to: (1) demonstrable AI benefits, (2) smartphone-AI integration for training notifications, (3) remote control applications, and (4) effective player-staff data connectivity through these technologies.

The researcher observes that the "Neutral" responses for items 1, 3, and 7 regarding AI implementation benefits in handball teams indicate that management includes technological advancement among its objectives. The "Disagree" response for item 5 suggests that fifth-generation computing systems currently fail to adequately track and store comprehensive player metrics throughout their careers or provide real-time results from these modern technologies.

These findings align with the study by Mohamed Ismail and Osama Saoudi (2019)(11), which concluded thatAI implementation accelerates workflow and task completion. Sports club management generally accepts AI adoption. AI technology should be integrated across all sports institution sectors. Practical applications like intelligent agents, fifth-generation computing, and neural networks significantly reduce time and effort.

The results from Table 8 show response percentages for Axis 3 (Challenges of AI Implementation) were distributed as follows: "Agree" (53.57% to 67.85%), "Neutral" (25% to 39.21%), and "Disagree" (1.78% to 7.14%). The calculated χ^2 values (19 to 35.286) exceeded the critical χ^2 value, confirming all Axis 3 statements were statistically significant.

The researcher attributes the "Agree" responses (items 1, 2, 4) to three main implementation challenges: Shortage of AI-specialized personnel. Lack of infrastructure (wireless networks, computers, software)

Difficulties analysts face using IoT technologies and integrating them with technical equipment For the "Neutral" response (item 3), the researcher notes moderate challenges in Retraining coaches and analysts. Upgrading their traditional skills to adapt to computer-based learning technologies.

The "Disagree" responses (items 5, 8) suggest relatively minor concerns regarding Players' difficulties understanding AI applications and Challenges analysts face developing appropriate smartphone-based programs for players

The results of this study align with the findings of Samah Halawa's study (2020), which indicated that applying artificial intelligence (AI) faces challenges such as a shortage of specialized human resources in AI, lack of infrastructure in terms of wireless communications,

computers, and software, as well as the difficulty of using performance analysts with the Internet of Things (IoT) and integrating them into technical devices.

From Table (8), which pertains to the statements in the fourth axis, it is evident that the percentage of responses indicating "Agree" ranged between (39.28% – 85.71%), while responses of "Neutral" ranged between (8.92% – 33.92%). The responses indicating "Disagree" ranged between (3.57% – 53.35%). The calculated Ka-square (χ^2) values ranged from (1.00 – 69.571), which are higher than the critical table values, indicating that all statements in the fourth axis are statistically significant.

The researcher attributes the agreement ("Agree") responses across all statements in this axis—specifically statements (3, 4, 6, 8)—to the necessity of providing club administrations with budgets for purchasing servers and remote control devices to implement AI applications. The "Neutral" response appeared in statement (11), indicating that AI application requirements include the ability to send reports on players' conditions by monitoring the implementation of appropriate training programs. The "Disagree" responses appeared in statements (9, 12), highlighting the lack of some necessary devices and the demand for modern technology-based devices to measure players' training conditions.

The results of this study also align with the findings of Mohamed Ismail and Osama Saudi (2019), which concluded that using AI leads to work development and faster task completion. AI applications in sports clubs are well received by senior management, and the integration of this technology across all sectors of the sports institution is essential. The study emphasized that AI applications in sports clubs, such as intelligent agents, fifth-generation computing, and reliance on modern neural network technologies, significantly contribute to saving time and effort.

Based on the above discussion, the research questions have been addressed.

Conclusion

- The use of artificial intelligence (AI) contributes to the development of both technical and administrative work within handball teams.
- AI highlights the necessity for clubs and handball coakang staff to adopt AI technology due to its importance in providing essential data on all players.
- Handball technical staff require modern technologies to keep up with global advancements in performance analysis and training program development.
- AI technology helps determine the optimal timing for using sports equipment and trains team staff on this advanced technology.
- There is a pressing need for digital transformation, improved infrastructure in wireless communications, computers, and software, as well as allocating budgets for purchasing servers and remote control devices.

Recommendations

Considering the conclusions, the authors recommend the following:

- Emphasizing the importance of AI technology as a key modern application aligned with technological advancements by establishing specialized AI units within all handball teams.
- Developing the skills of performance analysts in handball to keep pace with technological advancements and effectively utilize AI-based methods.
- Linking the research findings to other sports, considering that AI technology is increasingly being integrated across all fields.

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