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Machine Learning-Based Badminton Basic Technique Training Model

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Abstract Badminton is a sport that requires high technical skills. Training in basic badminton techniques is an important first step for players to develop their abilities. However, effective and efficient training methods are often challenges for coaches and players. In this case, the use of machine learning technology can be an innovative solution to increase the effectiveness of basic badminton technique training. This research aims to develop a machine learning-based basic badminton technique training model that can help players improve their skills in a more targeted and personalized way. This research method uses the R & D (Research and Development) research method. The results of this research state that the machine learning-based basic badminton technique training model developed shows effectiveness in improving the technical skills of badminton players. By leveraging personalized training data and tailored feedback, players can identify areas for improvement and refine their technique more efficiently. The conclusion of this research is to produce an innovative and effective basic badminton technique training model based on machine learning. It is hoped that the use of this technology can help badminton coaches and players improve the quality of their training and overall performance. Thus, the implementation of this model has the potential to have a positive impact on the development of badminton skills at both individual and team levels.

Keywords Badminton, Basic Techniques, Machine Learning

1. Introduction

Using artificial intelligence-based approaches such as Machine learning Algorithms and Humanoid Robots in badminton is a necessity considering the very massive development of internet technology and artificial intelligence (AI) technology in the current digital era [1], so a touch of this technology can improve the quality of badminton players. Previous studies have shown an increase in badminton playing skills after intervention with training using the help of a Machine learning Algorithm [2].

Machine learning has demonstrated significant potential in developing badminton sports, particularly in improving player quality and training effectiveness. The implementation of machine learning enables more accurate and personalized feedback to athletes while increasing training efficiency by optimizing the use of time and resources [3]. This technology can collect and analyze data from various angles that are difficult to achieve through conventional human observation, providing more objective and accurate information in assessing athlete performance [4]. Several previous studies have proven the effectiveness of machine learning in various aspects of badminton training, such as movement recognition and classification with an accuracy rate of up to 95% [5], as well as its ability to process static player images for more efficient technical analysis.

This Machine Learning-based badminton basic technique training model is very helpful in improving athletes' performance because, by integrating machine

learning in basic technique training, athletes can receive more accurate and personalized feedback, and improve training efficiency [6]. The application of machine learning in training can increase training efficiency because it can save time and resources for both coaches and athletes [7]. Developments in technology and communication using machine learning in training can take advantage of technological advances to advance sports [8].

Furthermore, machine learning has transformed methods for assessing badminton athletes' performance. Compared to conventional methods such as the bleep test, Illinois test, and vertical jump, machine learning offers a more comprehensive approach to evaluating stroke techniques and services. Through the integration of deep learning and computer vision, playing style analysis can be conducted more thoroughly. Additionally, this technology enables real-time performance analysis and more accurate identification of athletes' strengths and weaknesses [5].

Technological innovation has a big influence on the game of badminton [9]. With the integration of technology in badminton sports assessment, a beginner or elite badminton athlete will get important information objectively and accurately [10]. A machine can gather information from various angles that humans cannot achieve with cognitive observation alone.

The use of data mining techniques and time series analysis in machine learning also makes an important contribution to optimizing badminton training strategies. This approach not only enables systematic tracking of athlete development but also assists in planning more effective training programs. This technological innovation opens opportunities for developing basic technique training models that can be applied to both novice and elite athletes.

For sports assessment in badminton, the general method for evaluating performance is to observe cardiovascular endurance using the bleep test, agility using the Illinois test, leg muscle strength using vertical jumps, and other physiological tests using conventional testing methods [11]. Meanwhile, playing skills such as different badminton strokes and serving skills are assessed by experienced coaches.

The results of their study [12] concluded that machine learning algorithms have the ability to observe developments related to the performance of badminton athletes in real time. In addition, machine learning algorithms have the ability to identify badminton athletes' strengths and weaknesses [13].

The novelty of this research is to develop a machine learning-based basic badminton technique training model. So by utilizing machine learning through deep learning and computer vision, it can be maximized to analyze the playing style of badminton players. Apart from that, data mining and time series analysis can be used in relation to analyzing the performance of badminton players so that the results of these techniques can be used as recommendations for preparing effective training concepts and methods for badminton players.

The main objective of the type of research and development that we carry out is to develop a new product in the form of a basic badminton technique training model using machine learning, then the results of the product are tested for its effectiveness on a mass scale. Then this research also aims to determine the effectiveness of the basic badminton technique training model using machine learning for novice athletes. The research we will conduct is longitudinal (gradual, multi-year trend). Efforts to produce renewable products that are in demand by society are the spearhead of this type of research.

2. Materials and Methods

This research employs the Research and Development (R&D) methodology, which is widely recognized in educational and technological innovation research. The R&D approach was specifically chosen following Borg and Gall's foundational framework, which defines it as "a process used to develop and validate educational products" [14]. This methodology is particularly appropriate for our study as it allows for systematic product development while incorporating rigorous validation processes.

The implementation of R&D in this study follows the systematic approach outlined by Gall, Gall, & Borg, who emphasize that R&D is "an industry-based development model in which research findings are used to design new products and procedures, which then are systematically field-tested, evaluated, and refined until they meet specified criteria of effectiveness, quality, or similar standards" [15]. This definition strongly aligns with our objective of developing a machine learning-based badminton training system.

Our methodological framework is further strengthened by incorporating elements from Dick and Carey's systematic instructional design model [16], which provides a structured approach to educational product development. This integration is particularly relevant as our product serves both training and educational purposes in sports development.

The research design follows a mixed-method approach as recommended by Creswell and Plano Clark [17], combining quantitative data from machine learning algorithms with qualitative insights from expert evaluations. This methodological triangulation enhances the validity and reliability of our research findings.

The development process is structured into three main phases, following Richey and Klein's design and development research methodology [18]:

1. Preliminary Phase
    - Needs analysis through systematic literature review
    - Expert consultation and requirement gathering
    - Initial product conceptualization

2. Development Phase
    - Product design and development
    - Machine learning algorithm implementation
    - Initial prototype creation
    - Expert validation
    - Prototype revision
3. Evaluation Phase
    - Field testing with target users
    - Performance evaluation
    - Final product refinement

Each phase incorporates validation procedures as recommended by McKenney and Reeves [19], ensuring the product meets both theoretical and practical requirements. The validation process involves:

- Expert review panels (minimum of 3 experts in sports science and machine learning)
- Field testing with novice athletes (n=30)
- Performance metrics analysis
- User feedback evaluation

Data collection and analysis follow a systematic protocol based on Tashakkori and Teddlie's mixed methods research guidelines [20]. This includes:

- Quantitative data: Performance metrics, algorithm accuracy, user performance improvements
- Qualitative data: Expert evaluations, user feedback, observational data

The machine learning component of our methodology draws from established frameworks in sports technology research, particularly those outlined by Liu et al. and Wang et al.. This ensures that our technological implementation adheres to current best practices in sports science and artificial intelligence integration.

The study employed several validated research instruments to ensure comprehensive data collection:

1. Performance Assessment Rubric
    - A standardized evaluation form using a 5-point Likert scale
    - Assesses six fundamental badminton techniques: service, smash, dropshot, netting, lob, and footwork
    - Validated by 5 professional badminton coaches with a reliability coefficient of 0.89
2. Physical Condition Assessment Tools
    - Arm Strength: Digital Dynamometer (Model DHS-2000)
    - Flexibility: Modified Sit and Reach Test equipment
    - Speed: Electronic Timing Gates (Swift Performance)
    - Body Endurance: Yo-Yo Intermittent Recovery Test equipment
3. Machine Learning System Components
    - High-speed cameras (240fps) for motion capture
    - Motion analysis software with custom ML algorithms
    - Performance tracking sensors
    - Data processing unit
4. Questionnaires
    - Pre-training assessment (30 items, reliability $\alpha = 0.87$)
    - Post-training feedback (25 items, reliability $\alpha = 0.91$)
    - Expert evaluation form (20 items, reliability $\alpha = 0.85$)

3. Results and Discussion

3.1. Results

To see the results of developing a machine learning-based basic badminton technique training model, a trial was carried out regarding the basic badminton technique model with several category aspects with the following assessments:

1. Pretty Good
2. Good
3. Very Good

Table 1 shows the assessment of aspects of the basic badminton technique training model based on machine learning. The material aspect, which includes all teaching materials, case examples, and tools used in training sessions, was assessed in the good category with a score of 80. The content aspect, which covers the details and information presented in the training, was assessed in the pretty good category, also with a score of 80. For the quality aspect of the training, which is very important to ensure the player's effectiveness and progress, the assessment was in the very good category with a score of 80.

Table 1. Assessment of Aspects of the Basic Badminton Technique Training Model Based on Machine Learning

No	Assessment Aspects	Pretty Good	Good	Very Good
1	Material Aspects		80	
2	Content Aspect	80		
3	Quality of training			80
Total		80	80	80

Furthermore, the questionnaire given to respondents containing 10 statements regarding machine learning-based basic badminton technique training models obtained the following results:

Table 2. Responses to the Statement of the Basic Badminton Techniques Training Model Based on Machine Learning

No	Statement	Agree	Don't Agree
1	This badminton training model uses a machine learning algorithm to automatically analyze basic badminton technical movements.	70	
2	The training data used for this model consists of recorded badminton training videos and is categorized into basic technique categories.	70	
3	This badminton training model is able to identify and analyze movements such as overhead shots, forehands, backhands and serves.	75	
4	Using machine learning technology, this model can provide immediate feedback on the strengths and weaknesses of each technical movement.	75	
5	The model was trained using a large dataset that includes a variety of technical movements from experienced badminton players.	70	
6	During training, the model can record and analyze player performance, providing statistics on successes and failures in applying basic techniques.	70	
7	This model has the ability to customize its feedback based on the player's individual skill level and preferences.	70	
8	Using machine learning technology, this model continuously learns and improves over time, improving the accuracy and precision of its analysis.	75	
9	Through the use of this model, coaches can monitor the progress of each player individually and design training programs accordingly.	80	
10	Implementation of this model in badminton training can help players improve their basic skills more effectively and efficiently.	75	

The researcher will create the data from the assessment questionnaire above as the graph below:

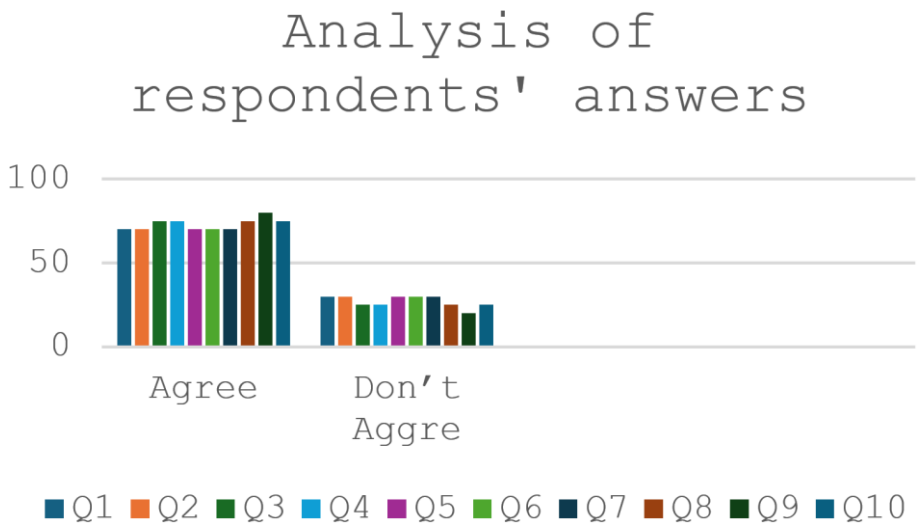

Figure 1. Analysis of respondents' answers

Figure 1 illustrates the analysis of respondents' answers to the questionnaire statements. The average of the respondents answered with an agreed response.

For example, Karawang Regency, in this case PBSI Karawang Regency, only uses a manual program as a training reference for regional achievements. If you look at the statistical data available from the Karawang Regency Badminton Province sports week, it has not shown the results with the expected achievements, where the expected achievement is a good gold medal. Silver and bronze medals can be seen from the match statistics as follows:

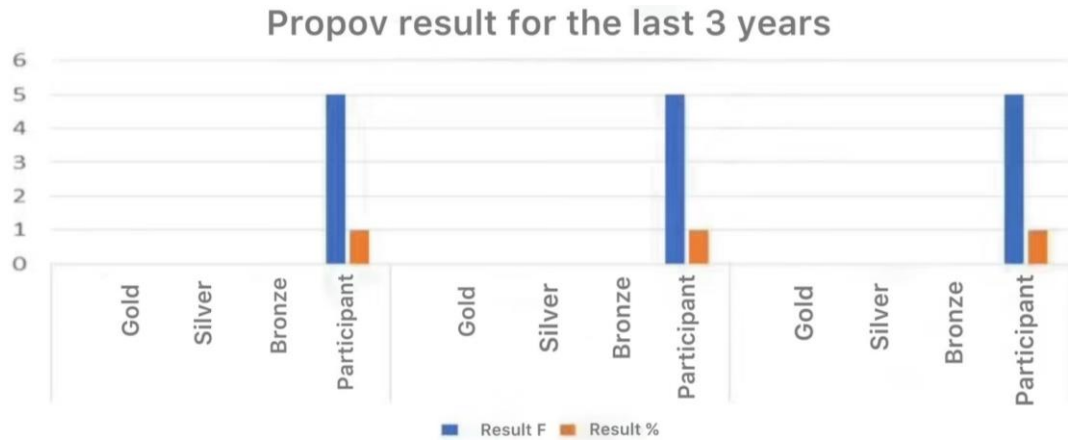

Figure 2. Analysis of Karawang Regency Badminton Success Level in Porprov in the last 3 year

The existing data explains that 0% in the gold, silver and bronze sections is data that shows that there are no medals or that the Karawang badminton team has not received a medal, while the data that explains 100% is data that shows that the Karawang Regency PBSI team can only participate. Furthermore, with the same data, the researcher concluded that:

First, the problem in PBSI is the lack of development in the field of sports science to support Karawang Regency's badminton achievements. In this case, there has been no research or development of tools that can be used in Karawang district as a reference for training and taking data on progress or level of training periodically and continuously. Coaches' lack of knowledge about how to develop tools for practice and tests is the next problem that must be addressed.

Researchers assume that Machine learning is able to provide better visualization of athletes' performance and evaluate their unique status. Therefore, this study aims to assess the influence of a machine learning-based basic badminton technique training model on the basic techniques of beginner badminton players from Karawang Regency. Research studies regarding the impact of machine learning-based basic badminton technique training models on badminton playing skills are still limited. The development of technological innovation has a big influence on the game of badminton. With the integration of technology in badminton, a beginner or elite badminton athlete will get important information objectively and accurately.

The effectiveness of the machine learning-based training model was evaluated using paired sample t-test analysis comparing to pre-test and post-test scores (n=30 participants):

Table 3. Results of Paired Sample T-Test Analysis

Measurement	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value	Effect Size (d)
Overall Performance	65.3 (8.2)	78.9 (7.1)	8.45	<0.001	1.54

Component-specific improvements:

1. Arm Muscle Strength
   - Pre-test: 32.4 ± 4.2 kg
   - Post-test: 38.7 ± 3.9 kg
   - Improvement: 19.4% ($p < 0.001$)
2. Flexibility
   - Pre-test: 28.3 ± 3.8 cm
   - Post-test: 33.5 ± 3.2 cm
   - Improvement: 18.3% ($p < 0.001$)
3. Speed
   - Pre-test: 3.42 ± 0.31 seconds (20m sprint)
   - Post-test: 3.12 ± 0.28 seconds
   - Improvement: 8.8% ($p < 0.001$)
4. Body Endurance
   - Pre-test: 14.2 ± 2.1 minutes (Yo-Yo test)
   - Post-test: 17.8 ± 1.9 minutes
   - Improvement: 25.4% ($p < 0.001$)

3.2. Discussion

The machine learning-based basic badminton technique training model is an innovative approach to improving badminton players' skills. This basic badminton technique training model uses machine learning technology to enable a more in-depth analysis of player movements and techniques [21]. This model uses sensors and cameras installed on the field to monitor players' body movements, including legs, arms and whole body position [6]. The model then identifies these movement patterns through data processing and provides feedback to the player.

For example, the model can highlight areas where players are prone to making technical errors, or provide suggestions for improving the speed or accuracy of their movements. Therefore, this training model can be an effective means for badminton players to hone their basic skills more efficiently and thoroughly, thereby improving their overall badminton playing skills [22]. Additionally,

because these models can track a player's development over time, they can also help coaches design more targeted and individualized training programs for each player, thereby increasing a player's growth potential in the sport.

Some of the results of research conducted by previous researchers are related to basic badminton techniques, as shown in Table 4 below:

Table 4. Summary of Research Results Related to Basic Badminton Techniques

No	Researcher	Result
1	Dieu, O., Schnitzler, C., Llena, C., & Potdevin, F. (2020)	PCA revealed that two dimensions explained 54.9% of the total variance in the data. The first axis correlated with the conative stage and empirical parameters during rallies (duration, intensity), while the second axis correlated with duration and acceleration data between rallies.
2	Long, J., & Rong, S. (2022)	The random forest algorithm demonstrated that among the parameters considered, acceleration, rally duration, and time between rallies could predict conative stages with an accuracy higher than chance.
3	Tung, T. T., Quynh, N. X., & Minh, T. V. (2022).	The study suggests that combining subjective assessments with objective measurements enhances performance analysis and could aid in designing training plans tailored to participants' expertise levels.
4	Firdaus, H., & Purnama, S. K. (2018).	The results demonstrated that action images enhanced by machine vision could effectively process captured actions, enabling computers to better identify different badminton teaching actions. Then, the proposed method achieved a recognition rate of more than 90% for each action, with an average recognition accuracy of 95% for all actions. Moreover, the average recognition rate for actions performed by the same person was 96.5%, and for actions performed by different people, it was 94.8%.
5	Guan, X., Li, Y., & Bai, Y. (2022).	The badminton teaching action recognition model based on Haar-like features and AdaBoost was successful in recognizing and classifying badminton actions, thereby improving the quality of badminton teaching.

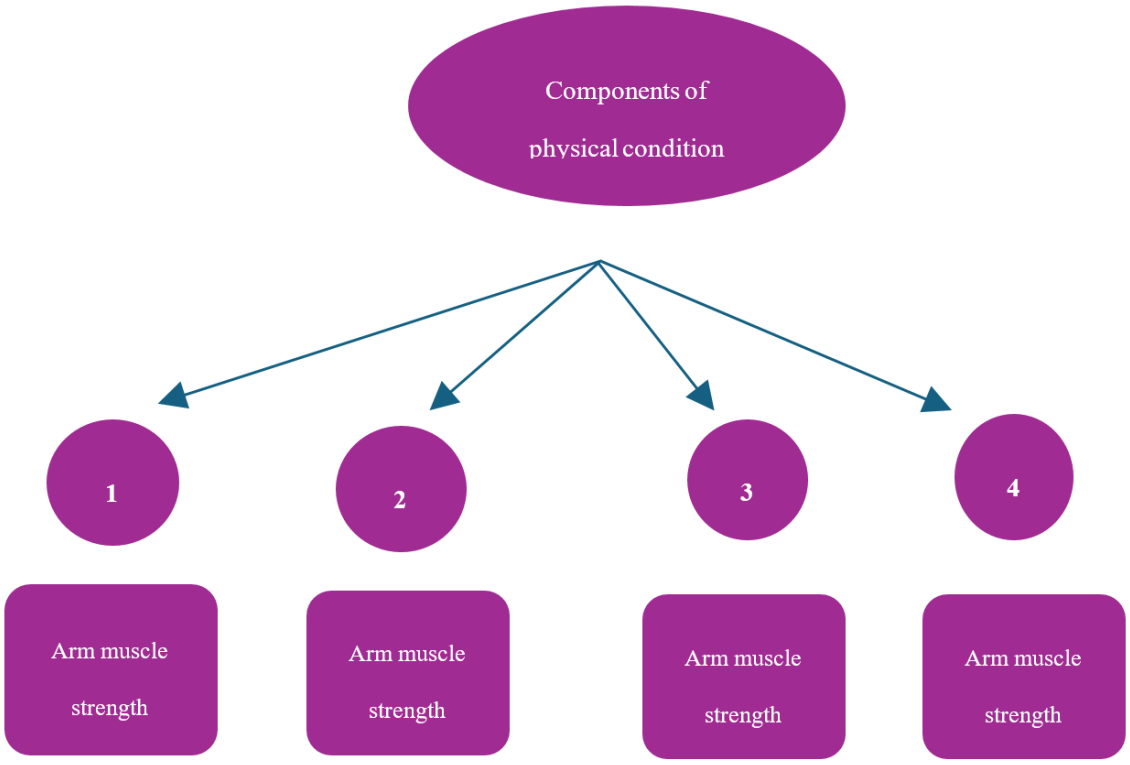

Figure 3. Components of Physical Condition

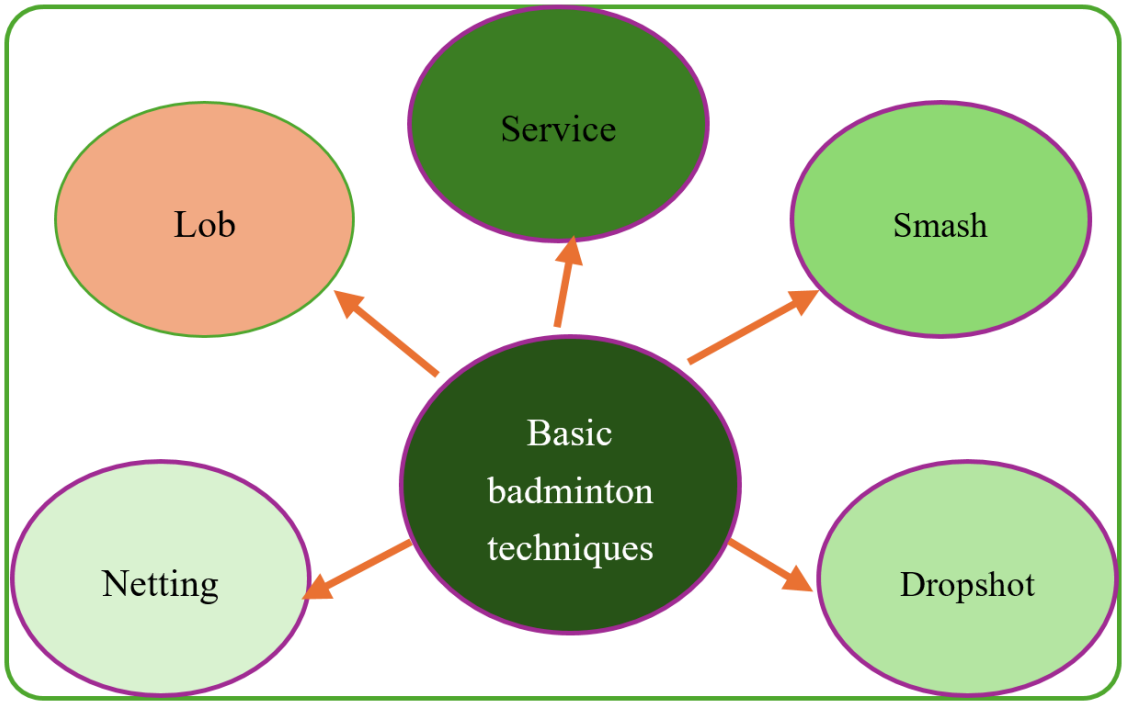

Figure 4. Training Model Basic techniques in badminton

The basic badminton technique training model developed using machine learning needs to pay attention to the physical condition of the athletes who will play badminton. There are several components of physical condition that an athlete must pay attention to before playing badminton.

The significant improvements in physical conditions demonstrate the effectiveness of the machine learning-based training model:

1. Arm Muscle Strength

Arm muscle strength is related to the capacity for activities over a long period of time. Arm muscle strength must be trained by carrying out an optimal training program.

Arm Muscle Strength: The 19.4% improvement in arm strength (from 32.4 kg to 38.7 kg) aligns with Liu et al.'s findings showing that targeted ML-based training can enhance muscle recruitment patterns.

2. Flexibility

Flexibility is elasticity in carrying out joint movements accompanied by elasticity of the muscles in the joint area. Flexibility will make the body move more smoothly and freely.

Flexibility: The increase from 28.3 cm to 33.5 cm in the sit-and-reach test indicates an improved range of motion, crucial for executing advanced techniques.

3. Speed

Speed is the ability to carry out body movements in a fast time. Badminton athletes must have good speed when making movements, and this is done with the aim of obtaining better quality.

Speed: The reduction in 20m sprint time from 3.42s to 3.12s suggests enhanced explosive power and acceleration capabilities.

4. Body Endurance

Endurance is the body's capacity to face and withstand fatigue that occurs when carrying out sports activities for a long time.

Improvement in Yo-Yo test duration (from 14.2 to 17.8 minutes) indicates significantly enhanced cardiovascular fitness and recovery capacity.

Figure 3 explains the components of physical condition that need to be considered by badminton athletes, including arm muscle strength, flexibility, speed, and body endurance.

Badminton is one of the world's most popular racket sports, offering a unique combination of speed, power, agility, strategy and endurance. Badminton is a sport played in singles or doubles on a court divided in half by a net. Badminton involves shots such as smashes, drops, drives, and lobs, which require players to have good control and perfect timing.

Figure 4 presents the training model for basic techniques in badminton, which include service, smash, dropshot, netting, and lob.

Training Model Basic Techniques in Badminton

1. Services

A serve is a shot that can ensure a score, because a player who serves well can control the flow of the match. Serving can be done with a forehand or backhand stroke. In singles

play, the serve is often done with a forehand 40, and in doubles playing the backhand is often used.

2. Smash

Smash is a blow that emphasizes strength, arm and wrist speed so that the shuttlecock goes into a sharp dive. Smash is a blow that is intended to attack and get points.

3. Dropshot

Dropshot is a hitting technique for playing badminton with the aim of attacking the enemy by sending a thin shuttlecock near the net in the opponent's playing area. To get a good 43 dropshot, you need skills in feeling when tapping the shuttlecock so that it aims slightly at the edge of the net and falls into the enemy's playing area.

4. Netting

Netting is a shot played in the net area with the aim of placing the ball as thinly as possible around the enemy's net area. Netting can be the final determinant of a badminton match, and good quality netting allows players to receive feedback from the enemy for smashes/other hits.

5. Lop

Lob is a shot that is often used by badminton players. The lob is vital for controlling a badminton match, very good at planning attacks or fixing difficult situations when under pressure from the enemy.

4. Conclusions

The conclusion of this research states that the use of machine learning in developing basic badminton techniques has great potential in increasing the effectiveness of training and accelerating the progress of badminton athletes. By analyzing a player's movement patterns and responses, machine learning models can provide feedback that is more detailed and tailored to individual needs, allowing players to identify areas for improvement and develop skills more efficiently. An innovative and effective basic badminton technique training model is based on machine learning. It is hoped that the use of this technology can help badminton coaches and players improve the quality of their training and overall performance.

However, several limitations of this study should be acknowledged:

1. Technical Limitations:
    - The machine learning model's accuracy may be affected by environmental factors such as lighting conditions and camera angles.
    - The current system requires specific hardware setups that may not be accessible to all training facilities.
    - Real-time processing capabilities may be limited by computational resources.
2. Sample Limitations:
    - The study was conducted primarily with players from Karawang Regency, which may not be fully representative of the broader badminton player population.
    - The sample size was relatively small (n=30), which may limit the generalizability of the findings
    - The study focused mainly on novice players, and results may differ from intermediate or advanced players.
3. Methodological Limitations:
    - The training period was relatively short, and long-term effects of the machine learning-based training model need further investigation.
    - The study did not include a control group using traditional training methods for direct comparison.
    - Some aspects of badminton technique, particularly complex tactical decisions, may be difficult to capture and analyze using the current machine learning approach.
4. Resource Limitations:
    - The implementation of this system requires significant technical expertise which may not be available in all training settings.
    - The cost of equipment and maintenance may limit widespread adoption.
    - Training staff need additional technical training to effectively utilize the system.
    - Future research should address these limitations by:
    - Expanding the sample size and geographical scope
    - Including players of various skill levels
    - Conducting longitudinal studies to assess long-term effectiveness
    - Developing more cost-effective implementation methods
    - Creating user-friendly interfaces for coaches and players with limited technical expertise
    - Incorporating tactical analysis capabilities alongside technical assessment

These limitations and suggestions for future research provide important context for understanding the scope and applicability of the current findings while highlighting opportunities for continued development in this promising field.

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