

# Artificial Intelligence-Enabled Muscular Movement Analysis in Wireless Body Area Networks for IoT based Fitness Assessment

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## Abstract

The game's physical and physiological stakes are equal for all players. The two dimensions that rely on the power of physical and physiological consequences are the pursuer and the defence. Whether a chaser or defender, male or female, the physiological actions that occur during the physical activity will have a good effect on the body and on the personality. A Wireless Body Area Network (WBAN) is a network that may transmit real-time traffic like data, speech, and video to monitor the state of essential organs capabilities while remaining external to the body. The present research provides a clear evaluation of how different bones and muscles function, metabolism, movement regulation, and energy generation in relation to varying environmental conditions. There are physiological differences between a chaser and a defender. The primary goal is to gain an in-depth IoT based understanding of how several physiological variables, such as resting heart rate, maximum heart rate, aerobic capacity, and the regulation and maintenance of red blood cells and haemoglobin, are affected by skeletal muscle contraction. It was discovered based on artificial intelligence that the defenders with high speed agility and flexibility performed better in the pre-test. Physiological variables have a considerable impact on speed, strength, agility, and flexibility tests.

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## 1. Introduction

In recent years, there has been a lot of buzz about using wireless technology to create a remote monitoring system for the human body's key organs. A Wireless Body Area Network (WBAN) is a network that may transmit real-time traffic like data, speech, and video to monitor the state of essential organs' capabilities while remaining external to the body. This study has provided a summary of WBAN technology and its prerequisites. Teachers and coaches in the field of physical education have become increasingly curious about their students' body composition since the introduction of a new physical fitness exam (AAHPER). To increase athletic performance and make informed decisions about which events or activities are most suited to a certain person's body type, it is necessary to be familiar with appropriate body composition norms. Measurements of muscle, bone, and fat are the mainstays of any body composition analysis [1]. This part discusses the criteria that can be used to rate the

various parts. The primary tools in this area are the hydrometer, densitometry, roentgenogrammetry, and somatometry on anthropometry.

Athletes have been the subject of numerous body composition studies. In these cases, it is essential to examine fat and skinfold at specific places. Leaner athletes, or those with less body fat overall but more muscle mass, have been shown to perform better in a variety of sports. Long-distance swimming, water polo, and synchronised swimming are sports where moderate levels of fat may act as an advantage, while athletes with a lot of adipose tissue have permanently increased energy demands due to the inert weight of fat, making the work more difficult to perform in activities where the body has to be projected, like jumping movements, or propelled against gravity over a long distance, like distance running [2].

In competitive sports like football, weight lifting, and the shot put, studies of body composition showed that athletes who were very thin yet heavy due to well-developed musculature were superior. However, athletes with a high percentage of adipose tissue have higher energy requirements during endurance exercises because they must move their heavier bodies for longer periods. Thus, the physical framework established may serve as a kind of talent scouting for a specific sport or game. If you want to be the best in your sport, you need to start training as a child.

It's possible that trying to mould everyone into a "Future champion" is a waste of time and resources [3]. The profiles of elite athletes or the physiques of the best performers in any given field can serve as a guide when picking participants. Given this scenario, potential future champions can be identified and groomed.

The importance of physical fitness to one's health and happiness cannot be overstated. Most authors define physical fitness as the ability to perform daily activities (both work and leisure) without experiencing undue weariness and with enough energy reserve for emergencies; this is the meaning behind the term "task intensity." Scientists have stressed the need to meet the body's biological requirements for optimal health, arguing that failing to do so reduces an individual's efficiency [4].

There is not one universally required minimum level of physical fitness. Nonetheless, all professionals, including doctors, engineers, CEOs, and others, require some level of physical fitness to execute their jobs effectively. However, the level of physical preparedness needed would change based on the individual's line of work. How fit you need to be depends on things like the kinds of work you do and how far you can push yourself physically. Individuals' needs and the requirements of their jobs determine their optimal level of physical fitness. Whereas the non-athlete needs less effort to maintain his or her level of physical fitness, the athlete must constantly work to enhance his or her strength, endurance, flexibility, speed, and cardiorespiratory efficiency [5]. A person's level of physical fitness will change as they adapt to new environments and experiences. There is a wide range of fitness levels. Physical activity is crucial to attaining fitness, and almost anyone may make improvements to their current level of fitness. A person who stays active all summer but stops when autumn rolls around will not maintain their physical health throughout the year. Fitness is the most priceless asset one can have; it can't be bought, it has to be won by a consistent workout regimen that improves one's health, appearance, and quality of life. What follows is the outline for the rest of the paper. The related work is briefly described in part 2, and the methodology and the theoretical foundations of the methods used are described in section 3. The simulation results and analysis are presented in section 4. For the research paper's final section, "key findings" we summarize the most important results.

## **2. Existing Work Done**

To fully understand the state of the investigation, it is necessary to review the pertinent literature. An in-depth examination of the field as a whole yields fresh insights, hypotheses, and comparative materials and aids in the refinement of research methodology. Books and libraries contain nearly all of humanity's accumulated wisdom. While other organisms must start from scratch with each new generation, man can build upon the foundation of past knowledge. Their ongoing maintenance of the massive information base makes advancement in every field of human endeavour feasible [6].

Similar to other disciplines, educational research requires the researcher to first learn everything he can about the topic before diving in and trying to solve an issue. By reviewing the relevant literature, researchers can determine if the current data provides sufficient solutions to the challenges at hand. Ideas, theories, explanations, and hypotheses are provided that aid the investigator in defining the problem [7]. It also provides the investigator with guidance on how to conduct the investigation and what resources to use. Finally, the linked literature adds to the investigator's general body of knowledge by providing access to comparable data valuable in interpreting the results of the inquiry.

The researcher has exhausted all possible avenues in his or her pursuit of relevant literature, including journals, periodicals, encyclopaedias, and volumes housed in some of the world's most prestigious libraries. In this chapter, we abstract the pertinent literature relative to the current investigation to offer the context necessary to assess the relevance of this study and to understand its conclusions. The relevant research is presented in the sections that follow [8].

Twenty female basketball players from the Oklahoma State University teams participated in the authors' study. He set out to create a statistical equation that would take into account a player's cardiovascular capacity, leg power, upper-body muscular strength and endurance, body fat percentage, and height to predict how well a player would fare in college basketball.

The study's 46 participants were all elite college football players with at least two years of experience. Their maximum VO<sub>2</sub>, speed, power, agility, strength, anaerobic capacity, and flexibility were measured [9]. Eleven anthropometric measurements were also taken, including skin fold depth, body circumference, and more. The assessments of three professional football coaches were used to determine the players' levels of talent and strategy in a variety of soccer-related areas. The following findings were derived from a multiple regression and zero-order correlation analysis of the data: Age (i.e., playing experience) is the most reliable indicator of future performance [10]. Height, LBW, and weight were all thought to be reliable indicators of athletic prowess. Both maximum oxygen uptake (VO<sub>2</sub>) and speed are valued highly in football. They didn't think that things like flexibility, agility, lactate concentration, and leg power were good indications of playability.

The authors of this study analysed data from 24 varsity volleyball players to determine how certain measures of strength and flexibility correlate with volleyball performance. According to her findings, she can better predict a player's volleyball success by testing their arm, abdominal, leg, and shoulder strength [11].

There was no discernible relationship between grip strength and volleyball skill. There was no correlation between wrist and ankle mobility and volleyball skill. There was a negative and statistically insignificant relationship between trunk flexibility and volleyball skill [12-14]. An examination of boys' and girls' volleyball has been developed by the American Alliance for Health, Physical Education, and Recreation. Serving, volleying, passing, and setting are only some of the skills that will be evaluated [15-18]. They found a lot of support for the reliability and validity of their findings [20].

Cardiorespiratory endurance, resting pulse rate, hand reaction time, speed of movement, response time, and body composition were found to have a significant relationship to hockey playing ability during the authors' research on selected physical, physiological, and psychological variables as predictors in hockey performance [21-23]. The correlation between body fat and performance indicated that a higher body fat percentage may be viewed as an extra burden or dead weight that the individual had to carry, resulting in a decrease in performance. Those hockey players who had had superior performances in terms of their playing abilities also had a lower body fat percentage [24].

### **3. The Proposed Work:**

The research aims to determine the role that gaming plays in the physiology and metabolic pathways of muscular activity.

Physical qualities like as strength, speed, endurance, agility, and flexibility were investigated because of their potential impact on the success of the players. By adhering to the generally accepted criteria in the sports industry, it provides excellent bodily movements that can be quantified on motor tests like speed, endurance, strength, agility, and flexibility.

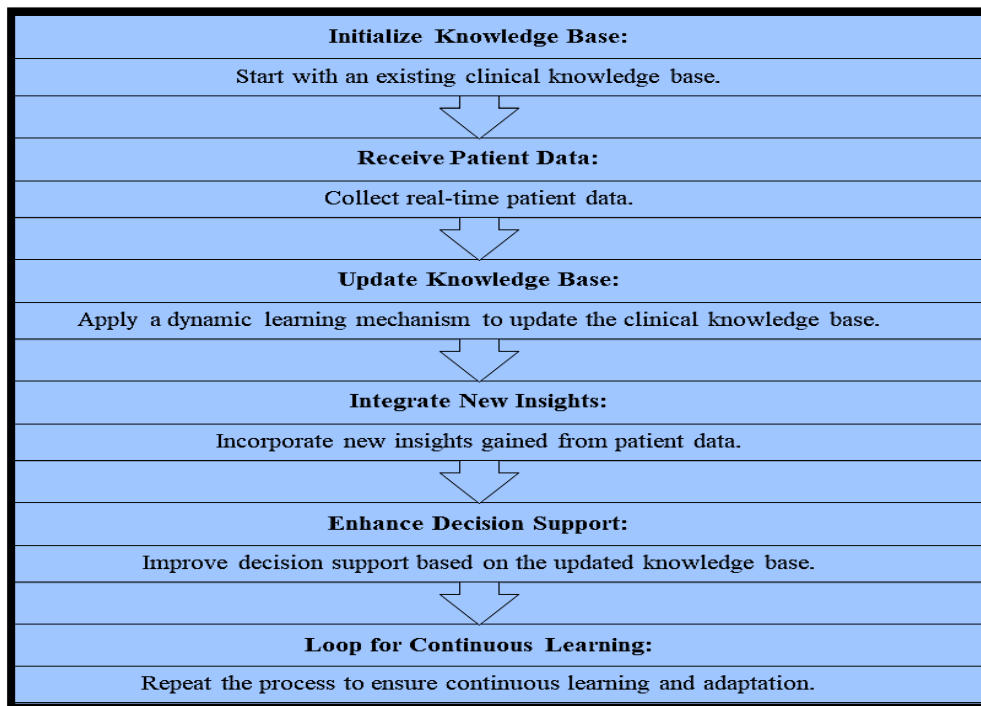


Figure 1: Continuous Learning for Enhanced Clinical Knowledge.

Based on global physical and physiological parameters, a sizable sample was chosen at random. Resting heart rate, maximum heart rate, blood pressure, haemoglobin, respiratory rate, and temperature were all measured. Once the minimum sample size (400) was determined using the scoring system, an even distribution of players was chosen using the parameters on which the motor tests were performed. A statistical analysis was performed on the results.

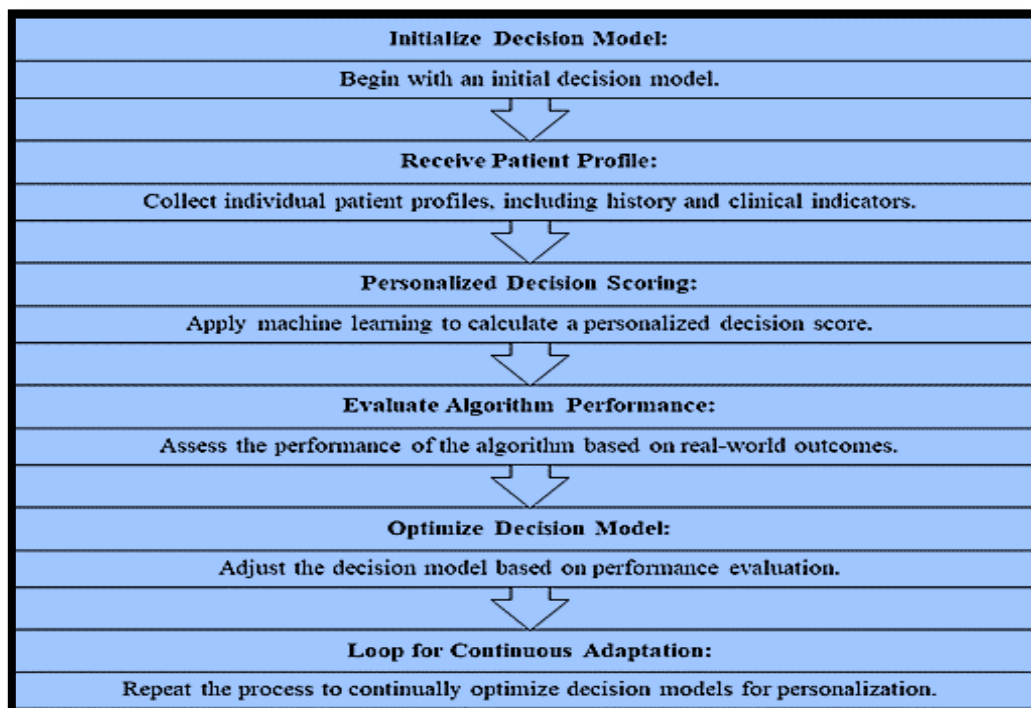


Figure 2: Personalized Decision Optimization through Adaptive Learning.

The Proposed Algorithm:

1. Scalability Equation:

$$S = N_{new} - N_{old} \quad (1)$$

Where:

- $S$  represents scalability.
- $N_{new}$  is the number of new devices or users added.
- $N_{old}$  is the initial number of devices or users.

2. Latency Reduction Equation:

$$L = T_{old} - T_{new}T_{old} \times 100\% \quad (2)$$

Where:

- $L$  represents latency reduction.
- $T_{old}$  is the previous latency.
- $T_{new}$  is the current latency.

3. Adaptable Security Equation:

$$A = S_{new} - S_{old} \times 100\% \quad (3)$$

Where:

- $AA$  represents the adaptability of security measures.
- $S_{new}$  is the security strength after adaptation.
- $S_{old}$  is the initial security strength.

4. Energy Efficiency Equation:

$$E = P_{old} - P_{new}P_{old} \times 100\% \quad (4)$$

Where:

- $E$  represents energy efficiency improvement.
- $P_{old}$  is the previous power consumption.
- $P_{new}$  is the current power consumption.

5. Exact Data Transfer Equation:

$$D = N_{correct}N_{total} \times 100\% \quad (5)$$

Where:

- $D$  represents data accuracy.
- $N_{correct}$  is the number of correctly transferred data.
- $N_{total}$  is the total number of transferred data.

6. Low Network Waste Equation:

$$W = W_{old} - W_{new}W_{old} \times 100\% \quad (6)$$

Where:

- $W$  represents the reduction in network waste.
- $W_{old}$  is the previous network waste.
- $W_{new}$  is the current network waste.

Attempts are made to determine whether there is a significant performance gap between the various subsets of the sample.

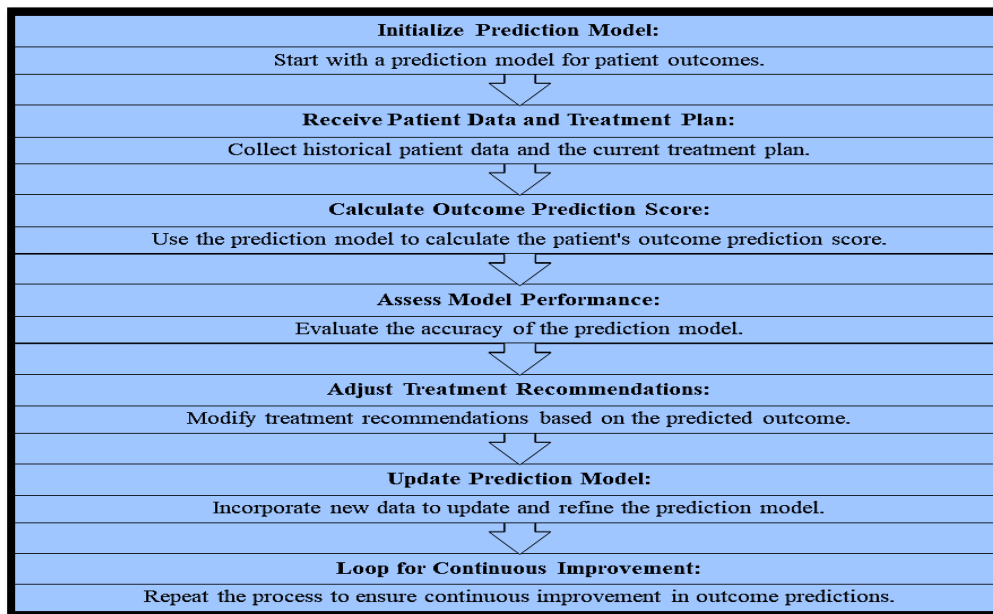


Figure 3: Predictive Precision for Personalized Patient Outcomes.

Each test or scale used to evaluate the physiological parameters is used as a criterion for dividing the sample into smaller subgroups. Accordingly, the abilities of the chaser and the defender are evaluated before the actual test.

#### 4. Result and Discussion

The physiological factors that contribute to the differences in game performances are analysed by calculating the mean score (SD) and t-values of physical tests (speed, flexibility, endurance, agility, and strength) of chasers and defenders in classified groups. Tabular displays of the prepared results are provided.

4.1. Mean (or average) is a statistical measure that represents the central tendency of a set of data points. It is calculated by summing all the values in a dataset and then dividing by the number of values. In WBAN analysis, the mean can be used to determine average values for metrics such as signal strength, data rate, or energy consumption.

4.2. Standard Deviation is a measure of the amount of variation or dispersion in a set of values. It indicates how much the individual data points deviate from the mean. In WBAN analysis, the standard deviation can help assess the variability in performance metrics like latency or packet delivery ratios.

4.3. t-Value is a statistic used in hypothesis testing to determine if there is a significant difference between the means of two datasets. In WBAN analysis, the t-value can be used to compare the performance of different network configurations or protocols under various conditions.

Table 1: Mean, SD and t-values of Chaser in Pre-test and Post-test (N=400).

Variable	Gender	Mean		Standard Variable		t-value	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Resting heart rate (bpm)	M	57.23	52.36	2.18	1.48	27.52	36.84
	F	56.23	51.49	1.15	1.83	51.92	29.81
Peak Heart Rate (bpm)	M	132.23	126.57	4.25	5.49	31.83	24.59
	F	134.56	128.75	2.73	3.28	52.86	39.42
Aerobic capacity (ml/kg/min)	M	56.74	64.82	3.49	4.21	18.29	16.84
	F	53.86	59.37	2.59	2.19	25.68	38.27
Red Blood Cells	M	4.37x10 <sup>5</sup>	4.37x10 <sup>5</sup>	0.15	0.12	32.57	49.37
	F	4.26x10 <sup>5</sup>	4.26x10 <sup>5</sup>	0.29	0.20	115.24	20.57
Haemoglobin	M	13.56	14.26	2.17	1.43	65.43	100.86
	F	12.84	12.93	1.46	0.75	190.46	75.49

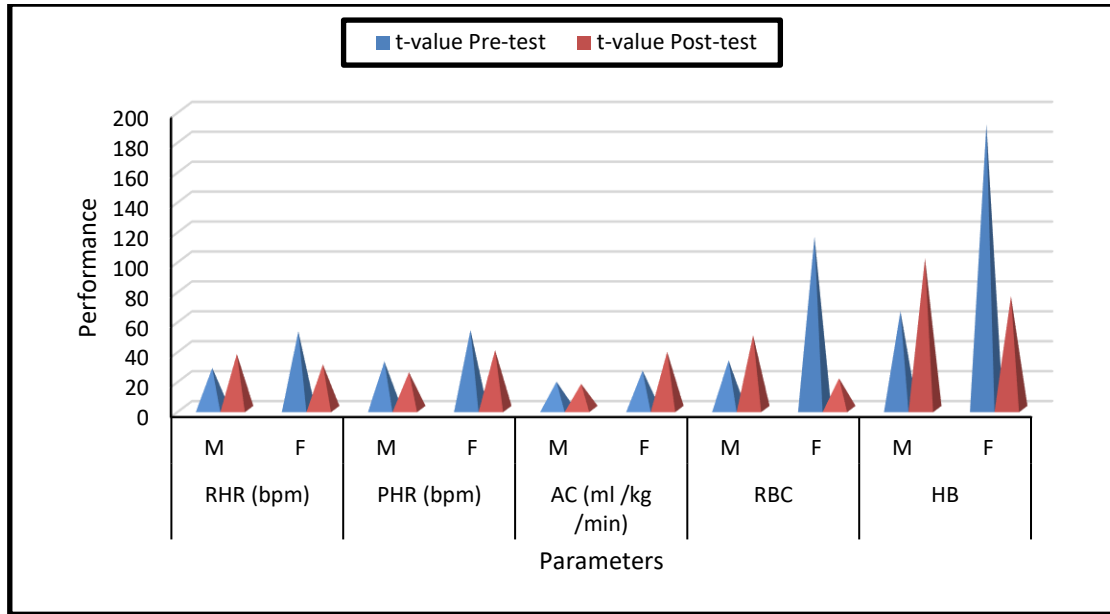


Figure 4: t-values comparison of Chaser in Pre-test and Post-test (N=400).

Table 1 displays the means and standard deviations of students' pre-test scores on measures of physiological parameters while they played the role of Chaser. The pre-test mean scores include both male and female chasers. The muscular movements of the male and female chasers will differ sufficiently based on the physiological characteristics listed in the table. This indicates a change in defensive effectiveness between the pre-and post-test levels in the game.

Table 2: Mean, SD and t-values of Defender in Pre-test and Post-test (N=400).

Variable	Gender	Mean		Standard Variable		t-value	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Strength One Minute Sit-ups	M	36.57	39.24	5.26	43.16	75.49	47.26
	F	29.48	30.49	9.27	10.25	32.46	29.34
Speed 40m. Sprint Test	M	6.57	6.23	1.49	1.26	53.17	55.63
	F	8.29	7.26	1.74	2.67	77.85	35.29
Endurance 12 min. Run / Walk Test (in Mts.)	M	2088.4	2141.23	397.5	402.38	52.49	53.67
	F	1982.5	2010.2	412.5	396.54	48.29	50.76
Agility (Shuttle Run)	M	19.24	21.59	11.26	10.34	16.43	19.37
	F	17.49	18.53	7.24	6.27	23.49	28.34
Flexibility Sit and Reach Test	M	21.56	22.19	4.23	4.38	50.23	50.23
	F	23.46	24.23	3.29	3.49	72.26	72.34

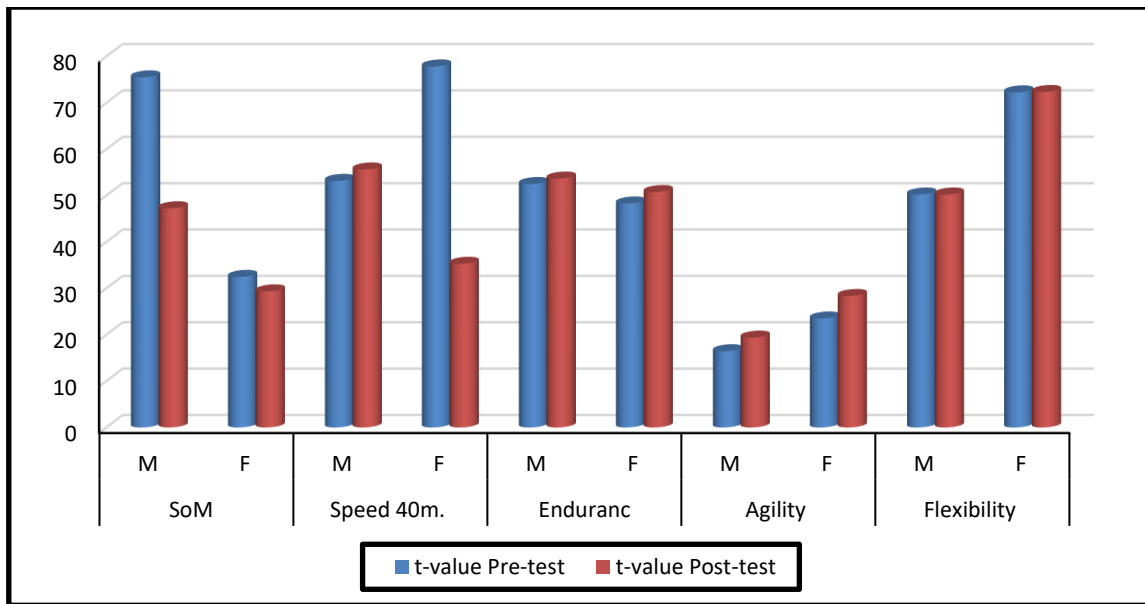


Figure 5: t-values comparison of Defender in Pre-test and Post-test (N=400).

Independent variables' effects on the battery of physical tests are also investigated. Heart rate at rest, maximum heart rate, aerobic capacity, resting basal metabolic rate, and haemoglobin are the primary independent variables. Analysis of variance (ANOVA) was conducted since these variables were hypothesised to affect the sample's biometric outcomes. The tables only provide the F-ratio for these significant independent variables.

Table 3 shows how factors such as resting heart rate, peak heart rate, aerobic capacity, rate of blood lactate production (RBC), and haemoglobin (Hb) affect a defender's performance in a fitness test. A subject's resting heart rate is an important independent variable in how well they perform on a speed test. This proves without a reasonable doubt that a low heart rate is necessary for optimal defensive performance. A defender's performance is driven by maintaining an optimal resting heart rate for maximum fast muscular activity. It may also encourage the defender to use more muscle. Therefore, the defender's speed test performance is significantly impacted by their resting heart rate.

Table 3: Influence in independent variables of Defender physical fitness test (ANOVA) (F-ratio) comparison for Pre and Post Test.

Health variables		Pre-test	Post-test
Resting heart rate	strength	1.13	1.43
	speed	0.63	0.82
	endurance	0.93	1.36
	agility	0.83	0.99
	flexibility	1.18	1.68
Peak heart rate (bpm)	strength	0.75	1.61
	speed	0.71	0.98
	endurance	1.24	1.92
	agility	0.73	1.33
	flexibility	1.36	1.62
Aerobic capacity (ml/kg/min)	strength	1.13	1.72
	speed	1.28	1.66
	endurance	0.43	0.29
	agility	0.46	0.82
	flexibility	1.26	1.98
Red Blood Cell	strength	1.36	1.87
	speed	0.37	0.73
	endurance	0.21	1.43
	agility	1.42	1.91
	flexibility	1.16	1.82
Haemoglobin	strength	0.13	0.35
	speed	1.14	1.46
	endurance	1.16	1.28

	agility	1.11	1.25
	flexibility	1.15	1.31

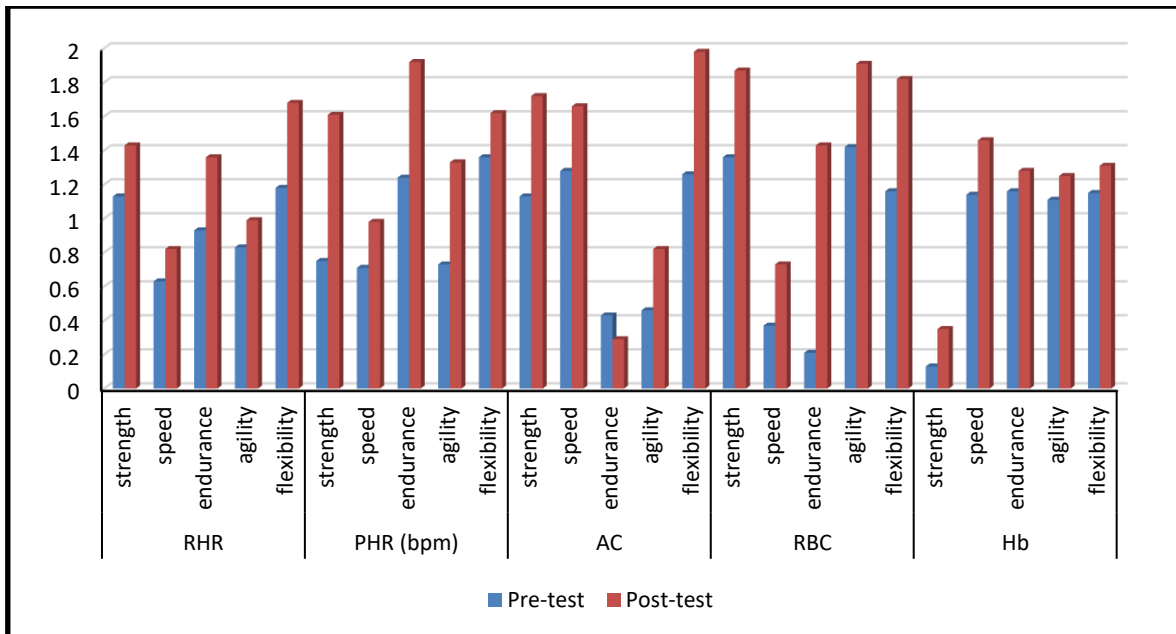


Figure 6: Influence in independent variables of Defender physical fitness test (ANOVA) (F-ratio) comparison for Pre and Post Test.

As a result, the defender's peak heart rate has had a major impact on his effectiveness. An individual's peak heart rate is a reflection of both their physical and physiological health. Active motion, speed, and fitness level all contribute to this goal. People with a higher peak heart rate are more active, more accustomed to a wide range of muscle movements, and have greater stamina, making them better able to protect themselves for longer periods. Conversely, those with a lower peak heart rate are unable to engage in any of these physically intensive pursuits because of their elevated heart rates. More metabolic processes and muscle action are involved in these than in low peak heart rate activities.

As the speed increases, the defender's maximum oxygen intake also rises, allowing for greater muscular movement, to and fro movement, rapid and random movement, bone and muscle movement, and overall excellence. Aerobic capacity is what allows the defender to exercise their muscles while taking in oxygen at the same time. This demonstrates that the quantity of red blood cells and haemoglobin in a defender's blood significantly affects his or her speed test results.

The lack of red blood cells (RBCs) and haemoglobin (HB) contributes to the rapid tiredness of the defender. If these two factors are inadequate, the defender will not be able to last for the allotted amount of time, even if the RBCs' low level of haemoglobin boosts involuntary muscles. Because RBCs and HBs are directly linked to speed, having a good source of suitable levels of these blood components makes the defender physically powerful and fast. Both sexes, male and female, contributed equally to fitness levels. In terms of speed, men consistently outperform women. As a result, red blood cell count and haemoglobin are thought to affect how well defenders do in speed tests.

Consequently, the results of the speed test administered to the respondents are significantly affected by all of the study's independent variables. It's common knowledge that defenders' resting heart rates rise when they exert themselves physically and mentally to protect themselves on the pitch. In addition to keeping your resting heart rate stable, endurance training can assist your heart rate remain steady during exercise. The ability to adapt to changing circumstances is the single most critical quality a defender, male or female, can have. When the HR is within a healthy range, flexibility is made available. The more adaptable a defender is, the faster they can relax. The unique muscular contractions are a continuous cycle from foot to crown. Increasing the amplitude of every physical action.

## 5. Conclusion

In the current investigation, a thorough artificial intelligence-based analysis of how the various bones and muscles function, as well as the metabolism, the regulation of movements, and the generation of energy in response to shifting conditions, is presented. This analysis is highly commendable. The physiological body of a chaser is

distinct from that of a defender in both appearance and function. When considering the body as a whole, it is helpful to keep in mind that the biceps and triceps are always operating, either simultaneously or alternatively. The male defender has a more advantageous effect on the body's motions than the female chaser. Both the defence and the chaser can reach the greatest point in the game, but the former requires more mental and physical strength to accomplish. Self-defence is difficult because it requires the player to be both aggressive and defensive at the same time. When these conditions coexist, the body is put through a full cycle of muscle contraction and relaxation, which raises oxygen consumption and speeds up the metabolic rate. Since red blood cells (RBCs) are the sites where haemoglobin and oxygen are transported, the capacity of RBCs to do so improves in response to an increase in oxygen usage. The holistic view anticipates that improving RHR, PHR, A.C., R.B.C., and HB, as well as speed, agility, strength, and endurance (purely physical entities), will be beneficial.

**Conflicts of Interest:** "The authors declare no conflict of interest".

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