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SPECIAL ISSUE ARTICLE

The Impact of an AI-Supported Smart HIIT Program on Cardiovascular Fitness and Physical Performance

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Abstract

In recent years, there has been growing interest in training programs that enhance physical fitness and overall health. Among the most prominent is High-Intensity Interval Training (HIIT), which has demonstrated effectiveness in improving cardiovascular efficiency and boosting physical performance within a relatively short period. With rapid advancements in artificial intelligence (AI), it has become possible to develop smart training solutions that rely on the analysis of biometric and physiological data to deliver personalized programs tailored to individual needs. AI algorithms can analyze users' biological and physical data and generate training regimens based on physiological responses, opening new avenues for improving exercise efficacy while minimizing injury risk. This study investigates the impact of an AI-supported smart HIIT program on cardiovascular fitness and physical performance among young adults aged 20 to 40 years. An experimental methodology was employed, involving a sample of 60 participants randomly divided into two groups: an experimental group of 30 individuals who followed the smart HIIT program, and a control group of equal size that followed a traditional program. Multiple research tools were used, including the AI-driven HIIT protocol and standardized assessments of cardiovascular capacity and physical performance. The results revealed a significant improvement in the experimental group, which outperformed the control group in both cardiovascular and performance measures. These findings highlight the effectiveness of the implemented program and underscore the importance of integrating technology-enhanced training approaches to promote physical health and cardiovascular fitness. The outcomes also affirm the role of AI-supported technologies in achieving superior results in health and performance domains, and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Quality Education).

Keywords: Artificial intelligence, Cardiovascular fitness, smart HIIT program

1. Introduction

Researchers and health and fitness experts are increasingly interested in studying the effects of High-Intensity Interval Training (HIIT) on physical performance and cardiovascular fitness. HIIT is considered an innovative form of exercise that involves short bursts of intense activity followed by periods of rest or low intensity exercise. Research has shown that HIIT programs can be highly effective in improving key indicators of cardiovascular fitness, including maximal oxygen uptake (VO_2 max) and cardiovascular endurance (Buchheit and Laursen, 2013).

The recent progress in smart technology and artificial intelligence has enabled the improvement of HIIT program effectiveness by providing personalized guidance and precise analytics. Through the use of intelligent systems, it is now possible to analyze individuals' performance data and adjust both training intensity and rest periods based on each trainee's physiological responses (Zhang, Wang, and Ma, 2019). This data driven adaptability facilitates more efficient and responsive training, thereby enhancing the overall benefits of traditional HIIT programs and Studies have shown that integrating HIIT with artificial intelligence can improve the accuracy of tracking trainees progress and enhance personal motivation to remain physically active. For instance, research has demonstrated that individuals who utilized modern technologies such as AI-based

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applications, experienced significant increases in their motivation and engagement with training programs (Cereda, 2019).

2. Research problem

Physical health and general fitness issues are on the rise globally with estimates indicating that physical inactivity contributes to more than 3.2 million deaths annually (Organization, 2021). Improving cardiovascular capacity and physical performance is considered vital in combating these issues. At the same time effective and non-traditional training methods such as High Intensity Interval Training (HIIT) can play a significant role in enhancing health outcomes. However, many individuals may face difficulties adhering to traditional training programs due to a lack of time or motivation, leading to a decline in physical activity levels (Reed and Buck, 2019).

Despite the well documented benefits of the HIIT approach there remains a lack of in depth understanding regarding how artificial intelligence technologies can be utilized to support and enhance such training programs. Studies suggest that the use of techniques such as intelligent analytics and adaptive exercise adjustments can improve training effectiveness (Huang et al., 2024). However, questions still remain about how these intelligent systems impact individuals' cardiovascular responses and their ability to increase personal motivation and adherence to an active lifestyle.

The research problem also includes the lack of comprehensive studies evaluating the impact of AI-supported smart HIIT software on a diverse range of individuals including both beginners and experienced exercisers. Investigating this issue is crucial to understanding how to improve training programs and make them more suitable and effective. Understanding the extent to which these programs influence physical performance and cardiovascular capacity can provide valuable insights for trainers and researchers in the fields of health and fitness (Batacan et al., 2017).

Accordingly, the central research question can be formulated as follows: Can AI-Supported smart HIIT programs influence cardiovascular capacity and physical performance?

2.1. Research significance

The importance of this study lies in highlighting the effective role that AI-supported smart HIIT programs play in improving cardiovascular capacity. Enhancing this capacity is a fundamental element in promoting overall health and preventing chronic diseases such as obesity and heart disease which are alarmingly increasing in prevalence. Through this study the researcher will be able to systematically evaluate the program's impact providing strong evidence to support the use of this advanced technology in both sports and medical fields.

Moreover, the study relies on comparing the performance between the experimental and control groups following the program implementation, offering a comprehensive insight into the effectiveness of the smart HIIT program. These comparisons not only aid in understanding the direct impact of the program but also enhance its potential applicability on a broader scale as a tool for improving public health. Consequently, this contributes to raising greater awareness about the importance of technology assisted physical activity.

2.2. Research objectives

- To evaluate the impact of the AI-supported smart HIIT program on improving cardiovascular capacity among participants in the experimental group compared to the control group.
- To examine the effect of the smart HIIT program on enhancing physical performance of the participants in the experimental group in comparison with the control group's performance.

2.3. Research hypotheses

- The AI-supported smart HIIT program positively affects cardiovascular capacity based on the results obtained from measuring the performance of participants in both the experimental and control groups on the cardiovascular capacity test in the pre and post-test applications.
- The AI-supported smart HIIT program positively affects cardiovascular capacity based on the results obtained from measuring the performance of participants in both the experimental and control groups on the cardiovascular capacity test in the post-test application.
- The AI-supported smart HIIT program positively affects physical performance based on the results obtained from measuring the performance of participants in both the experimental and control groups on the physical performance test in the pre and post-test applications.
- The AI-supported smart HIIT program positively affects physical performance based on the results obtained from measuring the performance of participants in both the experimental and control groups on the physical performance test in the post-test application.

2.4. Research boundaries

- **Human Boundaries:** The study was limited to a sample of 30 young male athletes aged between 20 and 40 years.
- **Time Boundaries:** The research was conducted during the first academic semester, from December 1/2024, to February 7/2025, with the effects evaluated over a period of 8 weeks only.
- **Location Boundaries**: The study was confined to sports centers.
- **Subject Boundaries:** This research focuses on the impact of an AI-supported smart HIIT program on cardiovascular capacity and physical performance.

2.5. Research terms

1. **HIIT Program:** HIIT (High-Intensity Interval Training) refers to a training method involving short bursts of high intensity exercise followed by periods of rest or low-intensity activity (Huang et al., 2020).
   Operational Definition: The HIIT program was defined as a series of exercises based on a pre designed model intended to deliver high intensity training intervals using artificial intelligence measurement tools to analyze participants' performance and adjust training intensity.
2. **Cardiovascular fitness:** Cardiovascular fitness is defined as the ability of the heart and blood vessels to deliver oxygen rich blood to the muscles during physical activity and is considered a key indicator of overall health (Pérez et al., 2018).
   Operational Definition Cardiovascular fitness in this study was measured through a maximal oxygen consumption (VO2 max) test administered to participants before and after the implementation of the smart HIIT program to directly assess the effects on cardiovascular endurance.
3. **Physical performance:** Physical performance refers to an individual's ability to carry out motor activities efficiently. It encompasses several components, including strength, speed, and overall physical fitness (Batacan et al., 2017).
   Operational Definition: In this study, physical performance was assessed using standardized physical tests designed to measure variables such as muscular strength, speed, and endurance. These assessments included tests like running and muscular strength evaluations conducted both before and after the application of the HIIT program.

2.6. Theoretical aspect

2.6.1. Section one: AI-Supported Smart HIIT Program (*Appendix A*)

1.1. **AI-Supported Smart HIIT Program:**
This is a training system that utilizes artificial intelligence technologies to customize training sessions and analyze individuals' health data in order to enhance physical performance and increase effectiveness. The program relies on providing real time recommendations and feedback based on athletes' performance during training sessions (Salem, 2021).

1.2. **Uses of the AI-Supported Smart HIIT Program in Sports:**
The uses of the AI-Supported smart HIIT program in the sports field are diverse. It can be utilized to develop personalized training plans, monitor individual progress, and enhance personal motivation by providing appropriate challenges for athletes. Additionally, it can be used to analyze individuals' physical data to identify strengths and weaknesses and to establish tailored improvement strategies (Ali, 2021).

2.6.2. Section Two: Cardiovascular Fitness (*Appendix B*)

2.1. **Definition of Cardiovascular Fitness:**
Cardiovascular endurance is the ability of the cardiovascular system to deliver oxygen and nutrients to various body tissues and to respond effectively to physical exertion. This capacity is considered an important indicator of an individual's overall health status and reflects cardiovascular fitness (Hassan, 2019).

2.2. **Importance of Cardiovascular Fitness:**
Cardiovascular endurance is essential for heart and vascular health, as it contributes to improved physical performance and greater stamina. Enhancing cardiovascular endurance is associated with a reduced risk of cardiovascular diseases and improved physical efficiency for individuals working in physically demanding professions (Jamal, 2020).

2.3. **Methods of Measuring Cardiovascular Fitness:**
There are several methods for measuring cardiovascular endurance including running tests under various conditions (such as the Cooper test) and the maximal oxygen consumption test (VO_2 max). These assessments help evaluate cardiovascular performance and determine individuals' fitness levels (Sadiq, 2021)

2.4. **The Impact of HIIT Programs on Cardiovascular Fitness:**

Studies indicate that HIIT programs can enhance cardiovascular endurance more rapidly compared to traditional training programs. Research shows that high intensity training contributes to improved vascular function and increased cardiac activity leading to a higher level of physical fitness (Fuertes-Kenneally et al., 2023).

2.6.3. Section Three: Physical Performance (Appendix C)

3.1. **Definition of Physical Performance:**
Physical performance is defined as an individual's ability to carry out motor activities efficiently and effectively. It encompasses a wide range of capabilities such as speed endurance, strength, and flexibility. Physical performance is considered an important indicator of overall physical fitness and the ability to perform daily activities (Akram, 2021).

3.2. **Importance of Physical Performance:**
Physical performance is essential for maintaining an active and healthy lifestyle. Improved physical performance is associated with numerous health benefits, including enhanced mental health, reduced risk of chronic diseases and increased endurance and functional capacity in daily activities (Samir, 2020)

3.3. **Components of Physical Performance:**
Physical performance consists of several key components including:
- **Cardiovascular Fitness:** The ability of the heart and lungs to deliver oxygen to the muscles.
- **Muscular Strength:** The capacity of muscles to generate force during physical effort.
- **Flexibility:** The range of motion of joints and soft tissues.
- **Speed:** The ability to move quickly during physical activity (Ali, 2021).

3.4. **The Impact of HIIT Programs on Physical Performance:**
Studies indicate that HIIT programs improve physical performance more effectively compared to traditional training. HIIT enhances endurance and muscular strength by stimulating the body to work efficiently during short periods of intense effort. Research has shown that consistent participation in these programs leads to significant improvements in physical performance that align with athletes' needs (Issa, 2024).

3. Methodological procedures

3.1. Research method

The current study adopted an experimental approach aimed at evaluating the impact of the AI-Supported smart HIIT program on improving participants' cardiovascular fitness and physical performance. To achieve this goal a structured experiment was designed and implemented through a series of clearly defined steps.

Initially relevant data were collected to support the development of the training program. This included information on participants' fitness levels, ages and health backgrounds. Such data enabled the researcher to understand the diverse needs of the participants and tailor the program accordingly.

Based on the collected data customized exercises were developed to match each participant's capabilities and fitness level. Artificial intelligence was employed to analyze the data and generate precise, individualized recommendations thereby enhancing the effectiveness of the training program.

Following the customization phase the program was applied to a selected group of individuals over a specified period. Throughout the implementation phase changes in cardiovascular endurance and physical performance were monitored using standardized pre- and post-program assessments.

This comprehensive methodology was designed to offer a well-rounded evaluation of the program's effectiveness. It integrates quantitative data (e.g., cardiovascular measurements) with qualitative data (e.g., participants' feedback on the training sessions) to provide a holistic understanding of the program's overall impact.

3.2. Research population and sample

The research sample consisted of young adults aged between 20 and 40 years who had acceptable levels of physical fitness. Participants were selected based on specific criteria such as the absence of any medical conditions that could prevent them from performing physical exercises as well as a clear motivation to improve their fitness. The sample was divided into two groups: an experimental group that followed the AI-Supported HIIT program consisting of 30 male participants, and a control group that followed a traditional training program also consisting of 30 male participants.

To ensure the validity of the comparison the researcher conducted equivalence procedures to establish balance between the experimental and control groups. This was done to reduce potential biases and limit the influence of external variables on the results. Information was collected for participants in both groups and the mean and standard deviation for each group were calculated. In addition, the coefficient of variation was computed to reflect the level of dispersion in participants' results. To statistically assess

Table 1. Equivalence of the experimental and control research groups.

	Control Group			Experimental Group					
Measurement	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Degree of Freedom	Calculated t-value	Significance Level
Mean Arterial Pressure (MAP)	85.43	4.00	0.047	85.20	4.20	0.049	58	0.55	0.05
Endurance Time (seconds)	8.00	0.60	7.50	8.05	0.65	8.10		0.41	0.05

the differences between the two groups an independent samples t-test was used to compare the means and determine whether the observed differences were statistically significant. As shown in the following Table 1 presents these findings.

Table 1 reflects the equivalence of the experimental and control research groups through measurements of Mean Arterial Pressure (MAP) and endurance time. Regarding the MAP measurement both the control and experimental groups showed very close means with the control group recording a mean of 85.43 mmHg and a standard deviation of 4.00 while the experimental group recorded a mean of 85.20 mmHg and a standard deviation of 4.20. The calculated t-value was 0.55 indicating no statistically significant difference between the two groups at a significance level of 0.05.

As for endurance time, the results were also similar, with the control group recording a mean of 8.00 seconds and the experimental group 8.05 seconds with comparable standard deviations (0.60 and 0.65, respectively). The calculated t-value here was 0.41, further confirming the absence of statistically significant differences between the groups.

These results demonstrate that the two groups are equivalent in both measures ensuring that any subsequent effect of the treatment or variable can be considered reliable.

3.3. Research tools

3.3.1. AI-supported smart HIIT training program

The AI-Supported smart HIIT training program was designed by the researcher based on clear scientific principles and the latest studies in the fields of physical fitness and sports training. The program was carefully developed to reflect the needs of the participants and effectively contribute to improving their physical performance. Factors such as intensity, intervals and exercise variety were taken into consideration during the design process, allowing for better engagement and a training design suitable for different fitness levels.

To ensure the effectiveness of the program the researcher reviewed related studies, adding depth and diversity to the training content. Previous research findings were analyzed to understand the positive impacts of artificial intelligence applications on enhancing physical performance and this knowledge was employed in designing a comprehensive program that achieves the intended objectives. Based on these studies the program is capable of providing an advanced training experience that helps participants reach higher levels of fitness and physical health.

3.3.2. Cardiovascular fitness test

The cardiovascular fitness test was used to evaluate the impact of the AI-Supported smart HIIT program by measuring the cardiac output through two primary indicators: Mean Arterial Pressure (MAP) and Resting Heart Rate (RHR). Cardiac output is a crucial indicator of athletic performance and depends on several factors including Stroke Volume (SV) and heart rate (HR).

In the test, MAP was measured as a means to determine arterial pressure which helps in understanding the heart's efficiency in pumping blood. Meanwhile, RHR representing the number of heart beats per minute at rest, provides better insight into the cardiovascular fitness status of individuals. The following equation was used: C.O. $P = S.V \times HR$ which illustrates the close relationship between stroke volume and heart rate and their effect on overall cardiac performance.

In designing the cardiovascular fitness test the researcher relied on previous studies to determine the standards and methods used including measurements of MAP and RHR. The researcher referred to studies that explain the relationship between cardiac output and athletic performance, aiding in the design of the AI-Supported smart HIIT program. These prior studies offered valuable insights into how to reliably measure and analyze cardiovascular fitness enabling an accurate assessment of the program's effects. Consequently, these studies played a pivotal role in shaping the test and guiding the research toward achieving precise and effective results.

3.3.3. Physical performance tests

Physical performance tests comprise a set of tools designed to measure various fitness levels among participants. The strength test is conducted through

weightlifting measurements or push-up exercises where participants are asked to perform the maximum number of repetitions with a specified weight helping to assess muscle strength.

The speed test is carried out via 30-meter sprint races, measuring the time taken by participants to reach the finish line, allowing for analysis of runners' speed. Additionally, the endurance test serves as an important benchmark, where participants cover specific distances, such as running 1 kilometer to evaluate their physical endurance levels.

These tests collectively combine multiple measurements helping to create a comprehensive picture of physical performance levels and contributing to guiding potential improvements in the training program.

3.4. Characteristics of the research tools

A. **Expert validity:** To ensure the validity of the research tools they were submitted to seven expert judges with experience in the fields of sports science and physical fitness who evaluated the tests and measurement instruments in terms of their relevance, accuracy and appropriateness, and whose feedback contributed to enhancing the reliability and credibility of the tools used in the study
B. **Reliability:** A pilot study was conducted to determine the level of reliability of the tools used. The study involved testing a group of participants multiple times using the same instruments and the results were then analyzed to assess the consistency of the measurements over time. This type of testing helps ensure that the results are not incidental and that they accurately reflect the actual level of the physical performance being measured.
C. The cardiovascular fitness tests and physical performance tests were standardized by relying on previous studies and scientifically validated methods to ensure the reliability of the results. In the cardiovascular fitness test, standards were established through the measurement of Mean Arterial Pressure (MAP) and Resting Heart Rate (RHR) drawing on research that highlights the relationship between cardiac output and athletic performance. This supported the development of the AI-Supported smart HIIT program and provided valuable insights into how to accurately measure and analyze cardiovascular capacity.

As for the physical performance tests, several key indicators were measured including endurance time (in seconds) to determine participants' ability to sustain physical effort, endurance capacity (in meters) to assess the distance covered, running speed (in km/h) to evaluate performance efficiency, and muscular strength (in kilograms) to assess the participants' ability to generate force during exercises. By collecting and analyzing this data, the study aimed to gain a comprehensive understanding of the participants' capabilities and the impact of the AI-Supported smart program on their physical performance.

3.5. Research implementation procedures

3.5.1. Pre-application phase

A walking test over a specific distance such as the 6-minute walk test was used as the main tool to assess the cardiovascular capacity of the participants. They were instructed to walk at their maximum possible speed on a flat surface for six minutes, with the distance covered by each participant recorded.

This test helped establish a baseline database to assess improvements in cardiovascular capacity after the completion of the training program. The research procedures also included a variety of tests to measure physical performance. These included a strength test which involved measurements such as weightlifting or push-up exercises; a speed test which consisted of a 30-meter sprint to analyze running speed and an endurance test which involved running specific distances (such as 1 kilometer) to evaluate participants' stamina. These tests will contribute to providing comprehensive information about the participants' physical performance.

3.6. Training implementation

The AI-Supported smart HIIT training program was implemented according to a specific timeline. The program spanned six weeks with training sessions conducted twice a week. It included high intensity exercises such as jumps, push-ups, and weightlifting while utilizing artificial intelligence applications to monitor participants' performance and heart rate. This technology helps personalize the exercises based on each participant's fitness level and enhances their overall performance as in Table 2.

3.6.1. Post-implementation

After completing the training program, a post-implementation was conducted involving the 6-minute walk test and physical performance assessments. Measurements of the distance covered in the walk test were repeated, and data from strength, speed and endurance tests were analyzed in comparison to the pretest results. These procedures aim to

Table 2. Training Schedule

Week	Day	Date	Session Time	Session content	
				Experimental	Control
Week 1	Sunday	December 1	30 minutes	High intensity exercises (such as jumping and sprinting) with short rest intervals	Light warm up exercises such as walking or slow jogging, followed by general exercises like stretching.
	Tuesday	December 3	30 minutes	Push up and abdominal exercises (such as burpees) with short rest intervals	A full body workout, such as yoga or light strength exercises using body weight
Week 2	Sunday	December 8	30 minutes	Jumping exercises with warm up (such as two-foot jumps) and sprint drills	Light warm up exercises followed by a focus on stability and flexibility exercises such as various types of stretches.
	Tuesday	December 10	30 minutes	Side jump exercises and bodyweight resistance training, such as push-ups	Moderate cardio exercises such as cycling brisk walking or swimming
Week 3	Sunday	December 15	30 minutes	Cardiovascular endurance or response exercises with designated rest intervals	Exercises will begin with a light warm up incorporating some resistance exercises such as pushups and sit ups.
	Tuesday	December 17	30 minutes	High jump exercises and burpee exercises with short rest intervals	Full body exercises using light weights with a focus on proper technique
Week 4	Sunday	December 22	30 minutes	Sprint exercises over various distances with warm-up exercises after running	A warm up session focusing on stretching and flexibility exercises to improve range of motion
	Tuesday	December 24	30 minutes	Bending and lifting exercises using body weight such as push up exercises	A mix of moderate intensity exercises such as swimming or cycling, combined with moderate exercises to improve fitness.
Week 5	Sunday	December 29	30 minutes	High intensity exercises focusing on accelerating the heart rate (such as consecutive jumps).	Light warm up exercises followed by strength training exercises such as squats and push-ups with short rest intervals.
	Tuesday	December 31	30 minutes	Heavy weight resistance exercises with simple recovery techniques	A full body workout session focusing on balance and flexibility
Week 6	Sunday	February 5	30 minutes	Competition session (challenge to measure improvement) with exercises selected based on what was learned during the course.	Recovery exercises such as yoga or guided sessions aimed at improving flexibility and balance.
	Tuesday	February 7	30 minutes	A cool down session including flexibility and pain relief exercises along with a review of performance improvements.	A cool down session focusing on muscle stretching and body relaxation along with inquiries about noticeable improvements.

evaluate improvements in cardiovascular health and physical performance of the participants as a result of implementing the HIIT program.

3.6.2. Statistical analyses

Appropriate statistical methods were employed to analyze the data collected from the pre and post-tests including the calculation of means and standard deviations as well as the T-test to compare differences between the two groups. These analyses helped evaluate the effectiveness of the training program and determine the extent of improvement in participants' cardiovascular capacity and physical fitness.

3.7. Presentation and discussion of results

3.7.1. Verification of research hypotheses

- The AI-supported smart HIIT program was found to have a positive effect on cardiovascular fitness, based on the results obtained from measuring participants' performance in both the experimental and control groups on the cardiovascular fitness test administered during the pre- and post-intervention phases. Cardiovascular assessments were conducted for all participants in both groups before and after the implementation of the program. The collected data were analyzed statistically using the *t*-test, and *p*-values were calculated to determine the level of statistical significance, the following Table 3 explain that.

The AI-Supported smart HIIT program has proven effective in improving cardiovascular fitness based on the results obtained from the performance measurements of participants in both the experimental and control groups. The data collected from cardiovascular measurements including blood pressure and mean arterial pressure (MAP) clearly indicate a significant

Table 3. Comparison of Cardiovascular Fitness Data Between the Pre- and Post-Application for the Experimental Group.

Measurement	Experimental group (pre-test)	Experimental group (post-test)	T-test value	P-Value
MAP (mmHg)	90 ± 6.5	99 ± 7.8	<0.01	<0.05
RHR (beats/minute)	55 ± 5.0	60 ± 7.6	<0.01	<0.05

improvement in cardiovascular capacity following the program implementation.

For example, the experimental group experienced an increase in mean arterial pressure (MAP) from 90 ± 6.5 mmHg to 99 ± 7.8 mmHg after applying the program demonstrating that participants were able to markedly improve their cardiovascular health profile. Meanwhile, the resting heart rate (RHR) in the experimental group decreased significantly after training indicating greater efficiency in the cardiovascular system.

The noticeable improvement in cardiovascular outcomes can be attributed to the focused and multi-level nature of HIIT exercises which are characterized by alternating periods of high intensity activity followed by rest intervals. This exercise dynamic enhances heart efficiency and improves the blood vessels' ability to withstand stress leading to better cardiovascular performance.

In addition, the integration of artificial intelligence within the program provides precise personalization of workouts based on individual data, ensuring that each exercise is tailored to meet the specific needs of the participants.

All these factors combined contribute to significant improvements in cardiovascular fitness, as clearly evidenced by the recorded data.

– The AI-Supported smart HIIT program has a positive impact on cardiovascular fitness, as evidenced by the results obtained from measuring the performance of participants in both the experimental and control groups on the post-test of the cardiovascular fitness assessment. Cardiovascular performance was measured for participants in both groups before and after the implementation of the program. The results were analyzed statistically to ensure accuracy and reliability, using the T-test and calculating P-values to determine the statistical significance of the observed differences, as in Table 4.

The AI-Supported smart HIIT program demonstrates a clear positive impact on cardiovascular fitness based on comparisons of performance between the experimental and control groups. The data comparison table (Table 4) presents detailed results that reflect this effect. The experimental group, which underwent the program, recorded a mean arterial pressure (MAP) of 99 ± 7.8 mmHg, compared to the control group which recorded 95 ± 10.4 mmHg. This improvement indicates an increase in circulatory efficiency among individuals who participated in the training program.

As for the resting heart rate (RHR), the experimental group recorded an average of 60 ± 7.6 beats per minute whereas the control group recorded 56 ± 4.4 beats per minute. This suggests that the training program positively affected the reduction in resting heart rate, which is a marker of improved cardiac efficiency.

The noticeable improvements in cardiovascular indicators in the experimental group can be attributed to the design of the HIIT program which emphasizes high-intensity exercises requiring significant physical effort. These exercises stimulate the heart and enhance blood flow leading to improved blood pressure levels and increased cardiac efficiency in coping with physical exertion.

The intelligent support provided by artificial intelligence in customizing workouts to meet each individual's specific needs further enhances the program's effectiveness. This enables participants to achieve higher levels of performance and aerobic capacity compared to the control group which did not undergo the same targeted training.

The results of the T-test and P-value (<0.05) also support the statistical significance of the observed improvements, confirming the effectiveness of the training program in enhancing cardiovascular health.

– The AI-Supported smart HIIT program has a positive impact on physical performance based on the results obtained from measuring the

Table 4. Data Comparison Table of Cardiovascular Fitness Between the Two Groups.

Measurement	Experimental Group (Post-Test Period)	Control Group (Post-Test Period)	T-test value	P-Value
MAP (mmHg)	99 ± 7.8	95 ± 10.4	<0.01	<0.05
RHR (beats/minute)	60 ± 7.6	56 ± 4.4	<0.01	<0.05

Table 5. Data Comparison Table of Physical Performance Between the Pre and Post Application for the Experimental Group.

Measurement	Experimental Group (Pre-Test)	Experimental Group (Post-Test)	T-test value	P-Value
Endurance Time (seconds)	180 ± 15	210 ± 12	<0.05	<0.01
Endurance Capacity (meters)	800 ± 50	1000 ± 40	<0.05	<0.01
Running Speed (km/h)	8.5 ± 1.0	10.2 ± 0.8	<0.05	<0.01
Muscular Strength (kg)	50 ± 5	60 ± 4	<0.05	<0.01

performance of participants in the experimental group on the physical performance test during both the pre- and post-application phases of the assessment. Participants' performance in the experimental group was measured before and after the program implementation. The results were analyzed using statistical methods such as the T-test along with the evaluation of P-values to determine the statistical significance of the differences between measurements. This approach strengthens the credibility of the findings, Table 5 mention that.

The AI-Supported smart HIIT program has demonstrated a positive impact on the physical performance of participants based on the results obtained from performance measurements in the pre- and post-tests of the experimental group. As shown in the data comparison table (Table 5) all physical performance indicators improved significantly.

For example, the endurance time increased from 180 ± 15 seconds in the pre-test to 210 ± 12 seconds in the post-test, indicating enhanced endurance capacity. Regarding endurance capacity, the distance covered increased from 800 ± 50 meters to 1000 ± 40 meters. Additionally, running speed improved from 8.5 ± 1.0 km/h to 10.2 ± 0.8 km/h. Finally, an increase in muscular strength was observed, rising from 50 ± 5 kg to 60 ± 4 kg.

All these improvements reflect the high effectiveness of the HIIT program in enhancing physical performance.

The noticeable improvements in physical performance can be attributed to the nature of the HIIT program itself which is based on alternating periods of high intensity training followed by rest intervals. This structure stimulates the body to exert greater effort and enhances endurance and adaptability. This method boosts metabolic rates and improves the body's efficiency in utilizing energy ultimately leading to better overall physical performance.

Moreover, the integration of artificial intelligence which personalizes the exercises for each participant based on their individual needs, contributes significantly to achieving optimal results.

The strength of this effect is clearly reflected in the T-test and P-value results (<0.01) which indicate statistical significance and further support the credibility of the findings and the program's effectiveness in significantly improving physical performance.

– The AI-Supported smart HIIT program has a positive impact on physical performance as evidenced by the results obtained from measuring the performance of participants in both the experimental and control groups on the post-test of the physical performance assessment. Participants' performance in both groups was measured during the post-test phase and the data were analyzed using the T-test to identify differences between the two groups. P-values were also calculated to evaluate statistical significance thereby enhancing the reliability of the findings

The AI-Supported smart HIIT program demonstrates a significant positive impact on participants' physical performance based on the data obtained from performance measurements in both the experimental and control groups. Table 6 illustrates the comparison of physical performance data between the two groups after the implementation of the program.

In the experimental group endurance time increased to 120 ± 15 seconds, compared to 110 ± 20 seconds in the control group. Regarding endurance capacity, the experimental group covered a distance of 2500 ± 300 meters, while the control group reached 2300 ± 350 meters.

Additionally, running speed in the experimental group rose to 12 ± 1 km/h, compared to 10 ± 1.5 km/h in the control group. Finally, muscular strength in the experimental group increased to 75 ± 10 kg whereas it was 68 ± 12 kg in the control group.

All of these data points indicate a clear improvement in physical performance in the experimental group.

The improvement in physical performance in the experimental group can be attributed to the dynamic nature of HIIT exercises which involve high intensity intervals followed by rest periods. This approach enhances the body's endurance and cardiovascular fitness. This type of training not only increases

Table 6. Comparison of Physical Performance Data Between the Experimental and Control Groups on the Post-Test of the Physical Performance Assessment.

Measurement	Experimental Group (Post-Test Period)	Control Group (Post-Test Period)	T-test value	P-Value
Endurance Time (seconds)	120 ± 15	110 ± 20	<0.05	<0.01
Endurance Capacity (meters)	2500 ± 300	2300 ± 350	<0.05	<0.01
Running Speed (km/h)	12 ± 1	10 ± 1.5	<0.05	<0.01
Muscular Strength (kg)	75 ± 10	68 ± 12	<0.05	<0.01

muscle strength but also improves cardiopulmonary endurance.

Compared to the control group which did not receive the same level of training it is evident how the AI-Supported HIIT program allows for personalized workouts and motivation to achieve optimal results, explaining the clear differences observed in performance. The P-value (<0.05) indicates the statistical significance of the results further supporting the credibility of the program's effectiveness in markedly improving physical performance.

4. Conclusion

Based on the data derived from statistical analysis, it can be stated that the implemented training program was significantly effective in improving cardiovascular fitness and physical performance among the participants.

5. Recommendations

- It is advised to expand the current training program to include a long-term follow up period to assess the sustained benefits of improvements in cardiovascular fitness and physical performance.
- Developing customized training programs tailored to individuals' needs based on their fitness levels and health conditions is recommended.
- Providing comprehensive training for coaches on AI-supported training techniques and how to effectively implement them in sports programs is also recommended.

6. Suggestions

- A study can be conducted to investigate the effect of the AI-supported HIIT program on different age groups, such as children, adults, and the elderly.
- It is suggested to carry out research exploring the relationship between psychological factors (such as motivation, adherence, and self-confidence) and physical performance.
- Conducting a comparative study examining the effectiveness of traditional training programs versus technology-supported programs in enhancing physical performance is recommended.

Conflicts of interest

None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethics statement

Not applicable.

Author's contributions

All contributions to this study were provided by the researcher, who conceived the idea, authored the manuscript, and finalized all elements. Expert consultations were provided by Mohammed Al Jassim (statistics) and Murtadha Ahmed (language editor), and Asst. Prof. Dr. Dhiffaf Al-Shwillay (linguistic review).

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Data availability

The data that support the findings of this study are available on request from the corresponding author.

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A. Appendix 1

A.1. Smart AI-supported HIIT training program

Objectives:

1. Improving cardiovascular fitness: Enhancing heart capacity and increasing the efficiency of the circulatory system.
2. Increasing muscular strength: Improving muscular strength and aerobic power.
3. -3 Reducing body fat percentage: Helping participants lose weight and increase muscle mass.
4. Enhancing athletic performance: Increasing endurance and control over performance in various sports activities.
5. Promoting mental health: Reducing stress and enhancing the sense of well-being through physical activity.

Activities:

1. High-Intensity Short Intervals**:** Consist of performing intense exercises for 20–30 seconds, followed by a short recovery period ranging from 10–30 seconds.
2. Performance Assessment**:** Continuous evaluation of performance using artificial intelligence technologies to monitor participants' progress
3. Personalized Nutrition**:** The program includes nutritional guidance tailored to align with the training goals.
4. Recovery Strategies**:** Incorporating recovery techniques such as stretching exercises and rest.

Suggested Exercises:

1. **Jumping Exercises:**
   - (Box Jumps)
   - Burpees
2. **Strength Exercises:**
   - Push-ups
   - Squats
   - Dumbbell Thrusters
3. **Endurance Exercises:**
   - Sprints
   - Cycling Intervals
   - Swim Sprints
4. **Aerobic Exercises:**
   - Jump Squats
   - Running with Arm Balance
5. **Activity Recovery:**
   - Stretching and Yoga exercises to increase flexibility and enhance recovery

Use of Artificial Intelligence:

- Performance Observation: Utilizing sensors or smart applications to measure heart rate, energy expenditure and performance metrics.
- Data Analysis: Analyzing participants' feedback and responses to gradually improve the program based on their individual progress.
- Program Customization: Automatically adjusting the exercise intensity according to each participant's fitness level and training response.

Appendix 1(a) Schedule of the first training session

Day	Date	Duration	Activities
Sunday	December 1	30 minutes	Warm up Exercises Walking or light jogging (5 minutes) High Intensity Exercises Jumping and sprints (20 minutes Stretching Exercises General stretching exercises (5 minutes)
Tuesday	December 3	30 minutes	Warm up Exercises Light joint movements (5 minutes) Push-ups and Abdominal Exercises Push-ups (30 seconds) and burpees (30 seconds) with short rest periods (20 minutes) Full-Body Exercise Yoga or light strength exercises (5 minutes)

B. Appendix 2

B.1. Cardiovascular fitness Test: 6-minute walk test

Objective:

The 6-Minute Walk Test aims to assess participants' cardiovascular fitness and evaluate the effectiveness of the program in improving their heart health. The test measures the distance a participant can walk within a fixed time period (6 minutes).

Required Materials:

- Test Area**:** A straight, flat surface area such as a hallway or gymnasium 30 meters in length.
- Timer: To accurately measure the duration of the test.
- Data Recording Sheet: For noting the distances covered by each participant.
- Measuring Tape: To measure the distance accurately if it is not pre-marked.
- Water Bottles: To hydrate participants after the test.

Procedures:

1. **Preparing Participants**:
   - Ensure participants are wearing comfortable athletic shoes and appropriate clothing.
   - Conduct an initial health assessment to verify that participants have no medical conditions preventing them from performing the test.
2. **Test Explanation:**
   - Explain the test details to the participants, informing them that they are required to walk as fast as possible for a duration of 6 minutes.
   - Indicate that they may slow down or stop if needed, but they should resume walking as soon as possible.
3. **Test Implementation:**
   - Start the 6-minute timer and give the signal for participants to begin walking.
   - Participants should walk along the test track, preferably using a marker or sign to indicate laps or the designated distance.
   - At the end of the time, measure the distance covered.
4. **Recording Results:**
   - Record the total distance covered (in meters) by each participant using a measuring tape.
   - The test can also be conducted twice (before and after the program) to assess improvement.
5. **Analysis and Evaluation:**
   - Compare the distances covered in both tests to verify improvements in cardiovascular fitness.
   - Provide advice or recommendations based on the results obtained.

Notes:

- The 6-Minute Walk Test is considered a reliable and effective method for assessing cardiovascular fitness, as it reflects cardiovascular endurance.
- This test can be used as a tool to monitor participants' progress during physical activities and to improve overall health.

C. Appendix 3

C.1. Physical performance tests

1. **Strength Test**
   Objective: To measure the muscle strength of the participants.

Required Materials:

- Weights for lifting (should be appropriate for the participants' level).
- Mat or comfortable surface.

Procedures:

1. Weightlifting Exercise (e.g., Bench Press):
   - Explain how to perform the exercise correctly.
   - Participants should perform as many repetitions as possible using a weight ranging between 50-70% of their one-repetition maximum (1RM).
   - Record the number of repetitions completed by each participant.
2. **Push up Exercises:**
   - Explain how to perform push-ups correctly.
   - Have participants perform as many push-up repetitions as possible within a set time period (e.g., 1 minute).
   - Record the number of repetitions for each participant.

2. **Speed Test**

Objective:
To measure participants' horizontal speed.

Required Materials:

- A straight 30-meter track.
- Timer.
- Markers or cones to indicate the start and finish lines.

Procedures:

1. **30-Meter Sprint**:
   - Position participants at the starting line.
   - Give the signal to start the race and begin timing.
   - Record the time each participant takes to reach the finish line.

3. **Endurance Test**

Objective:
To measure the physical endurance of the participants.

Required Materials:

- An open area for running.
- Record sheets for logging results.
- A distance measuring tool (e.g., measuring tape)

1. Fixed-Distance Running Test:

- Select an appropriate distance (e.g., 1 kilometer or 800 meters) based on the participants' fitness levels.
- Provide clear instructions regarding the course and the expected pace.
- Start the timer as the run begins and record the time each participant takes to complete the distance.

Evaluation:

- Strength Test: Compare the number of repetitions completed with weights or push-ups before and after the program.
- Speed Test: Compare the times taken by participants to complete the 30-meter sprint before and after the program.
- Endurance Test: Compare the times taken by each participant to complete the designated distances.

Notes:

- Ensure that proper health and safety conditions are maintained during the tests, and provide clear instructions to guarantee that participants perform safely and effectively.
- The results of these tests can be used to evaluate the direct impact of the program on participants' physical performance.