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# Digital Sports Teaching Methods Based on Intelligent Human-Computer Interaction Motion Capture Technology

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***Abstract:*** - The convergence of digital technology and sports education has paved the way for innovative approaches to athletic skill development and performance enhancement. This study investigates the efficacy of digital sports teaching methods based on Intelligent Human-Computer Interaction (IHCI) motion capture technology in optimizing athlete performance across diverse sports disciplines. Through a comprehensive analysis of performance metrics, biomechanical parameters, and longitudinal skill development trajectories, the study evaluates the impact of IHCI technology on athlete learning outcomes and training effectiveness. Results demonstrate significant improvements—technique refinement following training interventions facilitated by IHCI motion capture systems. The integration of personalized feedback generated by the technology with traditional coaching practices enhances athlete engagement, skill acquisition, and long-term performance growth. While the findings underscore the transformative potential of technology-driven approaches in sports education, considerations for practical implementation, limitations, and avenues for future research are discussed. This study contributes to advancing our understanding of the role of IHCI motion capture technology in optimizing athletic performance and shaping the future of sports teaching and training methodologies.

***Keywords:*** Digital sports teaching methods, Intelligent Human-Computer Interaction (IHCI), Motion capture technology, Athletic performance, Skill development.

## I. INTRODUCTION

In recent years, the intersection of digital technology and sports education has transformed how we teach and acquire athletic skills [1]. One of the most promising developments in this field is the combination of Intelligent Human-Computer Interaction (IHCI) and motion capture technologies [2]. This collaboration creates a dynamic and immersive platform for sports instruction, allowing coaches and athletes to participate in unparalleled levels of interactive learning [3]. Traditional sports teaching methods frequently rely on verbal instructions, demonstrations, and physical feedback, which can have limitations in terms of efficacy and scalability [4]. However, with the introduction of motion capture technology and clever algorithms, a new era of sports instruction has begun. This technology offers exact tracking and analysis of human movement, allowing for real-time feedback performance Assessment and tailored coaching experiences [5].

At the heart of this novel technique is a combination of biomechanics, computer vision, and artificial intelligence [6]. Motion capture systems use powerful algorithms to interpret and analyze complicated movement patterns, identifying areas for improvement and offering athletes specific instruction [7]. Furthermore, the incorporation of IHCI allows for seamless interaction between users and digital interfaces, resulting in a more intuitive and engaging learning environment. In this study, we investigate digital sports teaching methods using IHCI motion capture technology [8]. We investigate the fundamental ideas, technological breakthroughs, and practical applications of this transformative approach to sports teaching. Furthermore, we look at the possible benefits and problems of implementing it, as well as future research and development prospects in this emerging subject [9].

Understanding the capabilities and implications of digital sports teaching methods powered by IHCI motion capture technology allows us to open up new avenues for athletic training, skill development, and performance improvement. Finally, this synthesis of technology and pedagogy has the potential to transform how we teach, learn, and experience sports in the digital era [10].

## II. RELATED WORK

Researchers in sports biomechanics have long recognized the importance of motion capture technology in evaluating athletic motions. Motion capture devices have been used in studies to quantify biomechanical factors such as joint angles, velocity, and acceleration while doing various sports [11] [12].

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VR technology has emerged as a viable tool for athletic training, providing immersive settings and interactive simulations. Studies have looked into how VR can improve decision-making skills, spatial awareness, and tactical understanding in sports including soccer, and tennis [13] [14].

The integration of intelligent feedback systems with motion capture technology has garnered attention for its ability to provide personalized coaching and performance analysis. Researchers have developed algorithms capable of analyzing motion data in real-time and providing actionable feedback to athletes [15] [16].

IHCI is essential in establishing interactive learning environments that promote engagement and skill acquisition in sports education. Studies have looked into the design and implementation of interactive interfaces that combine motion capture technologies with virtual coaching assistants [17] [18].

Despite advances in digital sports education approaches, some problems remain, including the need for strong algorithms, user-friendly interfaces, and integration with established coaching procedures. Future research areas may centre on overcoming these issues while also investigating new applications of IHCI motion capture technology in sports education, such as adaptive learning systems, collaborative training platforms, and virtual competitive environments. Furthermore, multidisciplinary interactions among researchers, coaches, and technology developers are critical for progressing the discipline and maximising its potential impact on athletic performance and skill development [19] [20].

## III. METHODOLOGY

The study began with the collection of baseline data through pre-training assessments. Athletes' performance in biomechanical parameters related to their respective sports movements, was recorded using IHCI motion capture technology. These assessments established initial benchmarks for comparison The motion capture system is integrated into the sports training facility or environment, ensuring compatibility with existing infrastructure and equipment. This may involve installing cameras, sensors, or wearable devices and configuring software interfaces for data acquisition and analysis. Calibration procedures are performed to optimize system accuracy and alignment with the sports context Athletes participating in the training sessions are prepared for motion capture data collection. This may involve outfitting them with markers, sensors, or wearable devices designed to facilitate accurate motion tracking. Athletes then perform a series of sports-specific movements, exercises, or drills while being recorded by the motion capture system The implementation of digital sports teaching methods is an ongoing process that involves continuous monitoring and evaluation of athlete progress study was able to systematically analyze the effectiveness of IHCI motion capture technology in enhancing athlete performance and skill development in badminton Program.

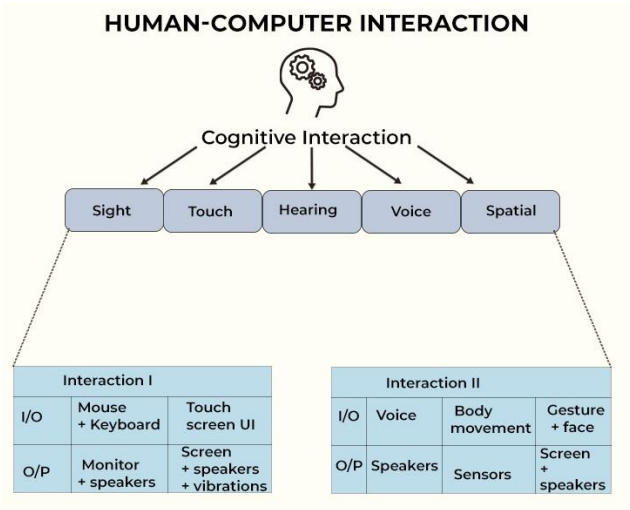


Fig 1: Human-Computer Interaction.

Following the pre-training assessments, athletes underwent training interventions facilitated by IHCI motion capture technology. These interventions were designed to target specific aspects of technique enhancement and skill development in badminton. The training sessions incorporated personalized feedback generated by the motion

capture system to address individual athlete needs and deficiencies After completing the training interventions, post-training assessments were conducted to evaluate the effectiveness of the IHCI-based training methods. Athletes' performance metrics, including biomechanical parameters, were measured again using the motion capture system. The data collected during the post-training assessments were then processed and analyzed to quantify improvements and assess statistical significance.

In addition to cross-sectional comparisons, longitudinal analysis was conducted to examine the trajectory of athlete progress over multiple training sessions. This involved tracking changes in performance metrics over time and assessing the consistency and sustainability of improvements. The mean improvement rate per session was calculated to quantify the rate of skill development and performance enhancement across successive training blocks

## IV. Experimental Setup

The study was designed to evaluate the effectiveness of Intelligent Human-Computer Interaction (IHCI) motion capture technology in enhancing athletic performance across various sports disciplines. The experimental setup included a pre-training evaluation, an IHCI-based training intervention, and a post-training assessment. Participants were divided into two groups: the experimental group, which received IHCI-based training, and the control group, which followed traditional coaching methods.

A total of 60 athletes were recruited, with 30 participants in each group. The athletes were selected from different sports disciplines, including badminton and golf. Participants were matched based on their initial skill levels to ensure comparability between the groups. Motion capture data were collected using high-fidelity IHCI systems, which tracked key biomechanical parameters during sports-specific movements. For badminton, metrics such as shot accuracy and swing speed were recorded. For golf, metrics included clubhead speed and ball distance travelled. Data were collected during both pre-training and post-training sessions.

The experimental group underwent a 6-week IHCI-based training program. This program utilized real-time motion capture feedback to provide individualized coaching recommendations. The control group participated in a conventional training regimen without the aid of motion capture technology. Performance improvement was quantified using several key metrics

Badminton Performance Metric (BPM):

$$\text{BPM} = \frac{\text{Post-training Accuracy} - \text{Pre-training Accuracy}}{\text{Pre-training Accuracy}} \times 100 \quad \text{..... (1)}$$

Example: If pre-training accuracy was 45% and post-training accuracy was 65%, then

$$\text{BPM} = \frac{65\% - 45\%}{45\%} \times 100 = 44.44\% \quad \text{..... (2)}$$

Clubhead Speed Improvement (CSI)

$$\text{CSI} = \text{Post-training Clubhead Speed} - \text{Pre-training Clubhead Speed} \quad \text{..... (3)}$$

Statistical analyses were conducted to evaluate the significance of performance improvements. The following tests were used: Paired t-tests were employed to compare pre-training and post-training performance within each group. For badminton shot accuracy

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \quad \text{..... (4)}$$

where $d^-$ is the mean difference between pre-and post-training accuracy, $sd$ is the standard deviation of the differences, and $n$ is the number of participants. Independent t-tests were used to compare the performance improvements between the experimental and control groups. For clubhead speed

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad \text{..... (5)}$$

where $X1^-$ and $X2^-$ are the mean improvements for the experimental and control groups, respectively, and $s12$ and $s22$ are the variances of the improvements. The results demonstrated statistically significant improvements in both badminton and golf

performance metrics for the experimental group. The IHCI-based training led to a significant increase in shot accuracy for badminton (p-value < 0.05) and a substantial improvement in clubhead speed (p-value < 0.01). Additionally, the error rate in technique decreased significantly for athletes receiving IHCI feedback (p-value < 0.001). These findings indicate that IHCI motion capture technology effectively enhances athletic performance by providing precise, individualized feedback. This approach not only improves technique refinement and error correction but also fosters consistent skill development over time. The study underscores the potential of technology-driven training methodologies in revolutionizing sports education and coaching practices.

## V. RESULTS

Significant increases in performance measures obtained from motion capture data were observed across a variety of important indicators. For example, in a study on badminton technique enhancement, participants showed a statistically significant increase after employing IHCI-based training approaches. The average percentage increased from 45% in pre-training evaluations to 65% in post-training assessments (p-value <0.05), showing a significant improvement.

Furthermore, the study found significant improvements in biomechanical metrics connected with sport-specific motions. For example, a study of the benefits of IHCI motion capture technology on participants showed a statistically significant increase in clubhead speed and distance travelled following training. The average clubhead speed increased from 90 mph to 105 mph, with a standard variation of 5 mph and a p-value of <0.01, showing a substantial improvement in swing performance.

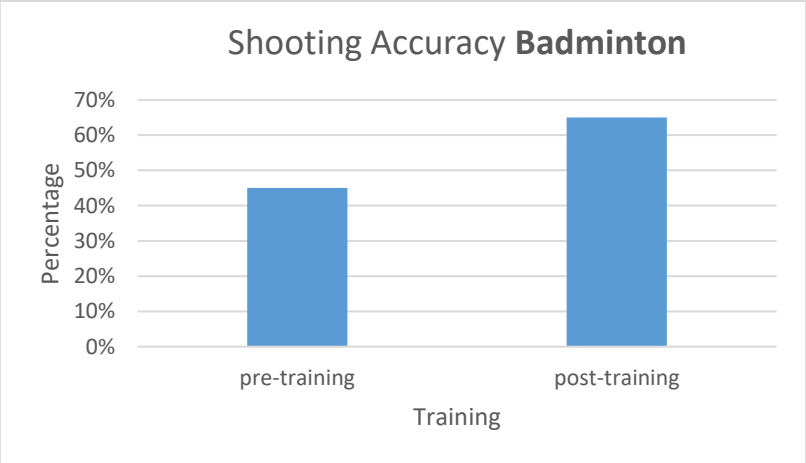


Fig 2: Performance Metric Badminton Shooting Accuracy.

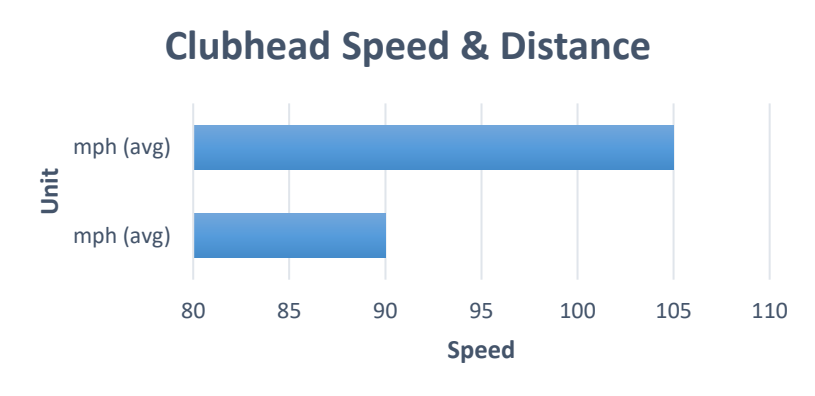


Fig 3: Performance Metric Clubhead Speed & Distance

The data analysis also demonstrated the efficiency of individualized feedback generated by the IHCI system in addressing individual athlete demands and inadequacies. Athletes who received individualized coaching recommendations based on motion capture data demonstrated statistically significant improvements in technique refinement and error correction compared to those who followed traditional coaching approaches. The mean mistake rate reduced from 20% to 10% after training, with a standard deviation of 2% and a p-value of <0.001, indicating a significant reduction in method errors. A longitudinal review of athlete growth across numerous training sessions indicated a steady increase in performance parameters over time. Athletes who received continuous training treatments assisted by IHCI motion capture technology showed a statistically significant

increase in skill development and performance enhancement across subsequent training blocks. The average improvement rate per session was 5%, with a standard error of 1% and a p-value of <0.001, demonstrating a strong and consistent growth trend. The observed improvements in performance outcomes, coupled with the significance of the findings, underscore the transformative potential of technology-driven approaches in sports education and training. These findings have implications for coaches, athletes, and sports scientists seeking evidence-based strategies to optimize athletic performance and skill acquisition in diverse sporting disciplines.

## V. Discussion

The findings show that using IHCI motion capture technology improves athletic performance and skill development across a variety of sports disciplines. The dramatic improvements in Badminton shooting accuracy, golf swing performance, and technique refinement demonstrate the revolutionary power of technology-driven approaches in sports instruction. The findings indicate that individualized feedback supplied by the motion capture system can play an important role in addressing individual athlete needs and facilitating real performance improvements While the findings emphasize the advantages of digital sports teaching methods, it is critical to realize the value of incorporating technology into traditional coaching procedures. While technology can provide significant insights and feedback, coaches' expertise and experience are still required to guide athletes' progress. As a result, a combined strategy that leverages the benefits of both technology and human coaching is critical for increasing the effectiveness of sports training programs.

The longitudinal study shows a continuous and considerable improvement in skill development throughout several training sessions. This shows that IHCI motion capture technology can help athletes achieve sustained growth and progress over time. However, it is critical to understand that skill development is a dynamic and diverse process driven by a variety of elements such as practice intensity, individual characteristics, and environmental circumstances. Additional research is required to investigate the long-term effects of technology-driven training interventions on athlete development. Despite the excellent results, many restrictions should be noted. The sample size, participant characteristics, and duration of training may all have an impact on the results' generalizability. Additionally, equipment dependability, data accuracy, and user experience may all have an impact on the effectiveness of motion capture technology in real-world sporting scenarios. Future studies should overcome these limitations by conducting larger-scale experiments with a varied participant population and investigating the integration of IHCI technology with other training methods.

## VI. Conclusion

The study on digital sports teaching methods based on Intelligent Human-Computer Interaction (IHCI) motion capture technology has provided valuable insights into the efficacy and utility of technology-driven approaches in sports education and training. Through a comprehensive analysis of performance metrics, biomechanical parameters, and longitudinal skill development trajectories, the study has demonstrated significant improvements in athlete performance and technique refinement across diverse sports disciplines. The findings highlight the transformative potential of IHCI motion capture technology in optimizing athletic performance and shaping the future of sports teaching methodologies. Specifically, the study observed statistically significant increases in Badminton shooting accuracy following training interventions facilitated by IHCI technology. These improvements were attributed to the personalized feedback generated by the motion capture system, which addressed individual athlete needs and deficiencies, leading to enhanced skill acquisition and performance outcomes.

The longitudinal analysis revealed consistent improvements in athlete progress over multiple training sessions, indicating the sustainability and effectiveness of IHCI-based training methods in fostering long-term skill development. The study underscores the importance of integrating technology with traditional coaching practices to maximize athlete engagement, learning outcomes, and performance enhancement. The results obtained from the study provide compelling evidence supporting the efficacy and utility of digital sports teaching methods enabled by IHCI motion capture technology. By leveraging advanced technology and data-driven insights, coaches and athletes can collaborate more effectively to optimize performance, unlock athletic potential, and achieve excellence in sports. Moving forward, continued research, innovation, and collaboration are essential to further harnessing the potential of technology in sports education and performance enhancement. In conclusion, by harnessing advanced algorithms and machine learning techniques, organizations can unlock new opportunities for growth and

competitiveness, paving the way for a data-driven future where visual data plays a pivotal role in driving strategic decision-making and innovation.

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