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Educational Wind Tunnel for the Sports Aerodynamics

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Abstract:
Tamil Nadu Physical Education and Sports University [TNPESU] is India's first university exclusively for physical education and sports in India includes research and courses in Sports technology and science. The Sports Aerodynamics is basic and needed research in the development of Sports products and athlete performance. TNPESU had a Wind Tunnel Laboratory for the Sports science and technology students for education and research purposes. Wind tunnel designed with the objective of analyzing different sports ball, to find the three forces and moments, Pressure distribution and the velocity streamlines in static and rotation of the ball

Keywords: *Sports University, Wind Tunnel. Athletic Performance, Sports Aerodynamics, Sports Ball*

I. INTRODUCTION

The wind tunnel is a facility used for the aerodynamics study to know the motion of air and to calculate the force and moment acting on the body. For the sports aerodynamics research and coursework, the wind tunnel is the essential facility [1].

A wind tunnel is designed based on the application, the velocity of the air in the test section and pattern or quality of the flow in the test section [1]. In the Sports Aerodynamics research the most common models are balls, disc, frisbee, cars, bikes, apparels, cyclists, athletes and stadium mostly all are tested in low Speed subsonic and Atmospheric Boundary Layer [ABL] is generated for the Stadium[1,2].

The Sports Aerodynamics wind tunnel designed and developed based on the maximum speed in the test section, test section size based on the model size with blockage ratio, not more than 5% and the space for fixing the required instruments for the wind tunnel analysis [2,3].

II. SPORTS AERODYNAMICS WIND TUNNEL

A wind tunnel is usually used for the research in Aeronautical, Space and Automobile models like airplanes, wings, rockets, missiles, cars, and trucks [2]. In recent developments in wind engineering, building aerodynamics and sports aerodynamics leads a lot of innovation in the development of the wind tunnel facility [2,3].

In sports aerodynamics wind tunnel the great challenge is to be large enough to study athletes, the length must be large to study the flow stream after the ball and to study the wind characteristics and ventilation inside the stadium[2].

The Education wind tunnel facility aim is to give knowledge and academic activities for students. We will facilitate the wind tunnel for studying sports products like different balls, shuttlecocks, frisbee, disc and apparel analysis with a feasible budget.

III. WIND TUNNEL DESIGN AND DEVELOPMENT

All low-speed Subsonic open circuit and suction type wind tunnel consist of the four main parts honeycomb with settling chamber, convergent

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section, test section, and divergent section. honeycomb with settling chamber will make the flow steady, linear and laminar flow into the wind tunnel[2,3]. The convergent section will reduce in cross-section area when the flow move to the test section will increase the velocity of the flow. The test section will be large enough to fit the model and measuring devices. The test section leads to the divergent section of the reduction of cross-section area with an increase in length to reduce the velocity of the flow, to avoid vibration and stress on the air suction fan blades [3].

Fig. 1. Low-speed Subsonic open circuit and suction type wind tunnel in TNPESU

Fig. 2. Honeycomb and settling chamber

The wind tunnel has a suction type, ten blade fans have coupled with an AC motor (3Ph, 440V, AC supply) with 7.5 Horse Power at maximum 1480 rotation per minute (RPM) will lead maximum flow velocity of 20 m/s in the test section.

Fig. 3. Wind tunnel fan with 10 blades

The wind tunnel different ball models have developed for education and research purpose. Each ball model was facilitated with pressure and force model. The pressure models will have a valve to connect with a multi-bank manometer or the computerized pressure transducer[4]. The force model to be fixed in Strain Gauge Balance for the measurement of the three axial forces and three moments of the model[5].

Fig. 4. Force model on the left and pressure model

IV. Wind Tunnel Measuring Instruments and Devices

To measure the flow characteristic like pressure, flow velocity, force acts on the model and the flow streamline pattern are in need of measuring instruments and devices. The inclined multi-bank manometer filled with alcohol or water with 13 tubes will help to measure the even a small pressure difference at the model. The pitot-static tube with a

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separate manometer will measure the flow velocity in the test section through static and stagnation pressure readings[4,5]. The pitot-Static tube will move vertically up and down to verify the effect of the boundary layer due to the wall of the wind tunnel. The D3D Camera is set to observe and record the flow patterns (smoke flow) and rotation of the ball [6]. The Smoke generator will generate the linear smoke flow to visualize the flow separation, circulation and the path of the flow streamline

Fig. 5. Wind tunnel control panel and Muti-Bank

Fig. 6. D3D Wind Tunnel Camera

Fig. 7. Smoke Generator

V. Computerization of Wind Tunnel Analysis

The latest development in the electronic instrument made the wind tunnel experiments easier, faster and accurate measurement. Pressure transducer and the Strain gauge balance play a huge role in wind tunnel experiments.

The pitot-static and the pressure models connected the pressure transducer which will display the flow velocity and pressure on the display and in the computer, where the inbuilt software will have the algorithm for the calculation

Fig. 8. Pitot-Static tube and Hotwire anemometer

The hot wire anemometer used to measure the flow velocity which works on the temperature difference due to the flow velocity in the test section. Used for the accurate measurement of the flow velocity in the test section[4].

The Strain gauge balance is used to calculate the 3 axial forces and 3 moments act on the body [3]. The Strain gauge balance mounting system not only supports the model but also rotate clockwise and anti-clockwise direction to study the different sports ball rotational effect.

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Fig. 9. Strain Gauge Balance

The computer had the software with an algorithm to calculate the Pressure distribution, forces acts on the body and the CL & CD measurements and to generate the graphs. All readings can be exported in Excel format[5,6,7].

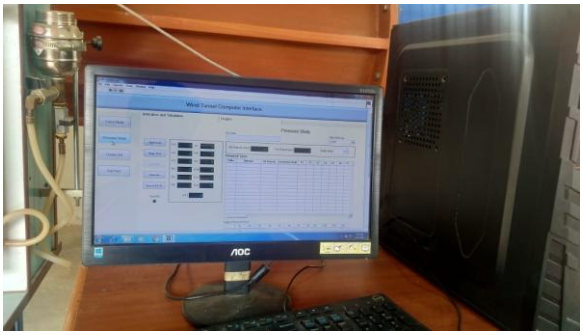

Fig.10. Wind tunnel Computer Software application

VI. CONCLUSION

The wind tunnel is an essential facility for education and research purposes in the Sports Aerodynamics program. The role of the engineer has increased in the development of sports products, infrastructure and athlete performance. Sports technology and aerodynamics skills will lead to a lot of research, career growth and the entrepreneur.

The sports aerodynamics wind tunnel test section is long enough to visualize the flow begin the ball models, the rotating force strain gauge balance is fixed and the multi-bank manometer is customized for the ball pressure models.

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Validating response of wearable prototype device on estimating gait pattern

R. Jayarajan, Nallavan

Abstract:
This experimental study is to validate the accuracy of response of the prototype device in estimation of gait cycle pattern. The mercury filed prototype device has multiple channels through which mercury flow in. The direction of flow of mercury is channeled in four different directions. The change in directions and amount of mercury in a direction is directly propositional to force influence on the device. This mercury flows freely in between light source and light sensor. Movement of mercury interrupts the light intensity which is sensed by light sensor. Sensing the movement in different chamber and change in flow direction results in estimating the direction of force acting on it, which is induced by the object/ person wearing the device. The device is referred as Force reaction vector meter (FRVM)
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Study on Intelligent Data Algorithms Implemented in Wearable for Sports Applications

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Abstract: Technological transformation is unlocking new opportunities in wearable devices used in sports application. Nowadays training the sports involves the use of integrating smart sensors, cameras, internet of things and intelligent data algorithms into a device which is wearable making the players to achieve their maximum performance. These smart devices replace the coach and manage all aspects of technical training except for the physical training given by the real coach. This paper provides a comprehensive study on the intelligent data analysis made on the data acquired from sensors to give a meaningful sense to it. The smart training methods employed currently in various sports are identified and presented. The future directions in this area of research are also presented.

Keywords: Wearable devices, intelligent data algorithms, sensors, technical training, sports

1. Introduction

The technological boom has influenced in all areas of human life. Smart devices have changed the way of looking the world. Sports field is not an exception. Wearables take new dimension in monitoring sports activities of the player. These devices incorporated with smart algorithms help the player to understand his performance and help him to compete to next level. Due to developments in internet and cloud services the collected data from sensors can be worked in a detailed manner. Here clever algorithms can be applied which extracts the features, train the data set and can be tested to verify its accuracy. With these resources the devices now become smart Artificial Intelligent (AI) devices which will help the player to train himself and achieve better results. Section 2 discusses the role of wearables in smart training. Section 3 briefs the sensors that are commonly used in devices. Section 4 summarizes the intelligent approach used in the sports wearables and the results obtained. Section 5 lists the challenges faced and section 6 concludes with the limitations and identifies the scope of futureresearch.

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2.Wearables in SportsTraining

The role of coach for a player is very important. Unfortunately all aspirant players do not get their dream coach. Sometimes financial support also poses some problem. So, wearable technology could reduce this burden by providing solution to the above problem. Intelligent algorithms incorporated in these devices gives clues to the player so that he can understand his game profile and take necessary steps to correct and achieve histarget.

Two important sections in wearable device are,

1. Hardware

a. Sensor selection
b. Noise removal
c. Communication to the decision making subsystem

2.Software which takes decision based on acquired signals.

The tasks performed during training require physical effort and it is a continuous process where the ultimate goal is to improve the perfection in the game played. The various stages involved in sports training are,

- Data acquisition
- Intelligent dataanalysis
- Assessment
- Targetrealization

The flow diagram for the sports training is shown in figure 1,

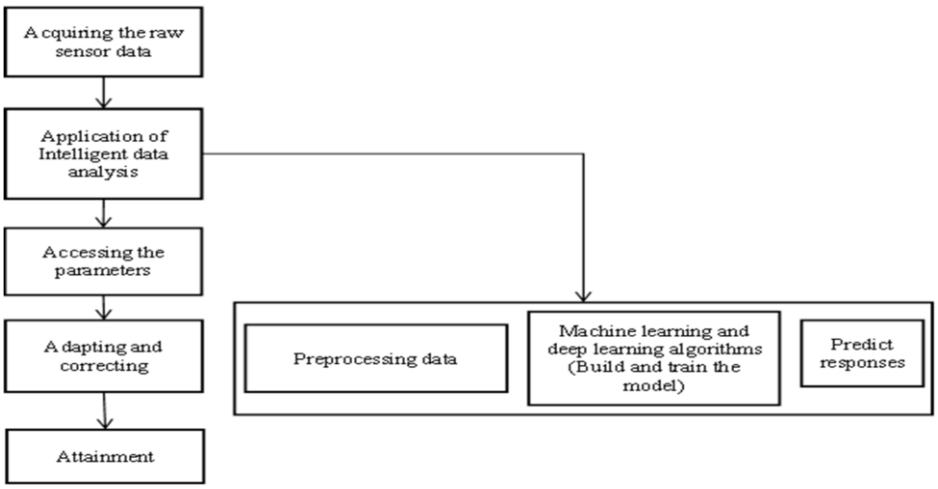

Figure 1. Flow diagram for sports training

3. Sensors

The important consideration for developing a wearable device is the selection of sensors. The sensors should be reliable, small in size, light in weight and durable. The data's from sensors can be used in activity recognition i.e. understand the body kinematics and movement parameters. The machine learning algorithms can be applied on the collected data's to bring out predictions. To get best results the user has to select the suitable algorithm to get the desired insight. The algorithm can be supervised or unsupervised. But all data processing algorithms cannot run on the device itself due to lack of its computational capacity, memory constraints and power back up. So with Bluetooth or wireless module the data's can be transported to a mobile or cloud services where intelligent algorithms can be performed to aid the player in decision making. This virtual coach assists the player in his training replacing the actual trainer. The various sensors deployed in sports wearables are inertial measurement unit which involves accelerometer, gyroscope and magnetometer, pressure sensor array, force sensor, motion sensor etc.

4. Intelligent data algorithms in sports

Intelligent data algorithms and data set can provide a method to analyze the performance parameter of an athlete and can improve his training plan to achieve the best results. Table 1 summarizes the information such as the name of the sport, the sensors used, the features detected, the goal, the classification algorithm and the accuracyobtained.

Table 1. Studies identified in sports wearable sensors with intelligent approach

Ref	Sport	Sensor	Features	Aim	Approach	Result
[1]	Basket ball	Motion sensor	Body acceleration , Gesture	Automatic recognition of basketball training type	Support Vector Machine (SVM)	99.5% accuracy with SVM algorithm or activity recognition
[2]	Basket ball	Accelerometer and Gyroscope	Arithmetic mean and Standard deviation	Classify the action of players	k-Nearest Neighbours (k-NN),Random Forests	Random Forests was more accurate than k-NN
[3]	Fitness	Multiple acceleration sensor on several parts of body/distributed across body	Mean, Maximum, Minimum, Range, Standard deviation, Root mean square	Examine the participant performance on collected data set from a smart wrist wearable device	k-NN, Linear SVM, Naïve Bayes with Gaussian kernel & Bernoulli(NB),SVM polynomial, Decision Tree (DT), Long Short-term Memory (LSTM)	LSTM is best with an accuracy of 92.5%

[4]	Fitness	Accelerometer and Gyroscope, Pulse rate sensor	Mean, Standard Deviation	Classify the indoor exercise activity such as biceps curl, Row, Pushup, Sit up, Squat and Triceps curl	k-NN,SVM, DT	95.3% accuracy for activity recognition and 99.4% for repetition count
[5]	Running	Wireless sensor network deployed in the area of training. MTS 400 sensor board, Crossbow MOTE2 IPR 2400	Mean, Standard Deviation	Develop a prototype to support athlete with ambient intelligent algorithms	k-NN, SVM, Spline Interpolation	Classification system achieves and accuracy of 80% in spline interpolation
[6]	Soccer	Data form video recordings	Mean, Maximum, Minimum, Standard deviation	Classify athlete position and predict the number of goals scored in the game	SVM, RF, Linear Regression (LR)	82% accuracy is achieved in RF and LR
[7]	Football	Data from data set at Tottenham Hotspur Football club	Maximum, Minimum	To predict the recovery time after injury without official diagnosis	SVM Radial basis function (RBF) kernel and polynomial kernel, Gaussian process with RBF and Laplace kernel, Artificial Neural Network (ANN)	Accuracy for SVM-98.43%, Gaussian process-97.4%,ANN –98%
[8]	Table Tennis	IMU sensor	Mean, SD, Skewness, Kurtosis	To detect and classify the stroke in table tennis	SVM linear, SVM RBF, RF, k-NN	SVM linear-95.6%, SVM RBF-96.7%, RF-95.7%, kNN-94.7%
[9]	Tennis	Video recordings	3 layer LSTM network	Classifies the activities in tennis shots	LSTM	81.23% to 88.16%
[10]	Volley ball	IMU, EMG sensors and video cameras	Mean, SD	Identifying and classifying the not allowed moves and providing feedback in training sessions	LSTM	F1 score of 0.74 for labels with 2 classes

[11]	Weight lifting	IMU	Mean, Variance, SD	Classifying the weight lifting exercises	SVM, Linear Discriminant Analysis (LDA)	94.36% accuracy in SVM
[12]	Cricket	Recorded videos	-	Develop AI training system to be used as a coach for trainees to become expert in batting, bowling and fielding	Fuzzy, ANN	Good classification accuracy
[13]	Cricket	Data form IPL matches	Mean, SD	To identify the best set of attributes in the player in the match played	SVM	81%
[14]	Golf	Strain gauge sensor, 3-axis accelerometer and 3-axis gyroscope	-	Investigate Golf swing data classification method	Convolutional Neural Network (CNN), SVM	95% of accuracy is achieved in deep CNN than SVM which is 86.8%

5. Challenges

Plenty of research is open in the field of sports training. Some of the challenges to be addressed are:

1. The authors have shown results conducted with certain method and approach and tabulated their findings. But they are not aware whether these methods will be adopted by all athletes over long term. So the researchers can share their views and results with the real world. Can interact with professional athlete and conduct more experiments and provide a wider scope to researchers.
2. Every player is unique, so integrating intelligent algorithms might not provide expected results for all as the body and thinking are different foreveryone.
3. All most all the design of wearables with intelligent algorithms is still in development phase, it means they are available in prototypes only. So with only proper validation these prototypes can be brought out as a commercialproduct.

6. Conclusion

This paper studies the various intelligent data algorithms proposed and implemented in the field of sports training. With technology the minute details of the game can be perceived. The accuracy and complexity of the models involved in this research vary due to the different classification problems that each model is tasked with. The study observes only few sports are concentrated and research should focus on the design and

implementation of wearable in other sports also. Moreover the security issues in data handling also have to be considered.

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A Survey on Sports Video Annotation Frameworks

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Abstract. Video annotation technique delivers many additional video processing capabilities for several applications. Sports broadcast video content is unique in regard to wealth of information as compared to any other video. Sports video annotation is becoming popular among researchers in recent times because of wide range of applications and challenges it pose. The demand for optimized design of framework for sports video annotation is at peak. This paper surveys state-of-the-art in annotation framework design, particularly for sports applications and provides insight into future aspects. This survey may help researchers to further conceive and develop advanced universal frameworks applied to all sports.

Keywords. Sports video annotation, annotation framework design, annotation architecture, broadcasting video, Machine Learning,Neural Networks

1. Introduction

Several technological developments in recent past of video broadcasting and presentation have improved sports video broadcasting quality with significant increase in the number of subscribers. Apart from the conventional TV broadcasting, the boom in OTT platform, web-based (internet) telecasting, reduction in data cost and higher data rate led to a tremendous growth of sports entertainment industry in the recent times. Sports video annotation is regarded as an assisting mechanism in many sports video applications like analysis, retrieval, indexing, summarization[2], browsing/surfing, content mining, video skimming [11], providing supplementary information [10], generate metadata/metainfo for advanced techniques such as artificial intelligence and machine learning [11], video management and many more boundless areas [3,13].

The people in front of various devices watching the broadcast/telecast sports video outnumber the people watching it live on the stadium. So broadcasters have the responsibility to convince the needs of these viewers/consumers to commercially succeed and continuously entertain and retain them as long term subscribers. Annotation in sports video is crucial for broadcasters or even end-users to satisfy their commercial or personal needs respectively [1]. The upcoming sections are categorized as follows: Section 2 outlines the uses of video annotation in various sports video as a specific case.

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Section 3 analyzes various sports video annotation attributes found in literature. Section 4 deals with existing challenges and future aspects on this area. In section 5, we summarize this work and its importance in current research context.

2. Sports Video Annotation

Sports video annotation is still considered as hot research area among researchers due to its knowledge generating capabilities [14] and commercial value [11]. It conveys additional useful information for all kinds of videos [12]. However, the richness of content in sports video is completely different from other general videos. Furthermore, each sport video is diverse in nature, thus demanding different ways of approach in video annotation. For example, ball-only type of sport video annotation is inappropriate for racquet based sport [16].

Framework design of sports video semantic annotation is challenging, complex and very demanding [1,3]. Design of conventional or small scale framework for large scale dataset is becoming impractical [6]. The motive of video annotation and its framework is to relate the video features (low-level) and semantic labels (high-level) [3,13,14]. Moreover the framework should define semantic meaning of objects, events and context [8]. It implies scene interpretation at higher level and data acquisition. It is considered as the toughest task even for computer vision techniques [11,16].

2.1. Framework design/structure

The framework design falls into any one of two major categories. They are specific or generic. Specific frameworks are suitable for many sports videos and they concentrate more on sports/games related annotation tasks and generic frameworks are applied for several genres of videos with sports video as a subset. The Survey related to AVA (Automatic Video Annotation) is proposed by [13] and applicable to all general videos. The literature survey related to Sport video as specialization is carried out in this work.

2.1.1. Specific Framework

Many frameworks proposed in literature are available as sports specific and some of them can be extended to general video applications. This section lists all sport- specific video annotation frameworks and briefly discusses them. Changsheng Xu et al [1] Contributed framework for video summarization and retrieval of sports video. Here, two-level annotation scheme is used. First level gives the overall summary taken from webcasting text. And second level annotates every event of video employing semantics of text as well as video boundaries grabbed from alignment of text or video.

Mentzelopoulos et al [4] has provided a system for extracting shot boundaries using low-level feature video processing algorithms. Campos et al [5] proposed an automatic sports video annotation framework based on Bayesian reasoning framework aiming to annotate court sport videos at all cognitive levels with adaptability and event classification at any time with user request.

Assfalg et al [9] contributed semantic annotation system that utilizes visual cum graphical features on the video frames. Additionally, color histogram is used for object tagging. Xue et al [10] designed an AVA system for archival sports video. This work delivers rich metainfo of the videos archived.

Kolekar et al [11] labeled video clips by automatic segmentation of broadcast videos and framework provides answers of difficult queries related to video clips. Deng et al [16] proposed data analysis annotation framework. It is dedicated to racquet sports videos and has provision for tools to carry out interactive annotation. In addition, they used supporting computer vision algorithms.

2.1.2. Generic Framework

The generic frameworks in literature have potential to satisfy the requirements of sports video annotation. These frameworks are considered in this survey of sports applications, because of having provision to modify them for sport needs. Zhang et al [2] proposed a semi-supervised learning framework with six types of sports events for analysis. It uses labeled, unlabeled, small scale and large scale videos to train the model. Aote and Potnurwar [3] had undergone a novel approach to define a two- level keyframe extraction method for AVA.

Hwang et.al [6] attempted to provide deep insight from enormous video datasets available in internet to train. Getahun and Birara [8] used audio element of scenes to assist identification of object and event using high level architecture. Islam et al [14] highlighted the importance of distributed framework for AVA. The concept is spatio and spatio-temporal oriented that provides application based solution for users. Human action in sports is taken for their analysis. Huskey and Hill [15] facilitated dedicated video pane in video annotation interface with many functionalities.

3. Literature Survey

Various attributes of sports video annotation framework are listed in Table 1 with both specific and generic framework taken into consideration.

Table 1. Attributes of Sports Video Annotation Framework

Reference	Framework Type	Approach	Applications	Sports Use Cases	User/Personal Preference
[1]	Specific	Web Casting Text	Semantic annotation Indexing & Retrieval	Soccer, Basket ball and other sports/ games	Summary Creation
[2]	Generic	Semi-supervised Learning	Training for event detection and annotation	Basket ball	Search and browse Videos

[3]	Generic	Machine Learning	Shot detection, keyframe and feature extraction	Generally sports	None
[4]	Specific	Active region detection & extraction	Automatic Video segmentation for annotation	Football, Squash & Basketball	None
[5]	Specific	Anomaly Detection & Transfer Learning	Annotate court sports video	Tennis	Event Classification
[6]	Generic	Mapreduce training	annotation for large datasets	Basket ball (As framework input)	None
[7]	Generic	Convolutional Neural Network	Analysis and Management	General	None
[8]	Generic	Video Scenes & associated audio	Event and Object Identification	Basket ball (Shot & Scene Identification)	Video addition, threshold setting, result visualizing and XML or SRT file generation for annotation
[9]	Specific	Visual & graphical features using neural networks	annotate videos at different layers of semantic significance	Several sport videos & Studio/Interview shots	Retrieval of specific shots on demand
[10]	Specific	Computer Vision	archival sports video	Baseball	None
[11]	Specific	Event & Concept level	Semantic labeling	Soccer	Answers difficult queries
[14]	Generic	Spatial & Spatio-temporal	1.End-user distributed VA services 2.Developer algorithm services	Baseball (Pitch), Skate boarding & running	create new VA algorithms through VA & APIs
[16]	Specific	Data Analysis with CV Techniques	Multiple level video data annotations	Racquet sports	User event acquiring from videos & offers interactive tools

4. Future aspects

With the advent of advanced learning methods such as machine learning, computer vision and neural networks [3,7,16], the annotation task becomes easier. But, the existing data acquisition abilities suffer from limitations [16] and faces challenges [3]. The need for universal annotation framework for all sports is essential. Preference must be given to scalability, adaptability and applicability features of a framework.

5. Conclusion

This paper summarizes domain-specific and generic frameworks with application to sports video. The characteristics/attributes of frameworks related to sports video annotation are presented. Investigators, particularly in field of sports video annotation may find this work useful for their optimized framework design.

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Smart Industry Monitoring and Controlling System Using IoT

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Abstract. Air pollution in an ecosystem has proliferated industrial automation. This dissertation concentrates more on industrial automation and has design an embedded device with sensors to monitor and control the toxic gases in industries. This entire prototype is an excellent result for observing the toxic gases in industry and generates information by using data acquisition and transmission of data."Internet of Things (IoT)" is a important technology behind this and it provide platform to bring together all the devices in the world to the internet. In this dissertation, the parameters monitored are temperature, humidity and gas leakages in industries. The sensor senses the parameters and uploads these data to the cloud with the help of NodeMCU. If observed gas level is above the threshold which is the safety limit of operation, the first alert is intimated from the Google cloud and the controlling action carried out (ie) automatically close gas leakage valves and then industry will take immediate step to control pollution. Or else, the second alert message is sent through Electronic mail (e-mail) to restore the safe limit, as government play role to power outage in the industries. Cloud is used to store the sensed data, which is then transmitted and processed.

Keywords. Air pollution, Toxic gases, ECO-system, ESP8266 and IoT.

1. Introduction

In the recent years wireless technology and IoT grasped the most industrial area especially automation and control has increasing for need of upholding various sectors. Healthcare has prime importance in our day to day life. This paper reviewed about new industrialization with ESP8266 and arduino UNO. Indoor Air Quality (IAQ) is highly worsens industrial environments, which then spreads from indoor to outdoor, creating a large scale effect around the industrial areas. Long term and short term effects caused by Air pollution causes the people to concern about the air they breathe. The effect of air pollution from industry is monitored scarcely. Our aim is to monitor the air pollution from the heavy industry which leads to undesirable effects on the health of human beings and also affects the environment. Pollution level in comparison to the ambient air quality standards can be done by using monitoring. To protect the people against extreme air pollution. Robust monitoring systems are necessary to alert people and initiate actions.

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2. Review of Related Literature

Kavitha.B.C et al. (2019), insists on using intelligent sensors for pollution monitoring. Collected data from the sensors are sent to the Google cloud makes it possible to monitor the air pollution from anywhere in the world. In case of threating levels of air pollution, alerting is used. This is used in industry and the pollution by vehicular emissions. Rajalakshmi.R et al. (2019), Observes the toxic gases present in the air to ensure the safety of the people in that environment and make it available at any place in the world for monitoring. The composition of chemicals in air like carbon monoxide, LPG, methane and flammable gases is monitored using sensors and this data is sent to the cloud server, which is then represented pictorially for better understanding of the statistics. Rupali et al. (2018), cares for home and industrial safety using fire and gas detection systems. This system detects the leakage of gas and fire using sensing circuit, which is then controlled by microcontroller which in turns triggers the alarm system to alert the leakage of gas and fire. Using GSM modems, SMS are being sent to notify the user. In addition, it is designed with mechanism to sprinkle the water using water sprinkler when there is a fire or gas leakage. MQ-6 and MQ-9 used as gas sensors to detect the gas leakage. IR flame sensor is used for fire detection, which detects the fire and notifies the user using SMS. Manish Verma et al. (2018), uses microcontroller based system to investigate about the toxic gas detection and alerting system. LCD display is used where the levels of hazardous gases like LPG and propane was displayed each second. Authorized person is notified with email and also using alarm generation mechanism. This automated detection and alerting mechanism helps to resolve the problem as soon as possible. Angelica Nieto Lee et al. (2018), this paper focuses on integrating all the contextual data, to provide accurate and relevant information as per the need. System information that already exists but has not been integrated into the monitoring system like 3D models and manuals. It is context aware industrial monitoring systems, which provide information based on system state, environmental conditions and functionalities of the devices in that environment. Ishwarya et al. (2018), insisted on automation of many small tasks around us using Internet of Things (IoT) in order to improve the quality of living. IoT is used for enhancing existing safety standards, using automation process. Gas leakages in open or closed areas can prove to be dangerous and fatal. Traditional gas leakage systems can able to detect the leakage but cannot able to alert the user. Alerting System can be established to alert the authorized person and to perform the data analytics from the obtained readings.

3. Proposed System

The figure 1 below shows the block diagram and prototype of the proposed system. The components used to design the hardware are Arduino UNO, Semiconductor sensor (MQ6 & MQ7), ESP8266, Relay , Power supply. MCP3008 is an analog to digital convertor. Analog values from the sensors are given to MCP3008, which is an 8 channel ADC, that converts the analog data to digital data which is then sent to NodeMCU. The parameters are monitored using DHT11, MQ-6, and MQ-7 sensors. The sensor senses their parameters regarding the temperature, humidity and gas level and uploads these data to the cloud with the help of WiFi device (NodeMCU). If the level of the gas reaches above the normal level, the first alert is intimated from the

Google cloud as it is automatically closes gas leakage valve and then industry will take immediate step to control pollution. Or else, the second alert message is sent through Short Message Service (SMS) to restore the safe limit intended so and as government play role power outage in the industries.

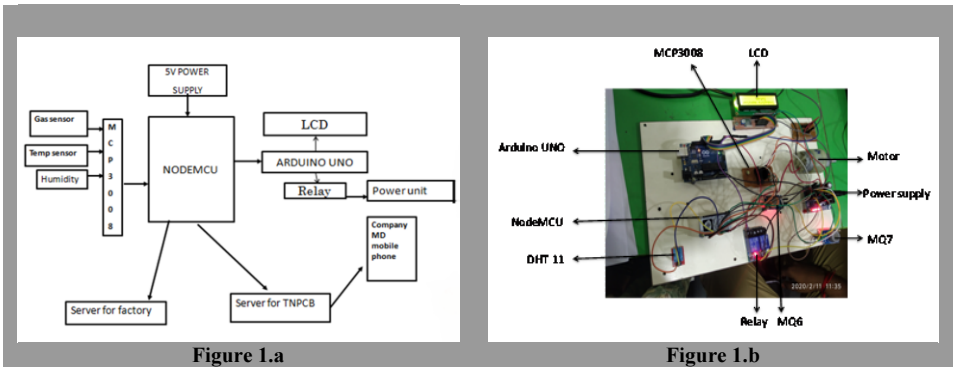

Figure 1. Block diagram and prototype of the proposed system

4. Result and Discussion

We are going to test our prototype for different cases are discussed below. For our analysis Gas-1 represents carbon monoxide (CO), Gas-2 represents Isobutane, Propane, Liquefied Natural Gas (LNG) and Methane. Temp represents temperature. Humi represents humidity. Status represents either normal or emergency based on the industrial gas leakage level.

Analysis for Gas-1

In the figure 2.a,the permissible level of Gas-1 is below 300. In this case, Gas-1 does not reaches permissible level, so it is not harmful to the environment. Hence the status is normal.In the figure 2.b, the permissible level of Gas-1 is above 300. In this case, Gas-1 reaches above permissible level so it is harmful to the environment. Hence the status is emergency.

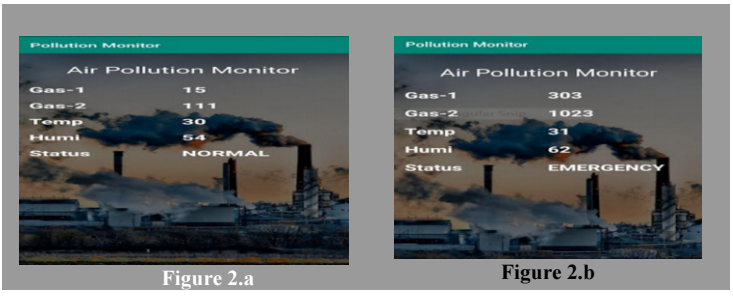

Figure 2. Output of Gas-1

Analysis for Gas-2

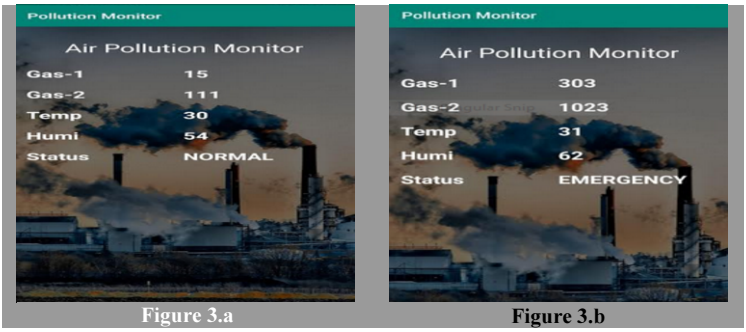

Figure 3.a Figure 3.b

Figure 3. Output Gas-2

In the figure 3.a, the permissible level of Gas-2 is below 300. In this case, Gas-2 does not reaches above permissible level so it is not harmful to the environment. Hence the status is normal. In the figure 3.b, the permissible level of Gas-2 is above 300. In this case, Gas-2 reaches above permissible level so it is harmful to the environment. Hence the status is emergency.

5. Conclusion

In this paper smart Industry Monitoring system based on IoT is proposed which can effectively monitor and controls with alert. A prototype based on Arduino UNO was developed which could sense the concentration of gases. The real time data information obtained from the different sensors has been uploaded to Google Cloud which displayed in the LCD. In addition to this other parameters like temperature, humidity was measured. Provision was also made to vigilant the workers in case of any emergency. The system provides consistently and accurate analysis to prevent any case of accidents. This system makes use of Arduino UNO providing cheap solutions for safety. Slight modification of the model enables the user to adapt it to any environment. Predictive maintenance is an upcoming industrial need, for which the proposed model can be improvised. In case of gas leakage the concentration of gas varies from point to point which has to be analyzed. Moreover, the gases diffusing out during leakage may also combine among themselves producing other by products which have to be dealt in detail.

6. Future Scope

This prototype helps the industrial site from gas leakage deduction and faster resolution of problems afforded by a higher level of expertise focused on control system. This methodology could be applied to monitor distribution network of natural gas as well as industrial, commercial, residential gas pipelines in order to provide a safe operation and to avoid severe human health injuries caused by gas leakages. Proposed solution can act as a automatic vehicle health feed for manufacturer to improve their quality by providing regular vehicle services.

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Intelligent Door Knocking Security System Using IOT

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Abstract: In current day security is very important. Nowadays, in all places many robberies are going on. In this security issue, lock is the major parameter. The trustworthy on the lock should me made improve. The lock may be for main door lock, baggage lock, shutter lock, grill door lock, interconnecting door lock etc. This project is based on arduino board and IOT. And also this can be used for main door and for locker door. This lock works based on the knocking pattern. The owners knocking pattern is stored in the register. When the knocking pattern is detected by the sensor, it passes it to the arduino board microcontroller. Based on the trustworthiness of the pattern the lock works. This framework is easy for installation. It can be implemented for commercial use also.

Keywords: IOT, Arduino Uno board, Power supply, Bylynk App, DC motor, Motor driver circuit, Knock pattern, GSM module.

1. Introduction

The World has progressed significantly throughout the years and it has changed the manner in which we live, the manner in which we impart, the manner in which we learn and the manner in which we change. One of those extraordinary headways is progression in Technology. From creation of things like blades out of rocks to things like 3D printer to a super PC, Technology has made some amazing progress. This headway in Technology has been outstanding in the 21st Century.

Be that as it may, with the points of interest and advantages, additionally came the disservices and difficulties. One of the instances of this headway can be taken as the creation of the IPhone. IPhone was a noteworthy redesign from the customary sort of utilizing a telephone since it was ready to call and content as well as had the capacity to play music, recordings, and download applications. Despite the fact that these were the favourable circumstances, there were numerous detriments like battery channel and the decline of vis-à-vis correspondence because of dependence on the cell phone. With such headways in innovation, there's dependably a requirement for security and protection.

One of the methods for verifying security is a mix of ‘lock and key'. Present day locks and the locking framework are unquestionably increasingly intricate and regularly utilize a dabbed system on the key which give a more prominent security. In any case, the drawback is that it's the equivalent 'lock and key' system, which means, the key can generally be imitated with some exertion. One of the arrangements is to totally dispose of the 'lock and key' instrument itself. This venture plans to do likewise by setting up solid security basing on a 'Mystery thumping example', therefore the name, "Thump Based Security System". This framework is involved gadgets like Arduino, GSM Module , Servo Motor and so forth and utilizations a 'Mystery Knocking Pattern' which is known just to the proprietor of that specific safe, bag or some other Property or item that the gadget is introduced on. The expansion in security in executing this framework comes into the image in a few different ways.

2. Existing Systems

RFID technology can be used in the intelligent door knocking system. When anybody tries to open or knocks the door then this action will be sensed and sends information to the user via GSM. But anyone with the false RFID can open door. In finger print method, door will be opened when unique graphical security must be matched. If the culprit has the finger print then they can easily open the door.

In another method, the wireless LAN module fixed on the board receives the transmitted signal and transmits to the microcontroller. The microcontroller passes the data to the servo motor in order to complete the operations on the Door [1].

In thump impression technique, when we thump it, the arduino begins observing the primary thump to secondary thump and keeps the time gap period. In this work 6 thump impressions are taken. Therefore 5 timespans will come. These time lapses were converted interms of variables. Example, if the time period is less than 500ms, then 0. If it is more than 500ms then 1. Like this the total 5 time lapses, converted into 5 digit password. These passwords are used to open the door lock. If it does not match, then lock will not be open.

3. Proposed System

If the entry way thump is entered correctly then the gate will be open. If the thump entry is wrong for consecutive three times then code will be locked and alert will transmitted to approved authenticated client.

Working Principle

In this project work, as an input device capacitive sensor is used. This sensor can detect the electrical capacitance of the human hand. This sensor is built by using aluminium foil, medium to high esteem resistor, wire and a capacitor. When touch sensor contacts with the finger the body capacitance is in parallel to the sensor's capacitance. This makes wavering recurrence decline. The microcontroller recognizes this property.

Here, 3 bits of aluminium foils are introduced on the external side of entry way. The clients can open the entry way by contacting these foils. Because of the usage of three foils, the detection of multifaceted of the finger is possible.

Here, the time period is characterized by RC. Where, R is the resistor, C is the capacitance of the foil. In this system we have to consider the capacitance experienced by the human finger. Suitable rearrangement can balance out sensor readings, making the entire framework solid.

Other than, microcontroller, voltage converter or comparator can be used. This framework can be further improved by using a touch cushion rather than aluminium foils. For example, if the independent momentary capacitive touch sensor used then it can send computerized flag specifically to microcontroller.

BLOCK DIAGRAM & DESCRIPTION

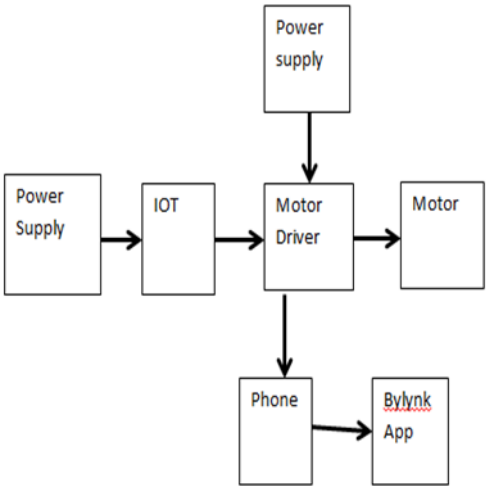

Fig. 1 Block Diagram of Intelligent Door Knocking System

In this work, the door lock is controlled by IOT and Bylynk app. The door is controlled by the motor driver. About the status of the door is delivered to the client mobile phone using bylynk app.

The description of the components are given below

IOT (Internet of Things)

It connects and exchanges the data with other devices and systems using internet. But the drawback is privacy and security. IOT can be used in consumer application field, commercial, industrial and infrastructure spaces. Recent technologies are developed in home automation systems, wearable technologies, in medical applications and remote monitoring systems.

MOTOR DRIVE MODULE:

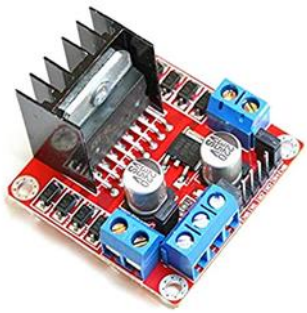

Fig 2 – L298N Motor Driver Module (Source: 2)

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.

When jumper is placed at that time only 78M05 voltage regulator is enabled. If the power supply is less than 12V, then the microprocessor is powered by voltage regulator. The speed control pin for Motor A is ENA and for

Motor B is ENB. The direction control pins for Motor A are IN1 & IN2 and for Motor B are IN3 & IN4. This module cab used in robotics, in stepping motors and in drive DC motors. The motor driver used in the project is shown in the Fig.2.

DC MOTOR

DC motor is operated by direct current. It converts DC electrical energy into mechanical energy. This motor works on the principle of when a magnetic field and electric field interact then the mechanical force called as motoring action is produced. Fleming's left hand rule gives the direction of rotation.

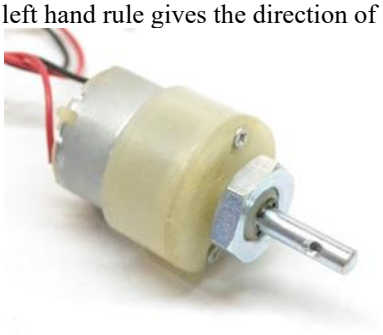

Fig. 3 – DC motor 60 RPM 12V

The Fig.3 represents the DC motor used in the project. The metal gear which is used in it has better wear and tear properties. It requires no maintenance because; the gear box is sealed and lubricated with lithium grease. It runs smoothly from 4V to 12V. It gives 60RPM at 12V.

Tests and Results

This home security system is having two stages. In first stage the client can fix where they want to mark the thump impression and successively they have to do the thump impression. In second stage, from the time gap between the thump impression code word is generated. If the code is correct then door will be unlocked.

The proposed door locks security system shown in the Figure 4. This system is attached on the door with the lock.

When the client wants to open the door, the thumping data were collected. To detect the thumping, piezo electric based vibration sensors were used. These sensor collected data transferred to the arduino. If the data was an authenticated data, then flag will be set to open the door.

All activities are connected with the client's mobile. So the status of the door was continuously monitored by the client.

If suppose any unauthenticated person trying to open the door immediately alert will be given to the client mobile. This system is shown in the Fig. 5

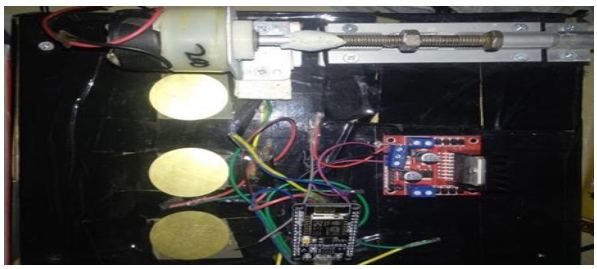

Fig. 4 Door lock security system

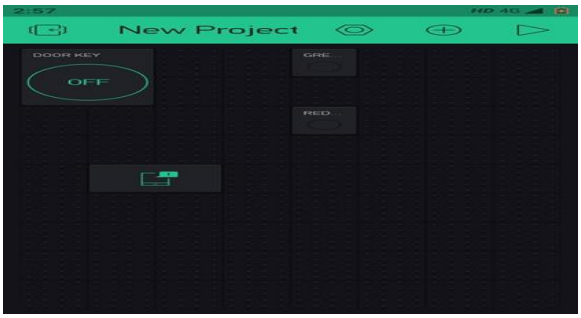

Fig 5: Mobile Alert using blynk app

Pros and Cons

The main drawback is if the door broken then no signal will be transmitted to the client. And the client not aware of this incident. And the advantage is, if any intruder trying to enter with wrong thumping, then alert will be sent to the client through their mobile phone.

In future, the following feature can be added with this project.

If the person is authenticated person and the client having trust then the client can open the door remotely.

4. Conclusion

Thus the proposed framework is very simple and cheaper. The accuracy of the system is very high. So the client can control the entryway remotely. The bylynk app is also a free app. Based on the thumping on the door this security systems works. In future many advanced features like, remote monitoring and contolling of the door can be achieved.

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Numerical and Experimental Verification of Strain Measurement on the Player Arm due to Impact of Ball on Cricket Bat

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Abstract

Cricket is one of the most popular games among young players in India. The game result is purely based on the runs scored by the teams within the prescribed "overs". Hence the players will put maximum effort to score maximum runs as much as possible. The effort is how much force the players can exert on the bat while hitting the ball so that the ball can travel maximum distance in the ground. The average velocity of the ball thrown by the bowler is in the range of 40 km/h to 150 km/h which depends on the bowling speed of the bowler. Due to such high velocity of the ball hitting on the bat, high impact force is generated on the bat as well as on the arm of the player. This paper studies the strain, stress and energy due to ball impact force with different velocities using numerical method. Also experimental verification for strain measurement is done in real time using data acquisition devices.

Role of Wearables in Sports based on Activity recognition and biometric parameters: A Survey

Publisher: IEEE

N. Nithya; G. Nallavan

Abstract:
Recently wearables have become a game changer in sports activities. Wearable devices influence the game in tracking and monitoring the performance of the player on field in real time. This paper aims to explore the uses and applications of wearables in the area of sports. These devices help to bridge the gap between technology and user. Also it gives a comprehensive analysis of the player to improve his skills and get real time feedback which would benefit himself and his trainer. This paper surveys the important research work done in the area of wearables under four categories: (i) performance monitoring (ii) sports injury (iii) biometric parameters and (iv) energy efficiency. These various considerations provide many opportunities for advancement in wearable technology with a goal of enabling non-invasive measurement of physiological and activity parameters of a player. Wearable technology is still in development phase and the paper concludes with the research opportunities and the challenges faced.
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Inertial measurement unit–based cricket stroke improviser using polynomial kernel support vector machines

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Inertial measurement unit–based cricket stroke improviser using polynomial kernel support vector machines

N Nithya and G Nallavan

Abstract

Wearable devices have now become virtual assistants, and the sports industry also aims in technological integration. The objective of this research article is to introduce a wearable device to detect and record the movement of a cricket player during his training session. The designed system collects the displacement and rotational information through a combination of accelerometer and gyroscope placed on the cricket bat. We propose a data-driven machine learning model which takes raw analog data as input for classifying the strokes. The algorithm used is the polynomial support vector machine, a supervised classification algorithm with 300 independent variables to enable accurate and real-time stroke classification. The system has a dedicated user interface for accessing these real-time details. This wearable embedded system does not require any cloud services as the complex analyses are performed in the processor itself. The player and the coach can get visual reference support, and the mistakes can be corrected during the training period itself. The device can detect the arm action of a cricket player with a success rate of 97%. The hardware is powered using a 10,000 mAh rechargeable battery.

Keywords

Wearable device, inertial measurement unit, movement classification, polynomial support vector machine, user interface

Date received: 24 June 2021; revised: 10 October 2021

Introduction

Background

The development of technological tools to monitor the sportsperson training has increased in recent years. Wearable technology was first seen in European Soccer Club in 2009 to measure the overall player workload during games. Timing the total minutes of physical activity, calories burnt, heart rate in day-to-day life, real-time tracking are the aspects in tracking the granular detail with the data obtained from the wearable device. With this data, we can set specific personal requirements, track the progress, and hopefully achieve goals. Wearable sports technologies are being used to monitor athletic training and in-game performance. Developments in this rapidly expanding technological niche are letting team administrators, coaches, trainers, and players excel in their sport. This will reduce the sports-related health issues. The data let the players and their coaches to evaluate their own body mechanics, improving their performance or adjusting techniques to avoid injury. This will greatly reduce the effort of the player. In sports such as cricket, baseball, tennis, basketball, boxing, swimming, and rowing, wearable devices can be used for monitoring the performance metrics of a sportsperson. The performance and biometric data include acceleration, angular speed, temperature, and pulse rate.

Assessing and managing physical and physiological parameters are gaining importance in personal health care and better monitoring in real-time.[1] Besides MEMS – based approaches, sports image detection technology and motion recognition from image processing are other similar applications.[2–4] Low-power wireless communication technologies and miniaturization of highly sensitive sensors have supported design engineers to develop small, delicate, and non-invasive wearable devices which can be integrated in sports tools or can be a wearable one to be worn on shoe, pad, elbow, or waist. For example, such devices consist of an inertial measurement unit (IMU), 3x gyroscope – 3x accelerometer which is worn near the waist of the athlete in volleyball.[5] Data recorded includes best jump, last jump, jump average, and jump amounts. The device is placed into the helmet to track the helmet impacts and frequency in football. Monitoring various metrics is important, and swing tracker devices were developed for measuring various swing metrics, such as speed, power, and the hitting zone.[6]

A flexible pressure sensor based on piezoresistive effect for clinical gait evaluation, foot diagnosis, and footwear analysis was developed. The sensitivity of the graphene

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Table 1. Summary of the literature review of the algorithms implemented in wearables.

Ref.	Sport	Data collection	Movements/ Parameters	Aim	Approach	Result
[12]	Basketball	Accelerometer and gyroscope	Shooting, blocking, dribbling	Classify the action of players	k-nearest neighbours (k-NN), random forests (RF)	Random forests was more accurate than k-NN
[13]	Fitness	Multiple acceleration sensor on several parts of the body	Abdominal exercise, back extension, chest press	Examine the participant performance on the collected data set from a smart wrist wearable device	k-NN, decision tree (DT), long short-term memory (LSTM)	LSTM is best with an accuracy of 92.5%
[14]	Fitness	Accelerometer and gyroscope, pulse rate sensor	Biceps curl, chest fly, row, push up	Provides automatic indoor exercise recognition for both in gym and home usage scenarios.	k-NN, SVM, DT	95.3% accuracy for activity recognition and 99.4% for repetition count
[15]	Running	Wireless sensor network deployed in the area of training. MTS 400 sensor board, crossbow MOTE2 IPR 2400	Sportsman data, environment data, speed, and completion time	Develop a prototype to support the athlete with ambient intelligent algorithms	k-NN, SVM, spline interpolation	Classification system achieves an accuracy of 80% in spline interpolation
[16]	Soccer	The training workload data of the player from a professional soccer club	Central backs, fullbacks, midfielders	Build a machine learning process to describe the players' rate of perceived exertion (RPE) by the external load extracted from the GPS	SVM, RF, linear regression (LR), DT, k-NN	Good accuracy was achieved in DT
[17]	Football	Data from the data set at Tottenham Hotspur Football Club	Age, injury, type, position, body part injury, reoccurrence	To predict the recovery time after injury without official diagnosis	SVM radial basis function (RBF) kernel, Gaussian process with RBF and Laplace kernel, artificial neural network (ANN)	Accuracy for SVM-98.43%, Gaussian process-97.4%, ANN–98%
[18]	Table tennis	IMU sensor	Drive, push, topspin in forehand and backhand stroke	To detect and classify the stroke in table tennis	SVM linear, SVM RBF, RF, k-NN	SVM linear-95.6%, SVM RBF-96.7%, RF-95.7%, kNN-94.7%
[19]	Tennis	Video recordings	Backhand, forehand, service, smash	Classifies the activities in tennis shots	LSTM	81.23%–88.16%
[20]	Volleyball	IMU, EMG sensors, and video cameras	Arm movement, hand movement	Identifying and classifying the not allowed moves and providing feedback in training sessions	LSTM	F1 score of 0.74 for labels with 2 classes
[21]	Weight-lifting	IMU	Squats, deadlifts, shoulder press	Classifying the weight-lifting exercises	SVM, linear discriminant analysis (LDA)	94.36% accuracy in SVM

sensor was good with a quick response time.[7] Head impacts in soccer games were evaluated by calculating the acceleration ratio between the upper spine and head as the attenuation index for workload measurement in this game.[8] This would be helpful in estimating the head impacts in front heading activity. A device for shot and pass classification during this match was proposed which used the technique of detecting the high-intensity peaks from the accelerometer data.[9] Challenges in using wearables for fast-moving games such as basketball and handball were addressed.[10] Smart wearable devices were proposed for counting the missed and success shots in basketball using the double sensor-node approach.[11] A sensor located on the net detects the missed shots, and the one placed on the wrist detects the tried shots. Sports professionals are driving the use of wearables as a part of their regime in their daily training sessions.

Literature review

A comprehensive literature review has been performed on the algorithms implemented in wearables for sports applications and is shown in Table 1. Wearables take new dimensions in monitoring sports activities of the player. These devices incorporated with smart algorithms help the player understand his performance and help him compete to

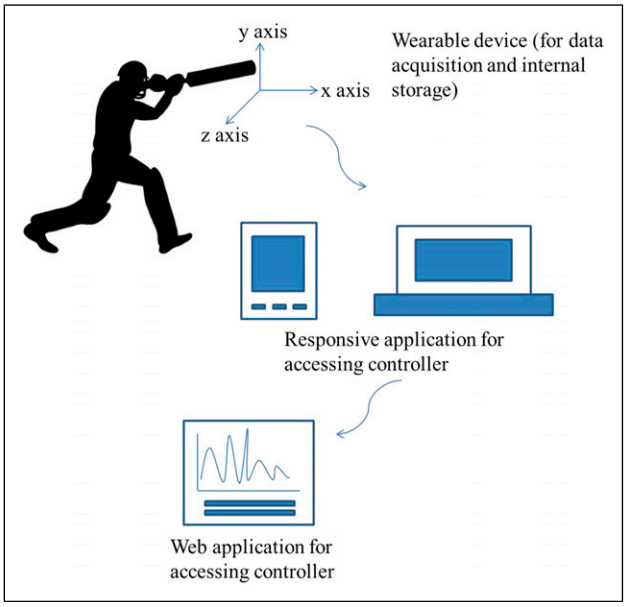

Figure 1. Architecture of the wearable system for movement detection and classification.

the next level. Here clever algorithms can be applied to extract the features, train the data set, and can be tested to verify its accuracy. With these resources, the devices now become smart wearables which will help the player to train himself and achieve better results.

It is evident from the literature review that studies performed on cricket concentrated on bowling phases and mostly the data were obtained from video recordings. Also, the classification accuracy using the support vector machine was around 81%. The support vector machine seems to be a superior classification algorithm giving good accuracy.[24,25] No interactive applications were developed to give instant feedback about the shots being played, to the player and as well as to the coach.

The proposed system is designed for cricket. Some of the previously designed systems support particular stroke detection on a video-based approach.[26–28] But, the proposed wearable device detects and records the movements of the player during the training sessions from the data collected by IMU without using any video processing techniques. This article aims on developing a wearable device incorporated with an intelligent machine learning algorithm to provide necessary feedback to the player by detecting and classifying the shots performed by him so as to achieve maximum performance. The coach can also analyze the performance of the player without his physical presence in the ground.

System architecture

The proposed system design is given in Figure 1. The system consists of three main sections: (1) Inertial Measurement Unit (IMU) for swing movement, (2) data processing module which consists of a main processor and graphics processing unit, and (3) dedicated user interface (UI) for accessing real-time details. This wearable embedded system need not require the internet for its operation. All complex and advanced analyses are performed in

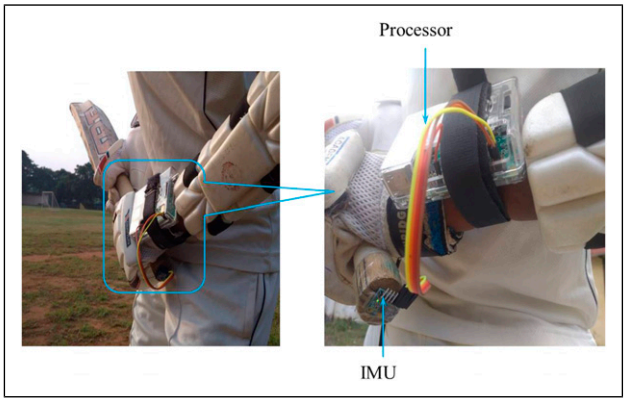

Figure 2. Movement data acquisition device position. The device is attached on the player's hand.

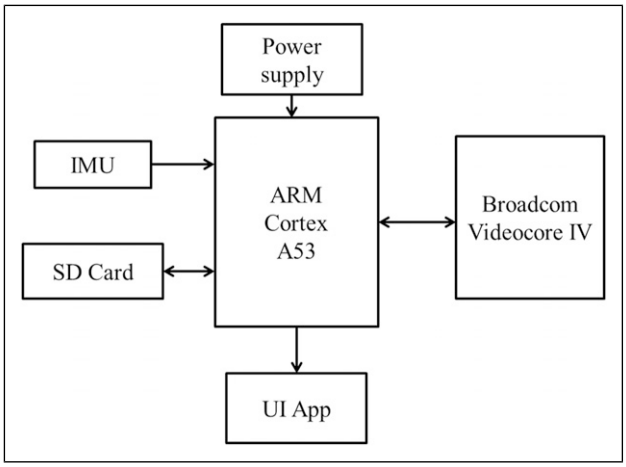

Figure 3. Block diagram representation of the proposed wearable device.

the processor itself. This model can provide support for real-time data processing by comparison with its reference statistics. The upcoming sections describe the individual parts of the system in a detailed manner.

Wearable embedded hardware design

The system's hardware aims to design a light-weight portable data acquisition module which can be used to record bat movement. The best suited place for the wearable device is to keep it on the player's arm. The translational and gyrational position of the bat is recorded using IMU which is placed on the top handle of the bat. The sensor is placed without disturbing the player's performance. The placement of the wearable device and the orientation of IMU are presented in Figure 2.

The data acquisition module operates in a stand-alone manner and detects the basic strokes in real-time. The block diagram of the proposed hardware is depicted in Figure 3. Our main processor is ARM cortex A53 which is a 64 bit RISC architecture processor. It is accompanied by a Broadcomm video core IV GPU. These two are the hardware cores of this project. The IMU used here is MPU 6050 which is a 3-axis accelerometer, 3-axis gyroscope, and a magnetometer. The accelerometer is intended to measure the 3D translational motion of the bat and the gyroscope is

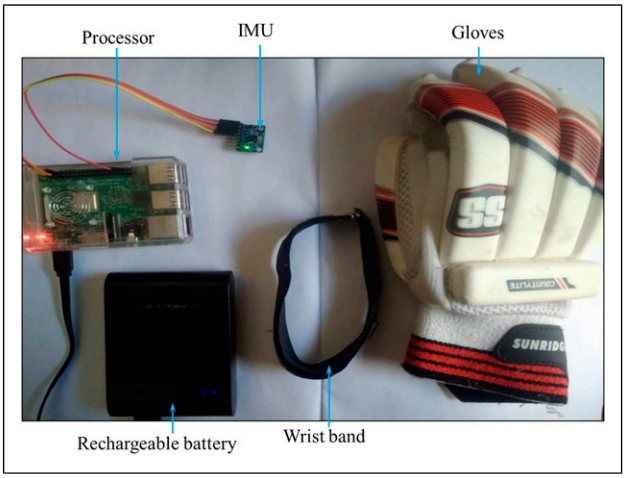

Figure 4. Physical implementation of the wearable device.

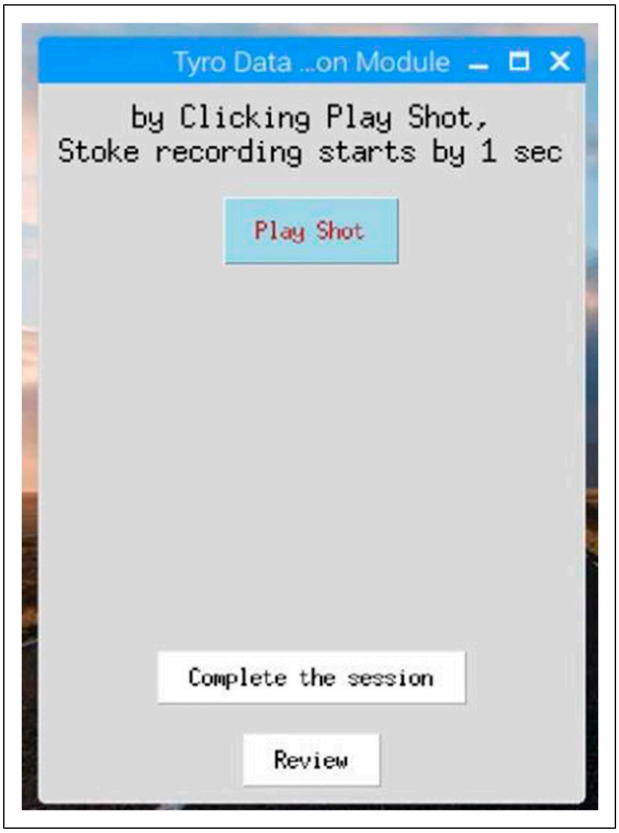

Figure 5. User interface for recording data.

intended to measure 3D rotational motion of the bat. These data are recorded every few seconds and then gets sampled at 50 different time slots. It also has an inbuilt wireless connectivity which ensures wireless data transfer between the user and the module. Also, the processor supports a 16GB SD card as its external memory along with its 1GB internal SD RAM.

The hardware setup for the wearable module is shown in Figure 4. The IMU sensor is placed on the tip of the bat and the processor is placed on the arm of the player. The battery can be placed under the arm guard used by the cricketer or in his pocket as per his convenience, so that the hardware does not disturb the training or practice sessions. Also, the user can connect his smart phone or laptop with this setup and avail the user interface applications.

The analog data are obtained from the IMU directly when the player has played the shot. These data are completely taken over by the processor and then sampled at 50 different intervals so that we can get 300 data points for a single shot. The IMU is connected to the processor using I2C bus. The important part of this hardware is the motion and biometric data processing device which is a high-performance, low-power 64-bit processor with RISC architecture. It is running at a 1.4GHz clock. It supports USB, SPI, and I2C interfaces. A micro electromechanical system (MEMS), IMU is used for sensing bat position while playing. It is composed of a 3-axis accelerometer and 3-axis gyroscope. Together, they form a 6-degrees of freedom (DOF) device. An I2C interface is used for communication with the processor.

The processor is supported with 1GB RAM which is useful for assisting the processing and classification operation. The memory can be expanded to 16/32GB which is used for storing the data records locally so as to avoid the use of online clouds which is expensive. This memory also assists in publishing the user interface by providing required memory specifications. The data are stored in the CSV format which is memory-inexpensive and accessible by all types of processors. In an average of 3 h, the total data accumulated by the wearable module is 18,000 IMU data, 60 shots measured by the IMU each with 300 samples.

Embedded software design

In order to compile and being an embedded system, we require software to control the hardware. The software design of the system is mainly focused on interactive application for visualizing the data which is acquired. The user application is designed using Tkinter and Node – RED software application. Python supports the application by providing a good front-end and back-end support. The Tkinter user interface for recording data is shown in Figure 5.

The application can be viewed in a remote desktop. Since the processor supports wireless connectivity, more than one user can access the recorded data simultaneously. After the motion and the biometric data are saved as CSV format, the recorded information is readily visualized and available for more detailed analysis. The users can analyze their current shot with the well-played reference shot data which is already stored in the module. So, the user can immediately visualize his efficiency for the current shot. More advanced techniques and statistical approaches can be used for analyzing data within the device itself as more memory resources are available.

An interactive user interface of the proposed system using Node – RED application is presented in Figure 6. The layout is set using the Node RED interface. The input, output and processing nodes are connected according to the functional requirement. This user interface gives the details of the various shots played by the player and the shot played recently. These details can be viewed either in the mobile or laptop as per the user's convenience.

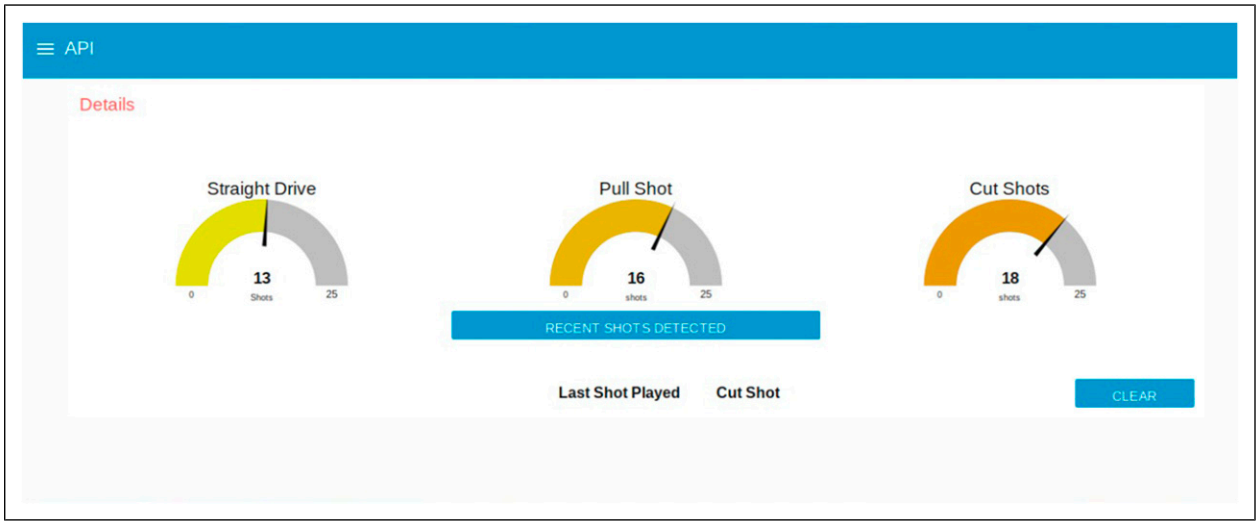

Figure 6. Interactive user interface of the proposed system.

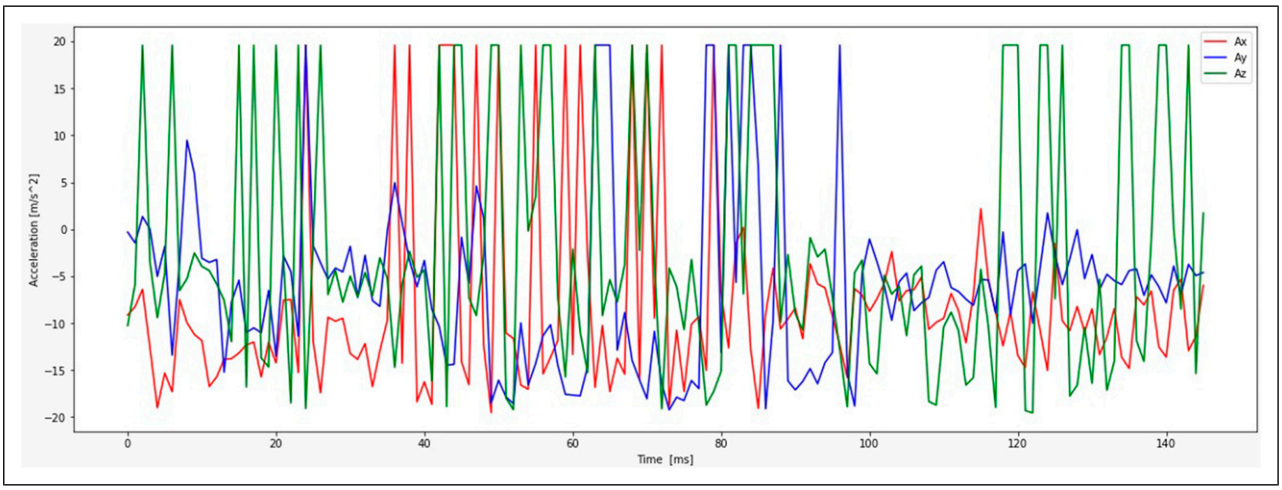

Figure 7. Graphical representation of accelerometer data (*x* axis, blue; *y* axis, red; *z* axis, green).

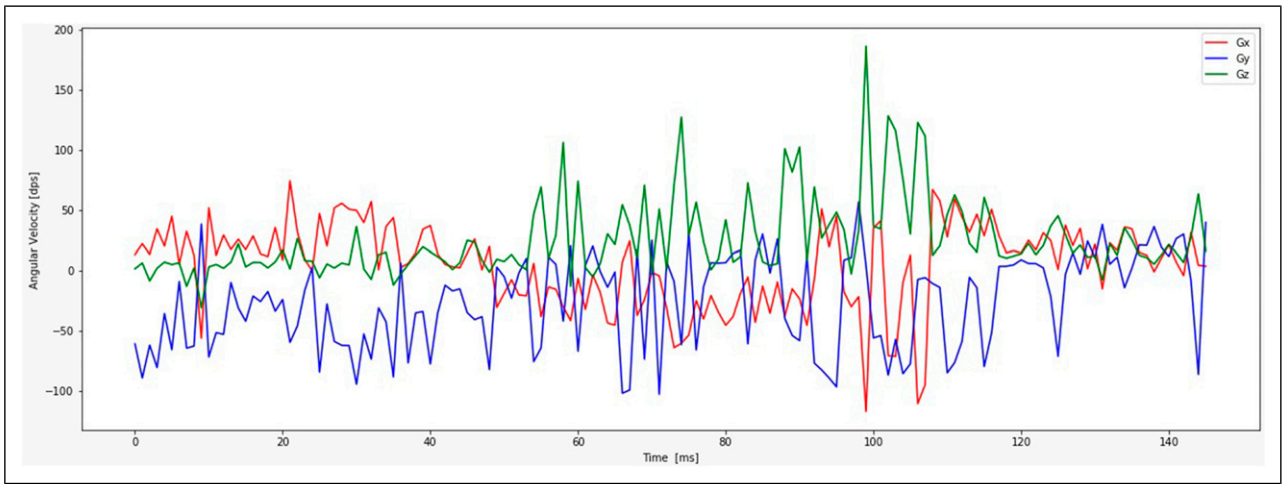

Figure 8. Graphical representation of gyroscope data (*x* axis, blue; *y* axis, red; *z* axis, green).

Motion data acquisition

This section explains the details of acquiring motion-sensing data and tracking them. Since the design is especially suitable for cricket, the performance of the proposed system was tested with a cricket professional's regular training. In the following sections, the challenges involved in cricket stroke detection, cricket stroke classification, and biometric data acquisition are discussed.

Motion sensing and classification

Cricket stroke detection. For the cricket stroke classification process, the individual cricket strokes first have to be detected accurately. Being a prototype, we primarily focused on detecting and classifying the three most common cricket strokes: straight drive, pull shot, and cut shot. From the accelerometer data shown in Figure 7, it is observed that for every stroke played, there are maximum peaks in accelerometer readings. The peaks are up to 20G in amplitude. Figure 8 shows the gyroscope readings. For detecting the stroke, the following procedure is followed after the ball is released. The accelerometer present on the bat starts recording the spatial position of the bat from the batting instance until the shot is completed. This action takes a few seconds to complete. Fifty distinct samples are taken within this interval. For every sample, we have three accelerometer and three gyroscope data. These raw data are preprocessed using the Kalman filter as they are contaminated with noise and vibrations from the IMU while batting. The total recorded data are sampled at 50 different time instances and this resulted in 300 spatial positions (50 time samples X 6 raw data stream), which are taken as featured input for classification.

Cricket stroke classification. The previous studies carried out in stroke detection were based on classification of image frames taken from the video recording while playing cricket, which requires a high-cost high-performance camera. This study focuses on the classification of cricket strokes from a wearable device. In order to perform classification of cricket shots, we need a database of predefined strokes, recorded from experts and coaches. This database acts as the training database for stroke classification. For this prototype, three shots are chosen: straight drive, pull shot, and cut shot. These shots are played and recorded for the working of this model. The training database has 44,100(147*300) data, which is sufficient for training our model in the test scenario. During practical scenarios, even more data are collected from the coaches of the clubs, where it is implemented. The classification algorithm used here is SVM (support vector machines). It uses Kernel to process the given data in the form of plotting them in hyperplane. In this prototype, a 300-dimensional hyperplane is used, as we are using 300 features for classification. The most common kernels are Linear kernel, Polynomial kernel, and Gaussian kernel or Radial Basis Function (RBF) kernel. The kernel used here is the Polynomial kernel, allowing the model to be non-linear. The Polynomial kernel is generally expressed as

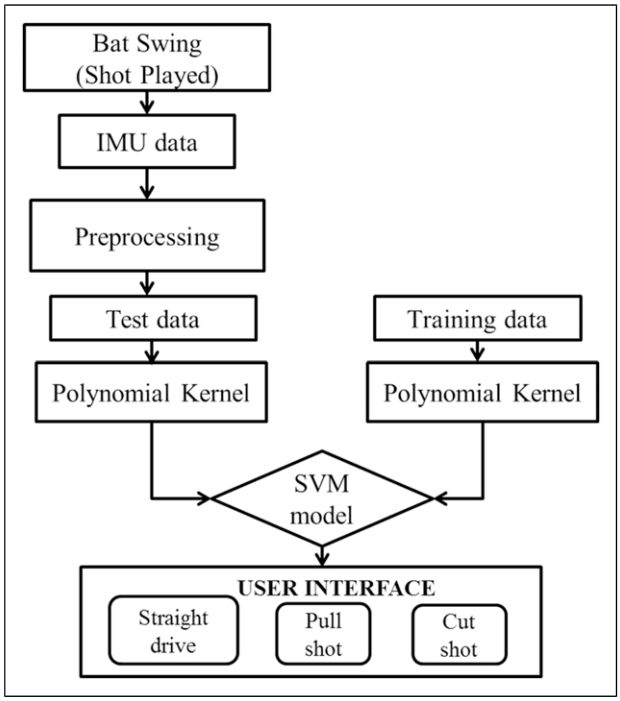

Figure 9. Work flow model of the cricket stroke classification.

$$K(X_1,X_2) = \left(a + X_1^{\mathrm{T}} X_2\right)^b, \tag{1}$$

where $K(X_1, X_2)$- polynomial kernel a - constant b - order of the kernel X_1, X_2 – vectors

These kernels convert the recorded data into the processed information and are used to plot them in the hyperplane of the SVM model. The training data are used to adjust the internal parameters of the model and help the model detect the player's stroke with maximum accuracy. The player's data are considered the test data, whose classes are detected by the SVM model. Classes are the output predicted by the model, which includes the type of stroke played by the batsman. Actually, the stroke classification begins with data acquisition of the IMU sensor. The data collected are stored in the temporary database for classification. The trained hyperplane of SVM consists of three classes based on the training dataset. When the test data are plotted on the hyperplane, the data get categorized into a specific group based on the processed features. All these processes are internally performed in the processor. The end result is shown to the user using Tkinter and Web application.

The work flow model of the cricket stroke classification is shown in Figure 9. First, the player needs to connect with the module through his smart phone or laptop. Then, the Tkinter-based application should be started and the application in turn allows the IMU to collect data and transfer it to the processor. These recorded data are sampled and saved as input CSV files. After saving, these files are given as test data set to our SVM model. The SVM model is trained using the training data set which we already collected from the coaches and senior players. The main software core of the project is the SVM classifier. SVM is one of the supervised machine learning algorithms. It uses kernel trick to process the data to plot the N-dimensional graph, where N represents the number of features or input given to the

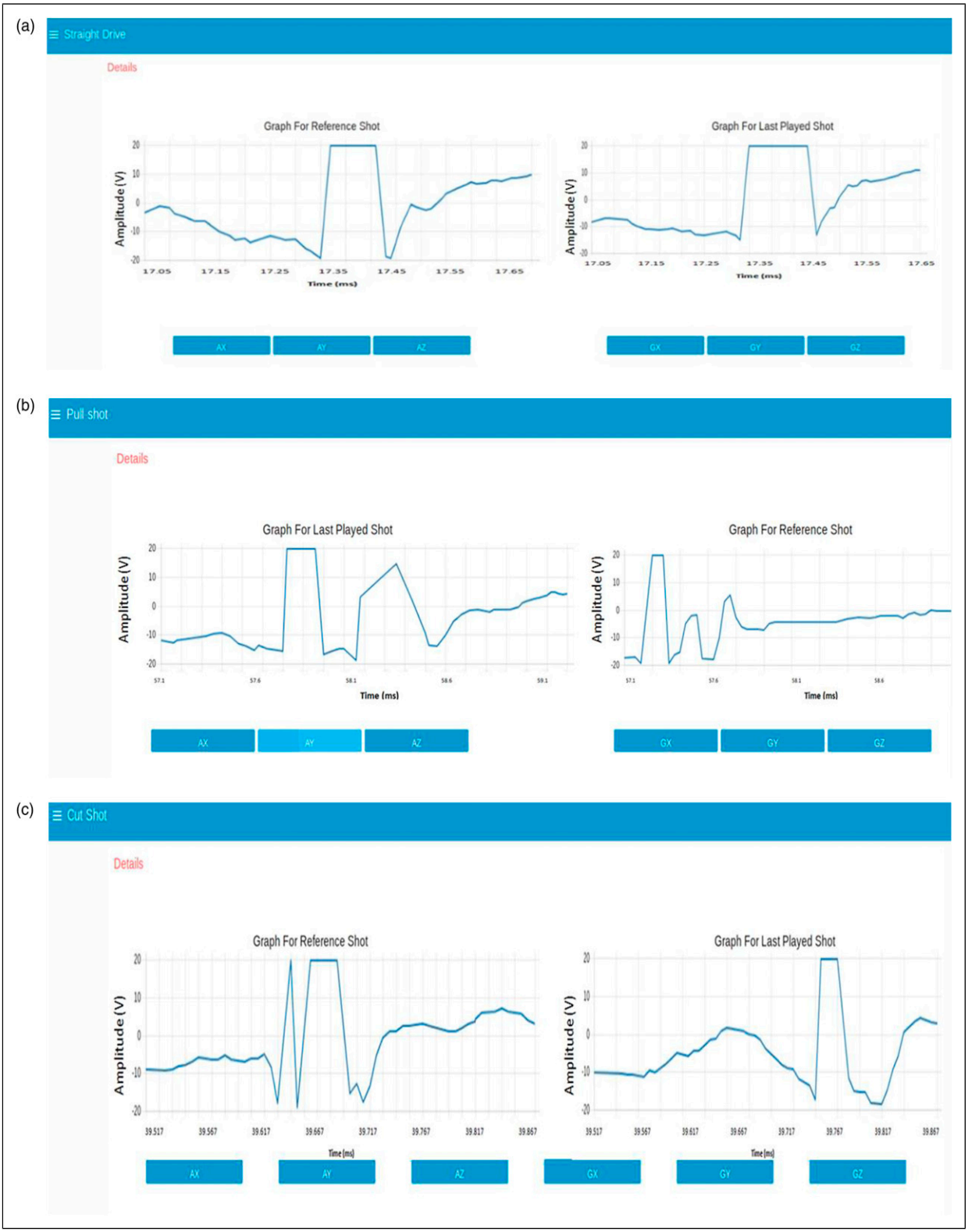

Figure 10. Analysis of (a) straight drive, (b) pull shot, and (c) cut shot in detailed manner.

model. Usually in SVM, we intended to plot all our data points into a high-dimensional space. Here, we are providing 300 features to our model. The work of the SVM classifier is to find the perfect hyperplane which can differentiate the classes.

The classes represent the type of strokes played by the user. Here, the kernel is considered to be the mathematical function used by the SVM algorithm. Its main work is to locate low-dimensional input to high-dimensional space which means we are providing amplitude versus time data as input from the IMU. It is plotted in 3-dimensional spaces in SVM models. Polynomial kernel is considered the best as the accuracy for this model is 97%. The specifically designed user interfaces are very interactive and provide instant updates about the type of strokes and the improvements need to be made.

Table 2. Cricket shots played.

Shots	Cut shot	Pull shot	Straight drive	Unknown
Straight drive	0	2	235	5
Pull shot	0	108	1	0
Cut shot	127	2	0	0

Table 3. Cricket shot classification for different shots.

Shots	Precision	Recall	F1-Score
Straight drive	0.93	0.98	0.96
Pull shot	0.97	0.97	0.97
Cut shot	0.98	0.94	0.97

Results and discussion

Software application

This section briefs on the working of software applications. Figure 6 is the front-end module designed using Tkinter and running in python. To run this application we need to press 'Play Shot.' This play shot allows the user to record his shot. The application shows whether the recorded shot is a straight drive, pull, or cut shot. It means that this application collects the data, processes it, and classifies the type of shots played by the user. The played shots are displayed for further reference of the player. If the player presses on 'Complete the Session', the application will be closed and then it will be switched off. If the player wants to review his shot then he needs to press the 'Review' button. This review button will allow the user to use the Node RED application shown in Figure 6 for visually analyzing the strokes. It gives the details of what, how many shots, and the last played shot the player has played. To specifically analyze a certain type of shot, the player needs to go to API tab menu and then choose the type of shots he has played. Figure 10 shows the detailed analysis of the straight, pull, and cut shot along with the heart beat rate and temperature for the particular shot.

Ax, Ay, and Az are accelerometer variations and Gx, Gy, and Gz are gyroscope variations. The player is provided with these many options and he can choose the one of his choice. Let us consider an example for pull shot. Figure 10a reveals that the timing is missed for straight drive. Figure 10b shows two peaks in closed manner, but the played shot has three peaks. This means the player has not played the shot in perfect manner. So this is how the software application gives a visual representation on the differences between the played shot and the reference shot. And for cut shot shown in Figure 10c the peaks obtained are less than those in the reference shot. We can interpret the perfect shot and understand the mistakes committed so that it can be corrected in the training process.

Cricket stroke classification accuracy

The accuracy of cricket stroke classification assessment was evaluated using the database containing recordings of nine different players. The database consists of 480 different cricket strokes. For this stroke classification, accelerometer and gyroscope readings are used. The classification is performed using the SVM model. Since 3 shots are more played, we have used this model to classify these shots and other shots are detected as unknown. Table 2 discusses the various shots played.

Polynomial kernel function for classification is used because it fits the model more accurately than other kernels. Since cricket strokes have less variance in playing style, linear and Gaussian kernels do not perform well in classifying the strokes. Since the classification model has to work on 300 different features, the polynomial kernel fits the model more precisely with good accuracy. Table 3 shows the classification result for the three different shots.

Result analysis. The polynomial kernel function is used for classification of the three common cricket strokes, straight drive, pull shot, and cut shot. The data set contains three classes with 50 samples each. Each sample is represented by 300 features. The data are further normalized to get the values between the range 0 and 1 to make the training faster and better. The goal of normalization is to change the values of numeric columns in the dataset to use a common scale, without distorting differences in the ranges of values or losing information. Principal component analysis is used to decompose these 300 features into two features.

Figure 11a gives the decision boundary of the SVM model with Polynomial kernel function. This decision boundary shows that the separation between the classes is as wide as possible, classifying the three different strokes with good accuracy. Figure 11b shows the receiver operating characteristics curve. The values of area under the curve obtained are 1.0, 0.96, and 0.99 for class 0, class 1, and class 2, respectively. It shows how well the model is capable of distinguishing between the three classes.

Table 4 gives the classification accuracy for various algorithms. It is inferred from the table that Polynomial SVM gives better accuracy, sensitivity, and specificity than other kernels.

Table 5 shows that the proposed system has good classification accuracy compared with the other classification algorithms. The contribution and outcome of the study is listed as follows.

(1) This article proposes data-driven machine learning concept instead of image-driven machine learning concept. This data-driven machine learning concept takes analog raw data as input for classifying strokes. So they require less internal memory for processing.
(2) The proposed system is designed for training purpose and future analysis. So, the player can easily get visual reference support where the mistakes can be learnt and corrected during the training period itself.
(3) The proposed model uses the IMU sensor to acquire the data. This model provides feedback to the player during his training session. The model will be able to classify the shot and provide visual feedback on the played strokes without using any computer vision. An existing video-based system uses high cost, high

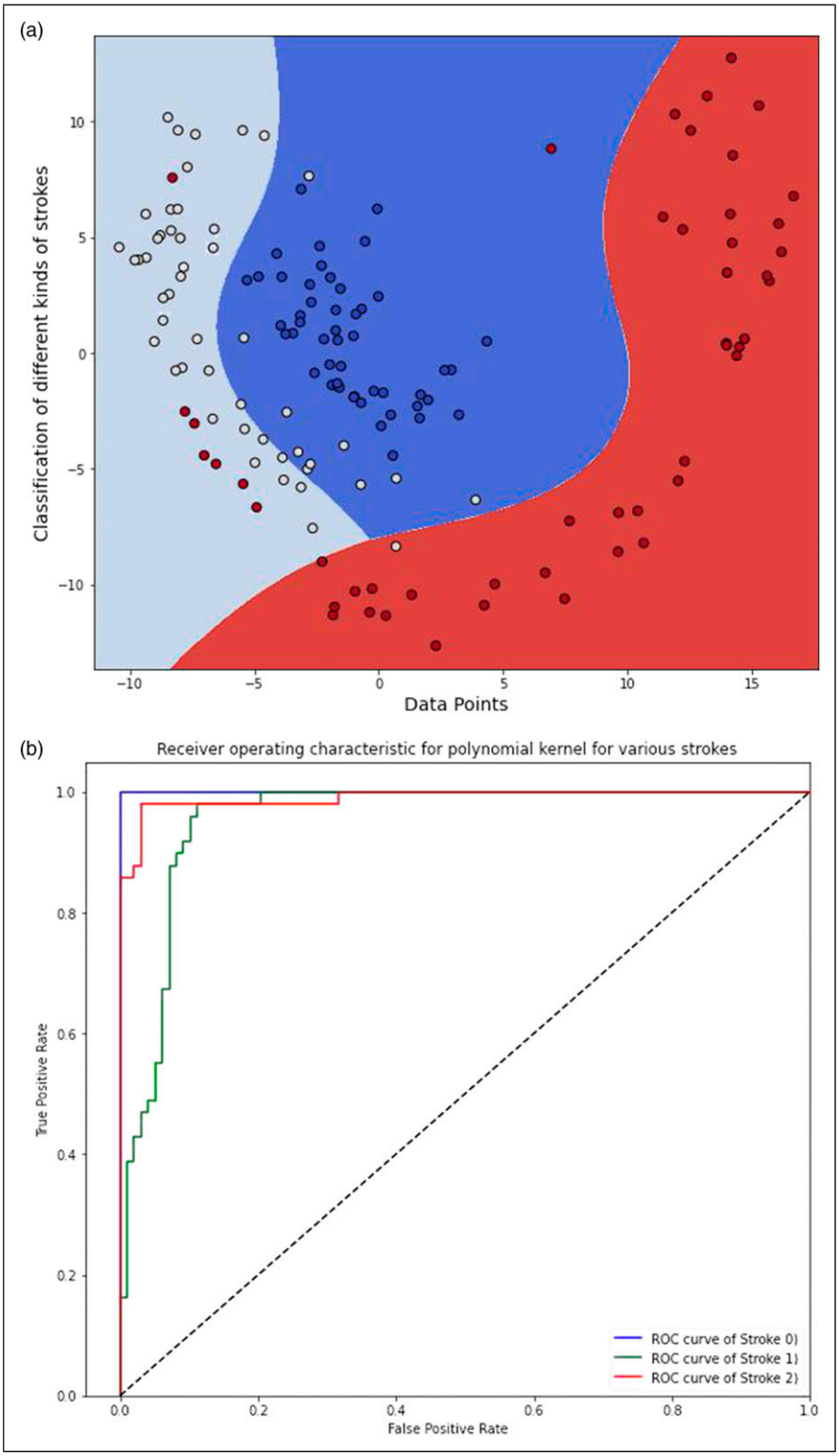

Figure 11. (a) SVM model with polynomial kernel; (b) ROC curves.

Table 4. Cricket shot accuracy for various classification algorithms.

Classification algorithm	Kernel function	Sensitivity (%)	Specificity (%)	Accuracy (%)
SVM	Polynomial	97.2	92.4	97
	Linear	91.4	89.2	93.2
	Gaussian	92.1	90.1	95.4
k-NN	Fine k-NN	93.2	91.1	95.4
	Weighted k-NN	90.3	89.4	93.9
	Medium k-NN	88.4	86.7	89.3

Table 5. Comparison of proposed classification accuracy in cricket with other classification algorithms.

Ref.	Data collection	Movements/ Parameters	Aim	Real-time feedback	Dedicated user interface	Approach	Result
[22]	IMU	Bowling phases	Classify bowling phases	No	No	RF, linear and polynomial SVM	Linear SVM accuracy is best
[23]	Video recordings	Data form IPL matches	To identify the best set of attributes in the player in the match played	No	No	SVM	81%
Proposed system	IMU	Straight drive, pull shot, and cut shot	Detect and record the movement of a cricket player and provide feedback to the player and the coach with a dedicated user interface	Yes	Yes	SVM–polynomial, linear, Gaussian k-NN–fine k-NN, weighted k-NN, medium k-NN	SVM polynomial–97% is better than others

performance, ultra speed, and a high frame rate camera for capturing the shots. Maintaining this camera in real-time is very difficult in training sessions. Also, processing these images requires more memory, high-end processor, and cloud computing which, in turn, provides an annual overhead and subscription cost.

(4) A comparison is performed on various kernels of SVM and k-NN classification algorithm and found that polynomial kernel outperforms the rest in terms of sensitivity, specificity, and accuracy.

Conclusions

A wearable miniature device to detect and classify straight drive, pull shot, and cut shot is developed for cricket sport. The accuracy of stroke classification is 97% which gives a detailed visualization on the player's performance. It has specifically designed user interfaces which are very interactive and provide instant updates about the strokes. This can be extended to any other swing-based sports by just changing the training data and the labels in the application. In future, we are planning to extend this application to all shot classifier, meaning it can detect every shot in cricket irrespective of their playing style. The system presented in this article enables automated assessment of batting skills in cricket using low-cost sensors and reliable machine learning analysis techniques.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Effect Of Strength Training on Anaerobic Power to Defensive Skills Among College Male Kabaddi Players

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Abstract

Physical exercise may be defined as a subset of physical activities that are planned and purposeful attempts to improve the health and well-being. The aim of this study was to find out the Effect of Strength Training on Anaerobic Power to defensive skills among Male Kabaddi Players. To achieve the purpose of the study 30 men Kabaddi players were selected as subjects from Academic Maritime Educational and Training deemed to be University Chennai, Their age ranged from 18 and 21 years old. The selected subjects were added divided into two some groups of Strengthening Training group and the Control Group of fifteen (N-15). The Training group was treat with systematic Strength Training for 3 sessions a week (Sunday, Tuesday and Thursday) Total twelve weeks. The test was carried out pre and post test. The Strength training selected physical variables are (50 yard) - test was used. To find out mean different of pre and post treatment (ANCOVA) was applied. The level of significance was fixed at 0.05 in all aspect. The results of the study show that the Strength Training on Anaerobic Power had a significant improvement and highlight the potential of using Anaerobic Power Training to improve speed for the most part of Defensive Skills Academic Maritime Educational and Training Deemed University Kabaddi players.

KeyWords: Defensive, Anaerobic exercise, systematic
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Introduction

Strength training picks up blood sugar levels and improves the use of insulin in the human body. Strength training on a regular basis may decrease the symptom associated with depression and anxiety and may help reduce. Proceeds of lifting weights include building muscle burning body fat strengthening your bones and joints. Reducing humanizing heart health and muscle. To lift weights safe and resonance important. It involves actions that make your muscles do more work than they frequently do same. A work out counts as strength training involves a intermediate to high-level attempt and if its work major muscle groups of the body Strength training perks up superiority of life and capacity to do day by day household tasks. Strength training also avoid wound to human joint. Structure muscle maintains balance and lower chance of decrease. Adult this protects autonomy Strength training has been shown to reduce symptoms of anxiety for individuals with and without anxiety confusion. Enhanced attitude healthier be asleep in advance bone density maintain mass defeat boost metabolism lower tenderness and staving off chronic disease among a laundry list of positive. Strength training may improve quality of life and improve capability to do daily actions. Strength training also protects joints from wound. Structure muscles contribute to well again sense of balance and reduce risk of falls.

Benefits Anaerobic Power

Anaerobic workout move forward body and human lungs to relay on force source stored muscles.

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The increase bone potency and compactness anaerobic motion similar to strength training add to the strength and density of Bone always life form broken down and replace.

Hypothesis

Significant different on preferred fitness variable of Kabaddi players.

Limitations

The Prime of life factors were not Prohibited. Involvement in various Tournaments could not be prohibited.

Delimitations

The study is delimited with thirty male choose from AMET University players (18-21)

Methods - Selection of Subject

To achieve these purposes was 30 Kabaddi (M) players were selected as a subject from Academic Maritime Educational and Training Deemed to be University Chennai Their age of 18 and 21 years aged. Selection of Variable = Speed – 50 yard – Performance (m/sec).

Selection of subject

The subjects were divided into two groups of 15 equally Strength Training group and the control group. The systematic program to Strength Training. Group I were gone for Weight Training exercise for three days in week. Preparation session six week was between 60 to 75 minutes impressive dumb Squat, Dead lift, Bench Press, Pull-Ups with warm up and fresh down. Group II The control group didn't do contribute any training programs.

Statistical Methods

The dates were analysis was using SPSS version 20. To mean difference of Pre and Post handling Statistically through ANCOVA. Significance 0.05 level.

Results and Discussions

Table 1: Analysis on Speed of Strength Training and the Control Groups

Test	TG	CG	SOV	SS	DF	MS	F
Pre Test Mean	7.81	7.69	B	0.15	1	0.15	0.17
SD	1.8	0.92	W	28.42	28	1.2	
Post Test Mean	7.6	7.91	B	3.42	1	3.42	3.19
SD	1.14	0.90	W	27.76	28	1.6	
Adjusted Post Test	7.8	7.91	B	5.97	1	5.97	186.76*
			W	0.66	27	0.03	

*sign at .05 level at p= .05 (1. 28 - 4.21) and 1, 27 - 4.20)

Table I, shows the analyzed date on speed pre test, post test and adjusted post test (7.81 - 7.69), (7.6 - 7.91) (7.8 - 7.91) of Strength Training group and the control group. The obtained 'F' ratio for Pre test .17 Post tests 3.19 and adjusted Post test 186.76. The obtained 'F' ratio post test 3.19 and adjusted post test were 186.76 the table value was 4.21 and 4.20 at.05 level of significance. The degree of freedom (1.28 - 1.27). Therefore it is proved that strength training group has been better than the control group.

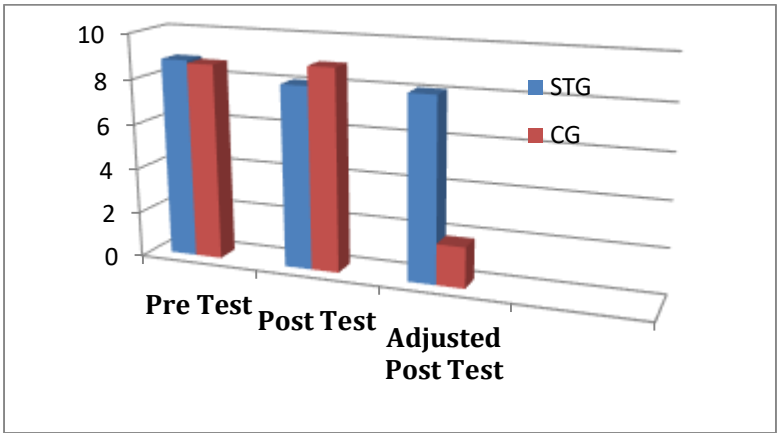

Figure 1: Training and Control Groups on Speed Perform.

Conclusion

The Speed was significantly improved due to effect of Strength Training on anaerobic power to defensive skills among college male Kabaddi Players. Significantly improved Speed Greater than that of Control Group of Men Kabaddi players of AMET.

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Role of aerobics exercise and kettlebell training improving on selected health related physical fitness parameters in obese male adults

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Purpose: The aim of the this research is to assess the improvement in various variables related to health fitness among obese adults on administrating a twelve weeks aerobics exercise training and kettlebell training.
Materials and Methods: Total sixty male adults with obese (Mean ± SD; age: 18.92 ± 1.54 yrs.; height: 172.4 ± 5.4 cm.; weight: 84.4 ± 6.3 kg) were randomly allocated into three equal (n = 20) groups: Aerobic Exercise Training (AET), Kettlebell Training (KBT) and a control group. The AET & KBT training protocol was performed three days per week for 12 weeks. All the selected variables of physical fitness has been examined at baseline and 12 weeks. Control group does not perform any exercise.
Analysis and findings: There were significant difference in terms of Flexibility (F), Muscular Endurance (ME), Muscular Strength (MS) and Cardiovascular Endurance (CE), between the AETG & KBTG have been compared with control group ($p < 0.05$). Body Composition (BF) significant reductions in AET & KBT groups have been compared with control group ($p < 0.05$).
Conclusion: Our findings suggest that AET & KBT protocols have greater effects than control group on health related physical fitness variables in obese male adult individuals. It is recommended that schools and colleges should administrate the aerobic exercise session and kettlebell training among adults for better health perspectives.
Keywords: Different exercise training, Aerobic exercise, Kettlebell training, Health related fitness, obese

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Анотація

Каруппасамі Говіндасамі, Чандрабабу Суреш, Саран КС, Мітхін Ананд, Ділпріт Каур, Джон Боско Аніта, Алі Алуї, Хіба Буганмі, Імен Ачурі. Роль аеробіки та тренування з гирями в покращенні вибраних параметрів фізичної підготовки, пов'язаних зі здоров'ям, у дорослих чоловіків із ожирінням

Мета. Мета цього дослідження полягає в тому, щоб оцінити покращення різних змінних, пов'язаних із фізичною формою здоров'я, серед дорослих із ожирінням під час виконання дванадцяти тижнів аеробіки та тренувань з гирями.

Матеріали та методи. Всього шістдесят дорослих чоловіків із ожирінням (середнє ± SD; вік: 18,92 ± 1,54 року; зріст: 172,4 ± 5,4 см; вага: 84,4 ± 6,3 кг) були випадковим чином розподілені на три рівні (n = 20) групи: «аеробні вправи», «тренування з гирями» та контрольна група. Протокол навчання груп «аеробні вправи» і «тренування з гирями» виконувався три дні на тиждень протягом 12 тижнів. Усі вибрані змінні фізичної підготовленості досліджувалися на початку та через 12 тижнів. Контрольна група не виконує жодних вправ.

Аналіз і висновки. Існувала значна різниця в показниках гнучкості, м'язової витривалості, м'язової сили і серцево-судинної витривалості між групами «аеробні вправи» і «тренування з гирями» у порівнянні з контрольною групою (p <0,05). Значне зниження складу тіла у групах «аеробні вправи» і «тренування з гирями» порівнювали з контрольною групою (p <0,05).

Висновок: наші висновки свідчать про те, що протоколи груп «аеробні вправи» і «тренування з гирями» мають більший вплив, ніж контрольна група, на пов'язані зі здоров'ям змінні фізичної підготовки у дорослих чоловіків із ожирінням. Рекомендується, щоб школи та коледжі проводили аеробні вправи та тренування з гирями серед дорослих для кращого здоров'я.

Ключові слова: різні вправи, аеробні вправи, тренування з гирями, фітнес, пов'язаний зі здоров'ям, ожиріння

Аннотация

Карупасами Говиндасами, Чандрабабу Суреш, Саран КС, Митхин Ананд, Дилприт Каур, Джон Боско Анита, Али Алуи, Разве Буганми, Имен Ачури. Роль аэробики и тренировки с гирями в улучшении выбранных параметров физической подготовки, связанных со здоровьем, у взрослых мужчин с ожирением

Цель. Цель этого исследования состоит в том, чтобы оценить улучшение различных переменных, связанных с физической формой здоровья, среди взрослых с ожирением во время выполнения двенадцати недель аэробики и тренировок с гирями.

Материалы и методы. Всего шестьдесят взрослых мужчин с ожирением (среднее ± SD; возраст: 18,92 ± 1,54 года; рост: 172,4 ± 5,4 см; вес: 84,4 ± 6,3 кг) были случайным образом распределены на три равные (n = 20) группы: «аэробные упражнения», «тренировка с гирями» и контрольная группа. Протокол обучения групп «аэробные упражнения» и «тренировка с гирями» выполнялся три дня в неделю в течение 12 недель. Все выбранные переменные физической подготовленности исследовались в начале и через 12 недель. Контрольная группа не выполняет никаких упражнений.

Анализ и выводы. Существовала значительная разница в показателях гибкости, мышечной выносливости, мышечной силы и сердечно-сосудистой выносливости между группами «аэробные упражнения» и «тренировка с гирями» по сравнению с контрольной группой (p<0,05). Значительное снижение состава тела в группах «аэробные упражнения» и «тренировка с гирями» сравнивали с контрольной группой (p<0,05).

Вывод: наши выводы свидетельствуют о том, что протоколы групп «аэробные упражнения» и «тренировки с гирями» оказывают большее влияние, чем контрольная группа, на связанные со здоровьем переменные физической подготовки у взрослых мужчин с ожирением. Рекомендуется, чтобы школы и колледжи проводили аэробные упражнения и тренировки с гирями среди взрослых для лучшего здоровья.

Ключевые слова: разные упражнения, аэробные упражнения, тренировки с гирями, фитнес, связанный со здоровьем, ожирение

Introduction

Machines have changed human life, and humans now enjoy the maximum level of physical comfort. Modern technology is working hard to make our lives easier, more luxurious, and more pleasant while also reducing our physical exertion. As a result, humans appear to be becoming increasingly inactive all over the globe. Humans now ride instead of walking, sit instead of standing, and watch instead of participating, and these lifestyle changes have definitely reduced physical labour while increasing mental stress and strain. As a result, it is critical to effect good changes in today's lifestyles through involvement in sports and physical education programmes. The development of physical fitness among the public or participants should be one of the major goals of every physical education and sports programme. Physical education should try to make every child physically, cognitively, and emotionally healthy, as well as to develop personal and social traits in him, allowing him to live happily with others and develop as a good citizen. As a result, an individual's health fitness can be enhanced through different variety of programmes [1].

Obesity is becoming more prevalent all over the world besides in economically developed or backward nations [2, 3]. Obesity is a life-threatening condition caused by a sedentary lifestyle. Obesity and overweight impact millions of people in both developed and developing nations. Obesity was once thought to be a issue only in developed nations [4]. Obesity, on the other hand, is on the rise in all types of nations at present. Obesity and overweight contribute the most to noncommunicable disease morbidity and mortality [5]. In 2008, the WHO estimated that over 1.4 billion adults have been found overweight in which 50% among them were being obese [6]. Obesity frequency was 39.6 percent among rural population in 2005–2008, as compared to urban population which has been recorded 33.4 percent as per investigation carry out by the National Health and Nutrition Examination Survey [7]. A latest ICMR-INDIAN survey has been conducted among three states of India (Maharastra, Tamil Nadu, and Jharkhand) along with Chandigarh a union territory of India. The number of people who were generally obese ranged from 11.8% to 33.6% [8]. When we observed the results of the two surveys conducted by the NFHS-2 (National Family Health Survey) during 1998–1999 and the NFHS-3 in 2005–2006, this revealed that the proportion of obese Indian women has gone from 10.6% to 12.6% [9]. When age was considered, the Chennai Urban Rural Epidemiology Study showed that 45.9% of people were obese [10].

Pavel Tsatsouline made hardstyle kettlebell training popular in the 2000s. Its techniques involve tension and relaxation and are said to improve health-related fitness [11]. In trial with participants (younger), there were progress in upper-limb perseverance [12], vertical jump and dynamic balance [13], leg power and trunk stamina [14], standing long jump and strength of grip [15], VO2 [16], and 1RM barbell deadlift [17]. Physical fitness and Aerobic exercise can be compared to anaerobic exercise, which includes running short distances and strength training. The two forms of exercise differ in how energy is made in the muscle and how long and hard muscle contractions are. The latest study on the endocrine functions of contracting musculature has discovered that aerobic and anaerobic exercise increases the release of myokines. This has several benefits, including tissue repair, new growth of new tissue, and anti-inflammatory functions that lower the risk of developing inflammatory diseases. The quantity of muscle contracted, as well as the duration and severity of contractions, all influence myokine secretion. Count is used in floor aerobics. Floor aerobics was created to eliminate the need for open-air exercise. Day by day, the women took advantage of the opportunities that were presented to them [18-20]. Many gyms and fitness facilities with a group workout programme offer step aerobics programmes. Previously Aerobic exercise and resistance training was investigated obese adolescents on the selected health related physical fitness parameters [1]. Hence, in our knowledge so far there is no investigation on the topic. Therefore, the presents study aims to effects the improvement in health related physical fitness among obese adults on administrating a twelve weeks aerobics exercise and kettle bell training.

Material and methods

Participants

Participants Recruitment

Sixty obese male adults were recruited from the SRM Institute of Science and Techlogy, Kattankulathur, Tamilnadu, India. The participants came from various family backgrounds and took part in similar academic activities. The participants were selected at random. Total sixty male adults with obese (Mean ± SD; age: 18.92 ± 1.54 yrs.; height: 172.4 ± 5.4 cm.; weight: 84.4 ± 6.3 kg) were randomly allocated into three equal (n = 20) groups: Aerobic Exercise Training (AET), Kettlebell Training (KBT) or a control group. The flow diagram is displayed in figure 1.

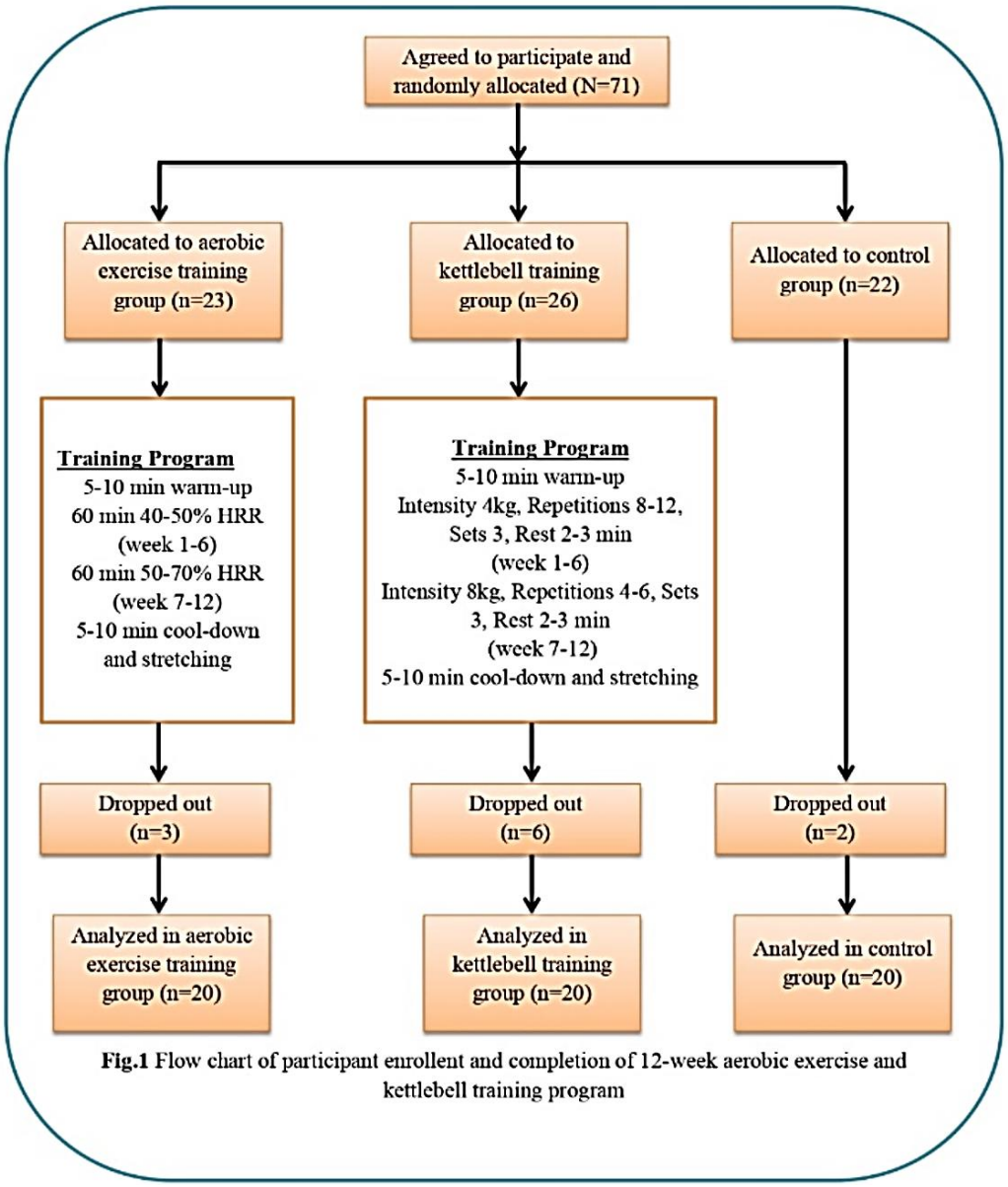

Fig.1 Flow chart of participant enrollent and completion of 12-week aerobic exercise and kettlebell training program

Fig.1. Flow diagram of the study program, AET, Aerobic exercise training group; KET, Kettlebell training group; CG, Control Group

Obesity

The following formula was used to calculate the obesity based on their BMI: Metric: BMI = kilograms/meters^2. Males with a BMI of 30kg/m^2 or higher are considered obese for the purposes of this research.

Study Design

The respondents were classified into three groups at random, with each group consisting of twenty participants subjects. All participants were randomly divided into three groups with 20 participants in each group: Aerobic Exercise Training (AET), Kettlebell Training (KBT) or a control group. AET and KBT group were intervened with respective workout for twelve weeks whereas control group does not perform any exercise. Parameters of physical fitness associated with health have been compared at baseline and at endpoint in all groups. First, before the study started, the participants were told everything they needed to know about the experiment, including how it would work, when they would work out, and what tests they would have to take. This was done to get their full cooperation with the work they had to do—the subjects trained a week thrice from 6:30 to 7:30 a.m., except on Saturdays and Sundays. The exercises were slowly brought in. Methods that ranged from easy to the complex were used. This study was conducted in accordance with the Declaration of Helsinki and the protocol was fully approved by the

local institutional ethical committee of the SRMCHRC, Kattankulathur, Tamilnadu India (Number 3070/IEC/2022) before the commencement of the measurements.

Measures of Health Associated Physical Fitness

The health associated physical fitness of people with obese adult individuals who participated in this study was measured using measuring instruments available in the department of physical education, kattankulathur campus, tamilnadu, India. As for the measurement criteria: Cooper's 12 Minute Run / Walk test has been applied to examine cardiovascular endurance. The test of Sit and Reach has been used to assess muscular flexibility. While Push ups method has been applied to assess muscular strength. The half squat jump test has been applied to examine muscular endurance. "The following formulae were used to calculate body composition. % body fat = 0.41563 x (sum of three sites)-0.00112 x (sum of 3 sites) 2 + 0.36661 x (age)+4.03653, where the sum of three sites was skinfold calibre measurements at the triceps, medial region of the suprailium and navel".

Training Intervention

At SRM IST's Fitness Center, exercise programmes were held for 12 weeks, with three 60-minute sessions a week that got progressively harder (Fig. 1). Every session had 10-minute periods to stretch and warm up, cool down. The AETG did aerobic exercises for 40–50% HRR in weeks 1–6 and 50–70% HRR in weeks 7–12. On a Polar Accurex monitor from Kempele, Finland, the heart rate was tracked all the time so that the workload could be changed to reach the target heart rate. The KBTG performed the kettlebell exercise for consisted of 30 sec to 1 min of rest between each exercise and 2-3 min rest between each circuit. Weeks 1-6 were used for fixed intensity 4kg, Repetitions 8-12, sets 3, The weight was progressed from body weight 4 and 8 kg and the circuits increased from two to three, while repetition remained at eight. Progressions during week's 4-12 intensity 8kg, Repetitions 6-8, sets 3 were based on the participants' ability. Throughout the 12-week study, all participants were told not to change how they ate or how much they practised. The CG was also related not to changing how they exercised or how much they did.

Statistical Analysis

All data were described using means and standard deviations (±), and the data's normality was determined using the Kolmogorov-Smirnov and Shapiro-Wilk tests. To ensure that there were no significant differences between groups, a one-way ANOVA was used to compare all of the baseline data among the three groups. To compare the changes of three groups for all variables, a two-way ANOVA repeated measures test (Groups by time) was used. Following a significant group-by-time interaction, a Bonferroni post hoc test was performed. Additionally, effect sizes (ES) were calculated using partial eta-squared from the ANOVA output. Furthermore, within-group ES were calculated using the equation: (mean post-mean pre)/SD = ES [21]. Hopkins et al. classify ES as trivial (0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2.0), and very large (2.0-4.0) [22]. To indicate statistical significance, a p-value of 0.05 was used. SPSS for Windows, version 23. 0, was used to perform all statistical analyses (SPSS Inc., Chicago, United States). The sample size was calculated to detect a difference in the study variables with a 95 percent confidence interval for the analysed measures.

Results

In all the study groups (i.e., control; AETG; KBTG), no significant differences ($p > 0.05$) were observed for age, weight, height, BMI, CE, MS, ME, F and BC (Table 1). Data's normality was determined using the Kolmogorov-Smirnov and Shapiro-Wilk tests (Table 2). Moreover, there were no significant differences ($p > 0.05$) between the groups for health related physical fitness variables at baseline (Table 3).

The following results can be found in (Table 3), unless otherwise stated. A significant interaction between group and time was observed for CE ($F2,57 = 79.9$ and ($p < 0.05$), MS ($F2,57 = 5.12$ and ($p < 0.05$), ME ($F2,57 = 5.02$ and ($p < 0.05$) and F ($F2,57 = 5.024$ and ($p < 0.05$) Health related physical fitness significantly increased in both training protocols (i.e., AETG and KBTG), when compared with the control group ($p < 0.05$). BC% ($F2,57 = 190.06$ and ($p < 0.05$)Significantly decreased in both training protocols (i.e., AETG and KBTG), when compared with the control group ($p < 0.05$). However, these increases were significantly greater in KBTG when compared with the AETG protocol ($p < 0.05$). Moreover, paired sample t-test indicated significant increases ($p < 0.05$) in health related physical fitness following 12 weeks when compared with baseline in both training protocols. Data analysis showed a significant increased was observed in AETG and KBTG protocols in comparison with the control group ($p < 0.05$). However a more significant decreases was observed in KBTG compared with the AETG protocol ($p < 0.05$). Neither training protocols showed significant increased from baseline to 12 weeks in CE, MS, ME, F and BC%.

Table 1

Mean and SD (±) Characteristics of Participants

Characteristics	Control	AETG	KBTG
Age (years)	18.95 ± 1.43	18.65 ± 1.13	19.15 ± 1.98
Height (cm)	174.7 ± 6.44	170.7 ± 4.52	171.9 ± 4.78
Weight (kg)	92.20 ± 6.96	87.25 ± 4.60	88.80 ± 6.59
BMI (kg/m^2)	30.18 ± 1.25	29.94 ± 1.31	30.00 ± 1.22
CE (ml/kg/min)	28.97 ± 2.15	28.89 ± 2.13	29.35 ± 1.74
MS (numbers)	18.90 ± 1.86	19.10 ± 1.37	19.15 ± 2.18
ME (numbers)	23.55 ± 1.63	22.85 ± 2.30	22.95 ± 1.82
F (cm)	23.20 ± 2.28	22.85 ± 1.75	21.95 ± 2.60
BC (%)	39.71 ± 0.42	39.46 ± 0.41	39.74 ± 0.56

AETG, aerobic exercise training group; KBTG, kettlebell training group, BMI, body mass index; CE, cardiorespiratory endurance; MS, muscular strength; ME, muscular endurance; F, Flexibility; BC, body composition.

Table 2

Normality Test Calculation

Group	Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CG AETG KBTG	CE (ml/kg/min)	0.092	60	0.200	0.986	60	0.733
CG AETG KBTG	MS (numbers)	0.111	60	0.063	0.971	60	0.163
CG AETG KBTG	ME (numbers)	0.109	60	0.072	0.974	60	0.240
CG AETG KBTG	F (cm)	0.108	60	0.076	0.972	60	0.178
CG AETG KBTG	BC (%)	0.102	60	0.191	0.968	60	.0114

AETG, aerobic exercise training group; KBTG, kettlebell training group, BMI, body mass index; CE, cardiorespiratory endurance; MS, muscular strength; ME, muscular endurance; F, Flexibility; BC, body composition.

Table 3

Pretest and the Posttest Mean and SD (±) Values of Health Related Physical Fitness Variables

Variable	Group	Pre	Post	Partial Eta Squared
CE (ml/kg/min)	AETG	28.89 ± 2.13	41.18 ± 2.92$^{*\#\dagger}$	0.93
	KBTG	29.35 ± 1.74	40.20 ± 2.62*†	
	Control	28.97 ± 2.15	30.82 ± 3.01	
MS (numbers)	AETG	19.10 ± 1.37	20.45 ± 1.43†	0.69
	KBTG	19.15 ± 2.18	20.90 ± 1.41†	
	Control	18.90 ± 1.86	19.95 ± 1.76	
ME (numbers)	AETG	22.85 ± 2.30	25.00 ± 1.16*†	0.77
	KBTG	22.95 ± 1.82	25.40 ± 1.27$^{*\#\dagger}$	
	Control	23.55 ± 1.63	24.10 ± 1.51	
F (cm)	AETG	22.85 ± 1.75	25.40 ± 1.27$^{*\#\dagger}$	0.78
	KBTG	21.95 ± 2.60	25.00 ± 1.16*†	

	Control	23.20 ± 2.28	24.10 ± 1.51	
BC (%)	AETG	39.46 ± 0.41	37.46 ± 0.32*†	0.98
	KBTG	39.74 ± 0.56	36.57 ± 0.33*#†	
	Control	39.71 ± 0.42	38.66 ± 0.35	

CE, cardiorespiratory endurance; MS, muscular strength; ME, muscular endurance; F, Flexibility; BC, body composition, AETG, aerobic exercise training group; KBTG, kettlebell training group
*Significant difference with the control group ($p < 0.05$).
#Significant difference between training protocols ($p < 0.05$).
†Indicates significant difference from baseline ($p < 0.05$).

However these changes in AETG and KBTG were significant ($p < 0.05$) after 12 weeks when compared with baseline. No significant changes were observed in MS in both training protocols when compared with the control group.

Discussion

Mendonça FR, et al. had previously investigated the effects of aerobics exercise, and resistance training on physical fitness regarding health among adolescents [1]. After undertaking aerobics exercise, combination resistance training for a period of twelve weeks, it was shown that adolescents showed considerable improvement in all of the selected health related physical fitness parameters. After participating in aerobics exercise, combination resistance training for a period of twelve weeks, adolescents showed significant improvements in muscular and cardiorespiratory fitness. Some another studies also investigated physical fitness and physical activity regarding health among schools of elementary education and the results showed significantly association in students [2]. Similar results were obtained in present study in which the health related physical fitness variables of the obese male adults was found to improve after twelve-week intervention of AET & KBT groups. Clary et al. Found the effects of step aerobics, Ballates, and walking on balance in women having age group of 50 to 75. When compared to the Ballates programme, walking programmes and step aerobics resulted in better improvements in static balance and postural stability (1). In our study however, similar results were obtained in case of aerobic exercise groups.

Melam et al. examine the impact of brisk walking and aerobics on overweight people. For ten weeks, this programme was carried out five days a week [2]. Body mass index, hip circumference and waist, subscapular area, and skinfold thickness of the belly, biceps, and triceps were measured before and after the study for all three groups of women. All attributes went down in women who walked quickly and did aerobics for ten weeks. In present study also, the body composition was found to be improved significantly among adult obese male after twelve weeks of aerobic exercises and kettle bell training. Maiyanga and Gunen observed the influence of step aerobics on per cent visceral and body fat in obese female nurses at Bauchi's speciality hospital. They found that step aerobics lowers per cent body fat [24,25]. Being piolet in nature, present study has several limitations that suggests the lacune on which future studies could be carried out. One limitation of the study is that we take only the male participants in current study. Obesity is also prevalent in females and therefore future studies could be conducted by taking the female participants. Other limitation of the study is that present study is focused specific age group, future studies could be conducted by taking all age group. This will help in validating the result of current study for all age groups. Another constraint of the this study is the size of the sample itself. Because the sample size of the present study is very small, the result of present study cannot be validated for general population. Moreover, present study is a single centric study, future study by taking the multicentric approach should be conducted to find the role of aerobic exercise in management of obesity among adults.

A randomised control design with strictly controlled supervised exercise sessions for both training protocols was one of the study's strengths. Given the exercise training for adult obese men, our KBT protocol could be an attractive proposition. However, more studies in different populations (e.g., individuals with obesity, diabetics, and cardiovascular patients) are required to confirm the effectiveness and tolerability of the protocols of this study.

Conclusion

Overall the components of health related physical fitness have been found significantly associated with the obese adults engaging AET & KBT but the control group there were not significant. Present study revealed significant improvement in adult obese in terms of muscular strength, body

composition, muscular endurance, cardiorespiratory endurance and flexibility domains after practising the AET & KBT. Aerobics exercise and kettlebell training proved to helpful in management the health related physical fitness in obese adult individuals. It is recommended that schools and colleges should administrated the aerobic exercise session and kettlebell training among adults for better health perspectives.

Ethics Statement

The studies involving human participants were reviewed and approved by the local institutional ethics committee of the SRM Medical College Hospital and Research Centre, Kattankulathur, Tamilnadu, India (Number 3070/IEC/2022). Written informed consent to participate in this study was provided by the participants.

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Conflict of Interest

The authors hereby declare that they don't have any financial and personal conflict of interest.

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Comparative analysis of mean platelet volume among female volleyball rugby players and yoga practitioners

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Abstract

Purpose. Several studies have shown that platelet size is a reliable indicator of platelet activity and, therefore, a valuable biomarker for cardiovascular events. Many inflammatory and prothrombotic disorders have been linked to it. As a biomarker for inflammation and neoplastic disease, This study aims to examine existing research on changes to mean platelet volume (MPV).
Materials and methods. The present study portrays MPV comparison among the female players who participated in two games and one yoga practitioners, Volleyball, and Rugby conducted at the university level throughout India with age groups ranging from 17 to 25 years in the sample. The sample size is 45, with 15 players chosen from each two game Volleyball, and Rugby and one yoga practitioners
Results:.The results mean, standard deviation (SD), standard error of the mean (SEM), and lowest and maximum scores were used to examine the data. Normality was assessed and confirmed using the Kolmogorov-Smirnov test. SPSS software was used to do the One-Way Analysis of variance. It was observed that there is a significant difference in the MPV of players from two distinct sports players and yoga practitioners. Furthermore, there exists a one-to-one correspondence between the MPV between the players participating in individual games. The present results displayed the values of MPV among players from different games and yoga practitioners are independent of one another and unaffected by one another. The p-value is 0.011252. The result is significant at $p < 0.05$. As a result, the null hypothesis is rejected in this study.
Conclusion. The study's findings indicate a significant difference in the MPV of players from two distinct sports players and yoga practitioners. However, when MPV of Volleyball and rugby players were compared, it was discovered that they were connected. In conclusion, MPV among players from different games yoga practitioners are independent of one another and unaffected by one another. Variability in MPV was also observed across all sample sizes in the study.
Keywords: mean platelet volume (MPV), yoga practitioners, volleyball, rugby, female players

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Анотація

Ділпріт Каур, Арвінд Малік, Каруппасамі Говіндасамі, Саран К.С., Мітхін Ананд, Чандрабабу Суреш, Джон Боско Аніта, Моу Праманік, Імен Ачурі, Хіба Боуганмі, Сігамані Джаясінг Альберт Чандрасекар. Порівняльний аналіз середнього об'єму тромбоцитів у волейболісток, у регбі та йоги.

Мета. Кілька досліджень показали, що розмір тромбоцитів є надійним показником активності тромбоцитів і, отже, цінним біомаркером серцево-судинних подій. Багато запальних і протромботичних розладів були пов'язані з ним. Як біомаркер запалення та неопластичних захворювань, це дослідження має на меті вивчити існуючі дослідження змін середнього об'єму тромбоцитів (MPV).

Матеріали та методи. У цьому дослідженні представлено порівняння MPV серед жінок-гравців, які брали участь у двох іграх і одній йозі, волейболі та регбі, проведеному на університетському рівні по всій Індії з віковими групами від 17 до 25 років у вибірці. Розмір вибірки становить 45, по 15 гравців, обраних із кожної з двох ігор у волейбол та регбі, і один практикуючий йогу

Результати. Середнє значення результатів, стандартне відхилення (SD), стандартна помилка середнього (SEM), а також найнижчі та максимальні бали були використані для вивчення даних. Нормальність оцінювали та підтверджували за допомогою тесту Колмогорова-Смирнова. Програмне забезпечення SPSS використовувалося для виконання одностороннього дисперсійного аналізу. Було помічено, що існує значна різниця в MPV гравців двох різних спортсменів і практикуючих йогу. Крім того, існує однозначна відповідність між MPV між гравцями, які беруть участь в окремих іграх. Нинішні результати показали, що значення MPV серед гравців з різних ігор і йоги не залежать один від одного і не впливають один на одного. P-значення становить 0,011252. Результат достовірний при $p < 0,05$. Як наслідок, нульову гіпотезу в цьому дослідженні відхилено.

Висновок. Результати дослідження вказують на значну різницю в MPV гравців від двох різних спортсменів і практикуючих йогу. Однак, коли порівняли MPV волейболістів і регбістів, було виявлено, що вони пов'язані. Підсумовуючи, MPV серед гравців із різних ігор йоги не залежать один від одного й не впливають один на одного. Варіабельність MPV також спостерігалася в усіх розмірах вибірки в дослідженні.

Ключові слова: середній об'єм тромбоцитів (MPV), йоги, волейбол, регбі, гравці

Аннотация

Дилприт Каур, Арвинд Малик, Каруппасами Говиндасами, Саран К.С., Митин Ананд, Чандрабабу Суреш, Джон Боско Анита, Моу Праманик, Имен Ачури, Хиба Буганми, Сигамани Джаясингх Альберт Чандрасекар. Сравнительный анализ среднего объема тромбоцитов у женщин, играющих в волейбол, регби, и занимающихся йогой.

Цель. Несколько исследований показали, что размер тромбоцитов является надежным индикатором активности тромбоцитов и, следовательно, ценным биомаркером сердечно-сосудистых событий. С ним связаны многие воспалительные и протромботические расстройства. В качестве биомаркера воспаления и неопластического заболевания это исследование направлено на изучение существующих исследований изменений среднего объема тромбоцитов (MPV).

Материалы и методы. В настоящем исследовании проводится сравнение MPV среди женщин-игроков, которые участвовали в двух играх и одной практике йоги, волейбола и регби, проведенных на университетском уровне по всей Индии, с возрастными группами от 17 до 25 лет в выборке. Размер выборки составляет 45 человек, по 15 игроков, выбранных из каждой игры в волейбол и регби, и один человек, занимающийся йогой.

Результаты. Для изучения данных использовались средние результаты, стандартное отклонение (SD), стандартная ошибка среднего (SEM), а также самые низкие и максимальные баллы. Нормальность оценивали и подтверждали с помощью теста Колмогорова-Смирнова. Программное обеспечение SPSS использовалось для проведения однофакторного дисперсионного анализа. Было замечено, что существует значительная разница в MPV игроков двух разных спортсменов и практикующих йогу. Кроме того, существует однозначное соответствие между MPV между игроками, участвующими в отдельных играх. Настоящие результаты показали, что значения MPV среди игроков из разных игр и практикующих йогу не зависят друг от друга и не зависят друг от друга. Значение p равно 0,011252. Результат значим при $p < 0,05$. В результате нулевая гипотеза в данном исследовании отвергается.

Вывод. Результаты исследования указывают на значительную разницу в MPV игроков двух разных спортсменов и практикующих йогу. Однако при сравнении MPV волейболистов и игроков в регби было обнаружено, что они взаимосвязаны. В заключение, MPV среди игроков из разных игр, практикующих йогу, не зависят друг от друга и не зависят друг от друга. Изменчивость MPV также наблюдалась для всех размеров выборки в исследовании.

Ключевые слова: средний объем тромбоцитов (MPV), занимающиеся йогой, волейбол, регби, спортсменки

Introduction

Hematological parameters may be important in deciding which game participants exhibit the best physical performance. Additionally, it provides information about the players' health and physical condition. Platelet size has been shown to correlate with platelet activity and appears to be a helpful biomarker for cardiovascular events both predictive and prognostic. There are many ways that platelets contribute to atherosclerosis, including sticking to injured endothelium and releasing their granules. Regular physical activity has been found to benefit physical, physiological, and other health outcomes. Scientific research indicates that the acute and chronic impacts of frequent exercise on a variety of physiological systems are beneficial.[1] MPV is regularly evaluated in automated hematological analysers, along with other parameters, as a sign of platelet activation and/or reactivity. As a result, it could be employed as a simple and low-cost biomarker of bodily activity in a variety of additional exercise settings.[2] Ahmadizad *et al.* discovered that anaerobic exercise resulted in a considerable rise in platelet count.

It has been observed that high-intensity interval training enhances platelet secretion by boosting epinephrine secretion. Physical activity affects platelet function both directly and indirectly. Numerous processes and cell/tissue types are thought to contribute to the observed impacts in this area. Acute exercise increases catecholamine levels, as well as shear and oxidative stress, which are all known to activate platelets. This is particularly significant because arterial blood flow and shear rate rise in direct proportion to exercise intensity.[3] Platelets are produced under controlled, stimulated conditions. The platelet count will increase during sports due to fresh platelet release from spleen arteries, bone marrow, and other platelet sources in the body. Epinephrine release causes a severe contraction of the spleen, which contains about one-third of the body's preserved platelets. This method may help to explain why platelets are increased in sports. Additionally, in the most extreme stages of platelet activation, such increases can be generated by alterations in the development of megakaryocytic components of the cytoplasm [4][5].

While physical activity has a significant effect on a variety of laboratory markers, data on medium-distance runners are unlikely to experience hematological alterations. After completing the 21.1 km marathon, the mean platelet volume rose rapidly and returned to normal within three hours. Before the run, at the end, and three hours later, blood samples were collected. For MPV (fl), the starting volume was 9.2, the post-run value was 9.5, the volume after three hours was 9.1, and the final volume after 20 hours was 9.2. The study concluded that moderate exercise increases mean platelet volume and restore it to its pre-exercise level within three hours [6]. One Aerobic and weight training session significantly improve the mean platelet volume in non-player women (They were randomly divided into three groups of 15 subjects: two experimental groups (resistance exercise group and aerobic exercise group) and one control group. The resistance training and aerobic training were conducted in one session for 60 minutes. The blood sample was obtained before and after the activity. They observed that before the resistance exercise group mean was 9.08(fl), the post-test mean was 9.18(fl), the control group's means was 10.11(fl). This research showed that Mean Platelet Volume considerably increases with resistance type of exercise.[7] Following a light intensity circuit resistance training session, the mean platelet volume of male physical education students (35 percent of a maximum repetition) is dramatically raised. The observer discovered that MPV (fl) in the Exercise group was 9.44 0.25, 10.13 0.36 P0.73. Where 9.03 0.17, 9.53 0.38, and P-0.319 are the values for the Control group, respectively [8].

Kirbas et al. conduct a study in which they compare the blood platelet levels of players who participate in sports regularly over five years to those of inactive university students. Blood samples were taken and platelet, mean platelet volume, platelet crit, and platelet distribution width were assessed for players and sedentary university students, respectively. This study included 18 willing male players from various team sports with an average age of 20.550.70 years and 18 sedentary university students with an average age of 20.880.75 years as subjects. To determine the difference between the two groups, an independent samples 't-test was performed (P0.05) [9] During an exercise stress test, Yilmaz et al. examined MPV. The mean MPV levels before and after treadmill activity were 8.520.63 and 8.450.58, respectively, in the control and experimental groups, respectively (P0.001). Before TMET, the patient group exhibited a substantial increase in MPV (P0.001), while the control group showed no significant increase in this parameter.[10]. Erdemir *et.al* conducted a study to analyze the hematologic parameters of high school students who exercised in the morning and evening. Twelve healthy, untrained male students, around the age of twenty, volunteered to participate in this study.

Blood samples were collected before and following submaximal activity in the morning between 8-9 a.m., whereas blood samples were

collected before and following evening exercise between 8-9 p.m. Platelets, platelet crit, M.P.V., and P.D.W. were also measured and evaluated using an Archem H3000 Hematology Analyzer. It was revealed that there was a substantial increase in PLT and MPV levels in the morning before and after exercise, as well as in the evening before and after exercise, at a significant level of P0.05. PLT levels increased much greater in the morning pre-exercise period than in the morning post-exercise period [11]. MPV is a numerical value generated by a machine that represents the average size of platelets detected in the blood. It is frequently included in blood tests as part of the complete blood count. Since the average platelet size increases when the body produces more platelets, the MPV test result can be used to infer platelet production in the bone marrow or platelet destruction problems. The usual range of platelet volumes is 9.7-12.8 fl (femtolitre), which corresponds to spheres with a diameter of 2.65 to 2.9 m. The normal range is 7.5-11.5 fl. However, the measurement must typically be considered in conjunction with various other parameters to decide what constitutes a good range for a particular subject. Additionally, research suggests that the average healthy size of platelets may vary amongst individuals from different parts of the world.[12] Hematology analysis has established that the effect of daily exercise on hematology is variable. According to the authors, these variances are due to the severity, duration, and frequency of exercise, as well as the subjects' physical and physiological conditions. Additionally, the intensity, duration, and frequency of exercise must be carefully planned to have a similarly excellent effect on blood biochemistry [13]. Monocytes and platelets were found to be more abundant in basketball players than in yoga practitioners, although red blood cells, neutrophils, eosinophils, basophils, and lymphocytes were comparable between groups [14].

Combination training has been shown to benefit physiological and haematological alterations, as well as the performance of elite basketball players [15]. Warlow and Ogston analyse 24 male colleagues and medical students between the ages of 20 and 35. All subjects were in good health for this study, but many were unfamiliar with intense activity. Before and after 15 minutes of intense activity, blood samples were taken. Using the spinning bulb approach, they discovered a highly significant increase in the venous platelet count without affecting platelet adhesion to glass [16]. In research on 15 inactive healthy male volunteers at rest or immediately following two standardized activity tests on a bicycle ergometer for 30 minutes.

The author discovered that when exercise was performed at a constant load equivalent to 50% or 70% of maximal oxygen uptake, the platelet count (x109 /l) increased significantly from rest to vigorous activity (Resting- 2185, 50% Vo2 Max- 247, 70% Vo2 Max- 2758, P0.001) [17]. Recent research examined the hematological response to acute and chronic exercise. While it is widely established that both acute and chronic exercise cause a variety of hematological alterations in humans [18]. Hematological parameters including RBCs and WBCs are associated with the physical performance of players. It is thought that an increase in the concentration of the RBCs indicates an improvement in aerobic performance [19]. In scientific studies, these reasons may explain why players' blood values are inconsistent. Research into the long-term effects of physical activity on blood parameters for a variety of age groups and populations is needed to accurately conclude the impact of regular exercise on blood parameters. Many kinds of research in the literature have focused on the acute and short-term effects of physical activity on hematologic markers [20-22]. Therefore, the purpose of the study was to find out comparative analysis of mean platelet volume among female volleyball rugby players and yoga practitioners. We hypothesized that there is no difference between the MPV of participants from the two different games and one yoga practitioners. No difference exists between the MPV of players in the two games and one yoga practitioners.

Material and Methods

To accomplish the study's purpose, the research assistant planned the entire process in terms of a study-appropriate research design.

Sample Size

Sample Selection: The population of the study is female players playing two games viz. Volleyball, Rugby and one yoga practitioners groups (conducted at the university level throughout India) with age groups ranging from 17 to 25 years in the sample. The sample size is 45, with 15 players chosen from each two game Volleyball, Rugby and one yoga practitioners group (Table 1).

Table 1

Illustrates the sample size selected for the comparative study

Physical activity	Total female players (Volleyball,Rugby) & practitioners (Yoga) = 45		
	Respondents from Volleyball	Respondents from Yoga	Respondents from Rugby
3	15	15	15

Research Design

Static Group Comparison (SGCD) was used:

1: There is no difference between the MPV of participants from the three different games.

2: No difference exists between the MPV of players in the three games.

Sample Collection

The data was taken from all subjects during the All India Inter-University Training Camps for all of the games. Regarding the sample collection, proper approvals were obtained from the individual coaches. A qualified medical technician venepuncture the blood samples from the Median Cubital Vein. The venepuncture site was first disinfected with antiseptic-soaked cotton before applying a tourniquet around the biceps area of the upper arm. Each participant received a new IV syringe, and spent syringes were disposed of, away with extreme caution

Mean Platelet Volume (MPV)

MPV is a precise assessment of their size that is determined by hematological analyzers using the volume distribution of platelets during standard blood morphology testing. MPV is between 7.5 and 12.0 fl, whilst the proportion of big platelets should be between 0.2 and 5% of the total platelet population.[23].

Analytical tools utilized in the present study:

In this study, Haematological Analyzer was utilized as a tool to measure the mean concentration of different variables of the individuals. Hematology analyzers are frequently used in clinical and research settings to count and categorize blood cells to diagnose and monitor the illness. Basic analyzers provide a complete blood count (CBC) and a differential white blood cell (WBC) count in three parts. Sophisticated analyzers determine the shape of cells and are capable of detecting tiny cell populations to diagnose uncommon blood disorders. In this study, we have used. Horiba's Yumizen H500 analyzer is capable of determining the concentrations of 27 parameters, including full WBC. It is based on cytometry and cytochemistry concepts. The following ideas are implemented using the DHSS (Double Hydrodynamic Sequential System). The incubators that come with this analyzer are used to store blood samples from patients who are being monitored by the system. It is necessary to combine a particular serum with the blood that is present in these incubators to keep the blood analyzable for the entire one-hour length of the experiment.

Statistical Analysis

Quantification of data is the process of converting quantitative data into qualitative replies to facilitate calculation. Data are presented as mean, standard deviation (SD), standard error of the mean (SEM), and lowest and maximum scores were used to examine the data in tables. Normality was assessed and confirmed using the Kolmogorov-Smirnov test. Data were analysed using a 3 (groups: volleyball, rugby and yoga) The alpha level of significance was set at $p \leq 0.05$. All data analyses were performed using the statistical package for social sciences (SPSS) software was used to do the One-Way Analysis of variance.

Results

The goal of the study was to compare hematological parameters in different types of sports. This study will give some hematological information and help us figure out how different each game player is from the rest. Figure.1 demonstrates the MPV (Fl) as a function of total number of female player participants of three different games. It can be Visualized for the figure that MPV values of female players playing yoga are remarkably higher than that of Volleyball and Rugby, whereas Volleyball and Rugby are comparable.

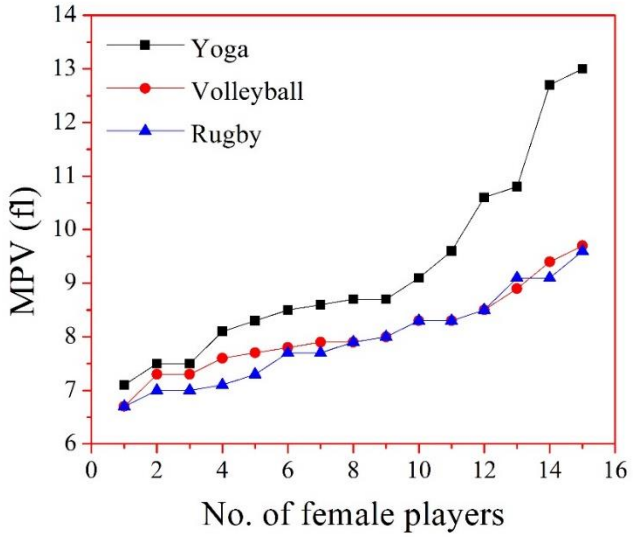

Fig. 1. Plot depicting MPV of female players for two different games and one yoga practitioners

Table 2

Descriptive statistics of MPV of female players for two different games and one yoga practitioners

Statistical Data	Yoga	Volleyball	Rugby
Mean	9.25	8.08	7.95
Standard Error	0.46	0.20	0.22
Median	8.7	7.9	7.9
Standard Deviation	1.79	0.79	0.86
Sample Variance	3.20	0.63	0.75
Kurtosis	4.17	3.96	3.04
Skewness	1.08	0.5	0.38
Range	5.9	3	2.9
Minimum	7.1	6.7	6.7
Maximum	13	9.7	9.6
Sum	138.8	121.3	119.3

Table 2. Displays the statistical parameter carried out using MPV values determined from the haematological samples obtained from the female atheletes participants of different games. It can be concluded that mean MPV value of the female yoga practitioners is the maximum as compared to the other two games i.e. volleyball and rugby.

Table.3 The mean and standard deviation of the MPV in female players participating in Yoga Volleyball and rugby are given in the table above. It presents a descriptive study of the data obtained on MPV in selected yoga practitioners, players from volleyball, and rugby. Their responses average between 7.9 and 9.2. This demonstrates their independence from one another. SD is also used to quantify variability, indicating that there is still a difference in the amount of MPV amongst players competing in different games.

Table 3

Mean and Standard Deviation (SD) of MPV in the female sports of volleyball and rugby players and yoga practitioners.

Indicators	Treatments			
	Yoga	Volleyball	Rugby	Total
N	15	15	15	45
∑X	138.8	121.3	119.3	379.4
Mean	9.2533	8.0867	7.9533	8.431
$\sum X^2$	1329.26	989.87	959.39	3278.52
Std. Dev.	1.7908	0.7999	0.8684	-

Table 4

Analysis of Variance (ANOVA) for a platelet count of female sportspersons and yoga practitioners of various categories

Source	Sum of Squares	Df	Mean Square Variance	F- Value
Between-treatments	15.3444	2	7.6722	F = 5.00269
Within-treatments	64.412	42	1.5336	
Total	79.7564	44		
The F-ratio value is 5.00269. The p-value is 0.011252. The result is significant at p < 0.05				

Table.4 summarises the findings of the statistically significant difference between the groups. The derived statistical value (5.0026) of the data collected is more than the significant level (0.05), indicating a substantial difference between and within players in terms of MPV level of the blood samples. The table demonstrates that MPV for players of two different games and one yoga practitioners is independent of one another. As a result, the null hypothesis is rejected in this study.

Table 5

Post-hoc Tukey's HSD test analysis MPV of female players among three different games

Pairwise Comparisons		$HSD_{0.05}$ = 1.0986 $HSD_{.01}$ = 1.3925	$Q_{0.05}$ = 3.43 $Q_{0.01}$ = 4.35
T_1:T_2	M_1 = 9.25 M_2 = 8.09	1.17	Q = 3.65 (p = 0.03523)
T_1:T_3	M_1 = 9.25 M_3 = 7.95	1.3	Q = 4.07 (p = 0.01703)
T_2:T_3	M_2 = 8.09 M_3 = 7.95	0.13	Q = 0.42 (p = 0.95321)

Table.5 shows the relationships within the group, such as the mean MPV of Yoga with Volleyball and rugby and the MPV of Volleyball with rugby. The statistics in the table indicates that there is a statistically significant difference between Yoga and Volleyball and between Yoga and Rugby. However, no difference in MPV was observed between Volleyball and Rugby at the indicated significance level. Because the null hypothesis is rejected in the situation of Yoga combined with Volleyball and rugby, it is accepted in the case of Volleyball and rugby.

Discussion

Nowadays, the hematological investigation of players was elucidated by routine blood morphology shed a light on players' physical fitness in terms of platelet crit (PCT), MPV, platelet count (PLT), and (PDT). In the present study, a modern hematological analyzer provides information related

to large MPV (> 15 fl) and gigantic platelets of MPV > 20 fl. The current research has depicted that parameters of platelet may have to contributes to the diagnosis of an athlete's physical conditions and can have an impact on prognostic value in some pathologies [24]. Currently, hematological studies on PLT and MPV are part of routine assessment and these are also recommendation made by by the International Committee for Standardization in Hematology (ICSH) [25]. MPV is a highly accurate and notable parameter that can be measured using haematological analyzers based on distribution of volume throughout routine blood morphology tests. MPV varies around 7.5 and 12.0 fl, while the proportion of giant platelets should be between 0.2 and 5.0 per cent [26]. In physiological conditions, the MPV is proportional to the platelet size, which is related to maintaining hemostasis and stable platelet mass [27]. This suggests that a rise in platelet production correlates with a decrease in average volume. Various disorders change this physiological proportion. Changes in PLT and MPV ratios might come from increased or atypical thrombocytopoiesis, growing wear, or the action of activating factors on blood platelets [28].

Furthermore, MPV correlates to platelet exercise and is therefore regarded as a platelet activity marker [29].

Platelets in the blood are not a relatively homogeneous group. Those with excessive MPV (>15 fl) tend to be younger and more responsive than those with average MPV. Their synthesis is related to the intense stimulation of mega karyocytes by cytokine, which also tends to enhance the ploidy of these cell lines and enable the release of larger platelets[30]. MPV could be an easy and inexpensive biomarker of the physical performance or fitness of the players. The present study portrays a comparative investigation of MPV of female athletes participating in different games viz. Yoga, Volleyball, and Rugby. The statistical analysis confirmed that the mean value of MPV of female participants of Yoga is more than that of Volleyball and Rugby. A one-way ANOVA test was carried out to find the association of fitness level of the female players participating in All-India inter-university tournaments. Keeping into consideration the data tabulated in Table.4 interprets the analysis into a narrower form so that significant relationships between and among the participants can be established. The significant value ($p = 0.011$) thus obtained from the ANOVA test corresponding to the F-statistical value (5.0026) is relatively lower than that of 0.05, which confirmed that the one or more statistical MPV data among the female player of three different games can be significant.

Consequently, the null hypothesis is rejected in this case**.** To determine the significant relationship between and among the MPV (hematological parameter) of the female players, post hoc Tukey HSD and Scheffé multiple comparison tests were implemented. Tukey's HSD test indicates that there is a statistically significant difference between Yoga and Volleyball and between Yoga and Rugby. However, no difference in MPV was observed between Volleyball and Rugby at the indicated significance level. Because the null hypothesis is rejected in the case of Yoga combined with Volleyball and Rugby, the hypothesis is accepted in the case of Volleyball and Rugby. This implies that the female players participating in Yoga exhibit enhanced MPV levels, which depicts their high fitness and physical condition.

The objective of the research was to compare haematological markers across various sports. This research will provide haematological data and help us determine how different each gamer is from the others. The analysis displays the MPV (fl) is the result of the total number of female players participating in three games. It can be seen from the graph that the MPV levels of female yoga players are much greater than those of rugby and volleyball, but volleyball and rugby have similar MPV values.

Conclusion

This study aims to determine the MPV among yoga practitioners, volleyball, and rugby players. To accomplish the study's objectives, data were gathered via questionnaires. Standard deviation and ANOVA were utilized to examine the effect of MPV on one another. ANOVA and post-Tukey's HSD were employed to determine the difference to determine the outcome following the study's objectives. The study's findings indicate a significant difference in the MPV of players from two distinct sports and yoga practitioners. However, when MPV of Volleyball and rugby players were compared, it was discovered that they were connected. In conclusion, MPV among players from different games are independent of one another and unaffected by one another. Variability in MPV was also observed across all sample sizes in the study.

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Conflict of Interest

The authors hereby declare that they don't have any financial and personal conflict of interest.

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A Wearable Biometric Performance measurement System for Boxing - A SURVEY

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J. Brindha; G. Nallavan

Abstract:
The performance measurement during the training period or competition is of major interest in the sports research domain. The requirements for an ideal sports performance measuring sensors are less costly, miniature size, and non-intrusive types. It was made possible by the recent developments in MEMS (Micro-Electro Mechanical Sensors) technology of inertial measurement units. The merging of technology with boxing during training and competition has become more common in today's sports scenario, which is a motivation for proposing this survey paper. The Inertial sensors are being used more commonly for action recognition and classification, automatic scoring of real-time bouts, head impact and performance monitoring of boxing during training and competition. For combat sports, it has become a trend to use inertial sensor technology. Totally 18 records were considered for survey to display the concept that inertial sensor measurements were primarily used for the measurement of boxing striking/hitting quality, boxing strike classification, automatic scoring of bouts, head impact, machine learning technique used, IMU placement on the body, and validation technique employed in boxing. The methods followed to select and implement the inertial sensor technology appear under-researched, and no appropriate protocols for study the results. Our survey helps in understanding of Inertial Measurement Unit (IMU) into application technology to boxing sport.
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A Study on Surface Electromyography in Sports Applications Using IoT

- N. Nithya,
- G. Nallavan &
- V. Sriabirami

- Conference paper
- First Online: 28 February 2022

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Abstract

In recent years, surface electromyography plays a vital role in monitoring muscle activities. Our every action depends on muscles, which help us to move our body, control neuromuscular system and do any sort of actions. But due to the over training of muscles, a condition called muscle fatigue occurs. Athletes use their muscles for a long term during their training. Due to over involvement, muscles may be subjected to the risk of muscle fatigue. To monitor the activities of muscles, surface EMG technique is vital. Research in this field has revealed that with the help of surface EMG methods, muscle fatigue can be monitored, detected and can prevent the injuries caused by it. This paper aims a complete study on surface EMG techniques in the evaluation of muscle fatigue that occurs during different sport activities prevent injuries, access performance in sports activities and signal processing methods involved in EMG signals. These considerations provide various advancement in measuring muscle fatigue condition of a player with the help of surface EMG method. This paper concludes with sufficient knowledge of surface EMG methods, challenges faced and the future development.

Health, sport, rehabilitation
Здоров'я, спорт, реабілітація
Здоровье, спорт, реабилитация

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ORIGINAL ARTICLES. PHYSICAL EDUCATION

Differential effects of a 12-week aerobic exercise program on health-related physical fitness, physiological and biochemical markers among obese adults: a randomized controlled trial

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript preparation; E – Funds Collection

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Abstract

Background. Work out is an valuable approach for improving standard of living physiological, biochemical, and physical strength in obese patients; though, few researches have mainly focal point on early survival rates, minorities, in physically passive men, and overweight men, or examined individual & combined workout plan and measured body composition markers.

Purpose. In this research we have describes the effect of a 12-week different aerobic exercise involvement on obese people's self-reported result, physical strength, physiological and biochemical markers in ethnically mixed, physically motionless, obese adults.

Material and methods. Total (n = 60) male adults with obese (Mean ± SD; age: 18.92 ± 1.54 yrs.; height: 172.4 ± 5.4 cm.; weight: 84.4 ± 6.3 kg) were randomly allocated into three equal (n = 20) groups: Step aerobic exercise training, floor aerobic exercise training or a control group. The step aerobic exercise training & floor aerobic exercise training protocol has been performed three days of a week during period of study (12 weeks). All the selected variables of physical fitness, physiological and biochemical markers have been examined at baseline and 12 weeks. Group under control have been found not performing workout.

Results. The exercise program step aerobic exercise training & floor aerobic exercise training group significantly improved in muscular strength, cardiovascular endurance, flexibility, muscular endurance, vital capacity, and breath holding time ($p < 0.05$). The workout schedule reduced significantly % body fat, mean resting pulse rate, respiratory rate and arterial blood pressure, ($p < 0.05$). Furthermore, the lipids levels of total triglycerides, cholesterol, and low density lipoprotein have been reduced significantly in step aerobic exercise training & floor aerobic exercise training, high density lipoprotein enhance significantly ($p < 0.05$).

Conclusion. Research's finding advocate that 12-weeks regular step aerobic exercise training & floor aerobic exercise training protocols have greater effects than control group on physical fitness of health related, physiological and biochemical variables in obese male adult individuals.

Keywords: aerobics exercise, strength, endurance, physical, exercise, lipid profile

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Анотація

Каруппасамі Говіндасамі, Чандрабабу Суреш, Ділпріт Каур, Моу Праманік, Джон Боско Аніта. Диференціальний вплив 12-тижневої програми аеробних вправ на пов'язану зі здоров'ям фізичну форму, фізіологічні та біохімічні маркери серед дорослих із ожирінням: рандомізоване контрольоване дослідження

Передумова. Тренування є цінним підходом до покращення рівня життя, фізіологічної, біохімічної та фізичної сили пацієнтів із ожирінням; однак деякі дослідження зосереджені в основному на ранньому виживанні, меншинах, у фізично пасивних чоловіків і чоловіків із надмірною вагою, або досліджували індивідуальний і комбінований план тренувань і вимірювали маркери складу тіла.

Мета. У цьому дослідженні ми описуємо вплив 12-тижневих різних аеробних вправ на самооцінку людей із ожирінням, фізичну силу, фізіологічні та біохімічні маркери у етнічно змішаних, фізично нерухомих дорослих із ожирінням.

Матеріал і методи. Загальна кількість (n = 60) дорослих чоловіків із ожирінням (середнє ± стандартне відхилення; вік: 18,92 ± 1,54 року; зріст: 172,4 ± 5,4 см; вага: 84,4 ± 6,3 кг) були випадковим чином розподілені на три рівні (n = 20) групи: тренування степ-аеробікою, тренування аеробікою на підлозі і контрольна група. Протокол тренувань з степ-аеробіки та аеробіки на підлозі виконувався три дні на тиждень протягом періоду дослідження (12 тижнів). Усі вибрані змінні фізичної підготовленості, фізіологічні та біохімічні маркери досліджувалися на початку та через 12 тижнів. Було виявлено, що група під контролем не виконує тренування.

Результати. У групі вправ із степ-аеробними вправами та аеробними вправами на підлозі значно покращилися м'язова сила, серцево-судинна витривалість, гнучкість, м'язова витривалість, життєва ємність і час затримки дихання (p <0,05). Розклад тренувань значно знизив % жиру в організмі, середню частоту пульсу в спокої, частоту дихання та артеріальний тиск (p <0,05). Крім того, рівні ліпідів, загальних тригліцеридів, холестерину та ліпопротеїнів низької щільності були значно знижені під час степ-аеробних тренувань і аеробних вправ на підлозі, ліпопротеїни високої щільності значно підвищилися (p <0,05).

Висновок. Висновки дослідження свідчать про те, що 12-тижневі регулярні степ-аеробні вправи та протоколи аеробних вправ на підлозі мають більший вплив, ніж контрольна група, на фізичну підготовленість, пов'язану зі здоров'ям, фізіологічні та біохімічні змінні у дорослих чоловіків із ожирінням.

Ключові слова: аеробні вправи, сила, витривалість, фізичні, вправи, ліпідний профіль

Аннотация

Каруппасами Говиндасами, Чандрабабу Суреш, Дилприт Каур, Моу Праманик, Джон Боско Анита. Дифференциальное влияние 12-недельной программы аэробных упражнений на связанную со здоровьем физическую форму, физиологические и биохимические маркеры среди взрослых с ожирением: рандомизированное контролируемое исследование

Предпосылки. Тренировка является ценным подходом к улучшению уровня жизни физиологических, биохимических и физических сил у пациентов с ожирением; тем не менее, несколько исследований в основном сосредоточены на ранней выживаемости, меньшинствах, физически пассивных мужчинах и мужчинах с избыточным весом, или изучали индивидуальный и комбинированный план тренировок и измеряли маркеры состава тела.

Цель. В этом исследовании мы описали влияние различных аэробных упражнений в течение 12 недель на самооценку людей с ожирением, физическую силу, физиологические и биохимические маркеры у этнически смешанных, физически неподвижных взрослых с ожирением.

Материал и методы. Всего (n = 60) взрослых мужчин с ожирением (среднее ± стандартное отклонение; возраст: 18,92 ± 1,54 года, рост: 172,4 ± 5,4 см, вес: 84,4 ± 6,3 кг) случайным образом распределили на три равные (n = 20) группы: степ-аэробика, аэробика на полу и контрольная группа. Протокол тренировок по степ-аэробике и аэробике на полу выполнялся три дня в неделю в течение периода обучения (12 недель). Все выбранные переменные физической подготовки, физиологические и биохимические маркеры были исследованы в начале исследования и через 12 недель. Было обнаружено, что подконтрольная группа не выполняет тренировку.

Результаты. Программа упражнений в группе степ-аэробики и аэробики на полу значительно улучшила мышечную силу, сердечно-сосудистую выносливость, гибкость, мышечную выносливость, жизненную емкость и время задержки дыхания (p < 0,05). График тренировок значительно снизил процент жира в организме, среднюю частоту пульса в покое, частоту дыхания и артериальное давление (p < 0,05). Кроме того, уровни липидов, общих триглицеридов, холестерина и липопротеинов низкой плотности были значительно снижены при выполнении упражнений степ-аэробики и аэробных упражнений на полу, уровень липопротеинов высокой плотности значительно увеличился (p < 0,05).

Выводы. Результаты исследования подтверждают, что 12-недельные регулярные степ-аэробные тренировки и протоколы тренировок на полу оказывают большее влияние, чем контрольная группа, на физическую форму, связанную со здоровьем, физиологические и биохимические показатели у взрослых мужчин с ожирением.

Ключевые слова: аэробные упражнения, сила, выносливость, физическая нагрузка, липидный профиль

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Introduction

Machines have changed human life, and humans now enjoy the maximum level of physical comfort [1]. Modern technology is working hard to make our lives easier, more luxurious, and more pleasant while also reducing our physical exertion [2]. As a result, humans appear to be becoming increasingly inactive all over the globe [3]. Humans now ride instead of walking, sit instead of standing, and watch instead of participating, and these lifestyle changes have definitely reduced physical labour while increasing mental stress and strain [4]. As a result, it is critical to effect good changes in today's lifestyles through involvement in sports and physical education programmes [5]. The development of physical fitness among the public or participants should be one of the major goals of every physical education and sports programme [6]. Physical education should try to make every child physically, cognitively, and emotionally healthy, as well as to develop personal and social traits in him, allowing him to live happily with others and develop as a good citizen [7]. As a result, an individual's physical fitness can be improved through a variety of programmes or activities [8].

Both industrialised and developing nations are seeing a rise in obesity [9]. Obesity is a life-threatening condition caused by a sedentary lifestyle [10]. Obesity and overweight impact millions of people in both developing and developed, countries [11]. Obesity was once thought to be a developed-world issue. Obesity, on the other hand, is on the rise in both developed and developing countries today. Obesity and overweight contribute the most to non communicable disease morbidity and mortality [12]. In 2008, Over 1.4 billion persons worldwide, with more than half of them obese, were considered by the World Health Organization to be overweight. [13]. As per the survey conducted by the NHHES (National Health and Nutrition Examination Survey) obesity prevalence was 33.4 percent among adults in urban areas and 39.6 percent among rural residents between 2005 and 2008. [14].

In a recent ICMR-INDIAB study conducted in three Indian states, the prevalence of generalised obese people increased from 11.8 percent to 33.6 percent among participants: Jharkhand, Tamil Nadu, and Maharashtra, along with Chandigarh as a UT [15]. Obesity prevalence among Indian women has increased from 10.6% to 12.6 percent, as per comparison among two main surveys have been conducted by the National Family Health Survey (NFHS-2) in 1998–1999 and NFHS-3 in 2005–2006 respectively [16].

The Chennai Urban Rural Epidemiology research found that the occurrence of generalised fatness was 45.9% when measured according to age [17].

Anaerobic exercise, which includes and short-distance running and strength training can be compared with aerobic exercise and fitness. The intensity and duration of muscular contractions, and how within muscles energy has been created, differ between the two types of exercise [18]. New research on how contracting muscles affect hormones has identified that both anaerobic and aerobic exercise have the same effect [19] promote the secretion of myokines, which has a variety of benefits including new tissue growth, tissue repair, and anti-inflammatory functions, lowering the risk of developing inflammatory diseases [20].

The quantity of muscle contracted, as well as the duration and severity of contractions, all influence myokine secretion. Count is used in floor aerobics. Floor aerobics was created to eliminate the need for open-air exercise. Day by day, the women took advantage of the opportunities that were presented to them [21]. Many gyms and fitness facilities with a group workout programme offer step aerobics programmes. Gin Miller came up with the concept of step aerobics in 1989. Gin hurt her knee and went to see an orthopaedic doctor. The doctor told her to build up the muscles that support the knee by having stepped down and up on a milk crate. Gin did this and then came up with step aerobics [22]. Therefore, we examined the presents study aims to analyze the effects of 12 weeks SAET & FAET improvement on physical, physiological, and biochemical, among obese adults men only.

Materials and Methods

Participants Recruitment

Sixty (60) obese male adults were recruited from the host institute. The participants came from various family backgrounds and took part in similar academic activities. The participants were selected at random. They were in the age group of 18.92 ± 1.54 yrs.

Obesity

The following formula was used to calculate the obesity based on their BMI: Metric: BMI = kilograms/meters2. Males with a BMI of ≥ 25 kg/m2 higher are considered according to South Asian country BMI guidelines followed by obese for the purposes of this study.

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Experimental Design

The participants were classified into three groups at random, twenty participants within each group consisted. With 20 participants in each group, all participants were divided into three groups at random: step aerobics exercise training, floor aerobics exercise training and control group. step aerobics exercise training and floor aerobics exercise training group were intervened with respective exercises for twelve weeks whereas control group does not perform any exercise. One day of pre-testing, 12 weeks of training, and one day of post-testing were included in the study design. 12 weeks training intervention pre- and post-testing sessions were separated by three days to prevent any negative impacts from the testing or training. Physical physiological and biochemical markers were compared at baseline and at endpoint in all groups.

All individuals fasted for longer than 8 hours on the days before and after the tests, and venous blood was drawn between 7 am and 9 am in the morning following stabilisation. vital capacity, mean arterial blood pressure,

The after 45 minutes break physiological parameters such as; resting heart rate, respiratory rate, breath holding time were ordered in the morning and measured, 3 hours following lunch the health related physical fitness such; cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, body composition were measured. Prior to the study's administration, the participants were informed of the needs for the experimentation, testing, and exercise programme in order to ensure their full participation with the required effort. Except on Saturdays and Sundays, the subjects finished their training three days a week from 6.30 to 7.30 a.m. The exercises were introduced gradually (Table 1 & 2). Methods that ranged from easy to hard were used. This study was done in line with the Declaration of Helsinki, and the regimen was fully approved by the regional institutional committee on ethics of the SRMCHRC, Kattankulathur, Tamilnadu, India (Number 8484/ IEC/2022) before the measurements began.

Table 1

Training intervention step aerobic exercise training programme for 12 weeks

Week	Exercise Training	Duration of Exercise (min)	Intensity of training (%)	Set & Repetition (times)	Frequency (days/weeks)	Rest Between Exercise	Rest Between Set
1 to 3 Weeks	Warm-up	10 min	65 to 70%	4 times & 60 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
4 to 6 Weeks	Warm-up	10 min	65 to 70%	4 times & 120 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
7 to 9 Weeks	Warm-up	10 min	65 to 70%	4 times & 180 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
10-12 Weeks	Warm-up	10 min	65 to 70%	4 times & 240 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					

Table 2

Training intervention floor aerobic exercise training programme for 12 weeks

Week	Exercise Training	Duration of Exercise (min)	Intensity of training (%)	Set & Repetition (times)	Frequency (days/weeks)	Rest Between Exercise	Rest Between Set
1 to 3 Weeks	Warm-up	10 min	65 to 70%	4 times & 60 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
4 to 6 Weeks	Warm-up	10 min	65 to 70%	4 times & 120 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
7 to 9 Weeks	Warm-up	10 min	65 to 70%	4 times & 180 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					
10-12 Weeks	Warm-up	10 min	65 to 70%	4 times & 240 times	3 days	30 sec	10 sec
	Main Exercise	40 min					
	Cool-down	10 min					

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Anthropometry Characteristics

On an electronic scale, respondents have been weighed to the closest to 0.01 kg whereas wearing slight clothing and lacking of shoes. The height has been observed to the closest 0.1 cm with use of height measuring scale Stadiometer (Seca, Hamburg, Germany) following previously reported standard protocols [23]. The formula for calculating BMI (body mass index) is body mass (kg)/height2 (m).

Cardiovascular Endurance (Cooper's 12-Minute Run)

During the 12-minute test session, participants were told to finish as a lot of laps as feasible on track (outdoor). Pacing oneself throughout the measurement has been emphasized. During the 12-minute test session, the administrator tallied the laps done while announcing the elapsed time at 3, 6, and 9 minutes and vocally encouraging the individuals. After the 12-minute session, the test officer commanded the participants to "stop" and then utilized as a wheel of measuring to calculate the percentage of the final lap accomplished by every subject. This distance has been got to add to the distance based on the frequency of completed laps to establish the overall distance travelled throughout the test. The distance ran was then converted to an estimate of VO2max (ml•kg-1•min-1) using Cooper's (4) standard equation: VO2max (ml•kg-1•min-1) = (22.351 x distance covered in km) - 11.288 [24-26].

Muscular Strength

The student should be lying on their back on the mat, hands under shoulders, fingers extended, and legs straight, tucked under and slightly apart. The mat pushed off by the student until their arms are straight while keeping their legs straight and back. Body lowers by students until their forearms are parallel with the floor and elbows of the students are at angle of 90 degree. Instructions have been passed to students to perform as many 90º push-ups as they could while following a certain rhythm denoted by the letters "down" and "up."

When a student committed a second fault, such as their own knees collapsing to the ground, their or lower and upper back shaking, their arms not completely outstretched, or their elbows without twisting to 90 degrees, they were stopped. Their score was the number of correct 90-degree push-ups they accomplished [27].

Muscular Endurance

Muscular endurance has been examined through the sit-up test (BS-SU, In body, Seoul, Republic of Korea) [28,29]. Before measuring physical endurance, we had participants perform the following: Lay on the mat with their heads and backs up. Position of their knees at a 45° angle and create a fist-sized space amid them. Complete sit-ups for 60 seconds whereas holding your hands behind your head. It has been observed that the two elbows always make one contact with the knees before shifting back to their initial positions. The element of physical stamina assessment was the frequency of repeats per 30 seconds. To help individuals comprehend the method, we allowed them to practice two to three times with the assistance of helpers and communicated the repetitions during the assessment.

Flexibility

The sit, as well as reach test was conducted following detailed instructions. Sitting whereas attempt to extend forward as far as probable while a knee holding straight, the flexibility of the lower body was evaluated. Sit and reach boxes measured the hand's reach in centimetres [30].

Body Composition

The subjects' stature was measured using a bioelectric resistance analyzer (InBody 770) and Cm and km were calculated using a scale of height-weight (BSM 330) by In body (Republic of Korea, Seoul) [31]. Respondents' body mass indexes were determined by dividing their kilogramme weights by their metre heights. Subjects were classified (BMI 23)as an average weight while (BMI 25), overweight or obese (BMI 25) based on predetermined BMI cut-offs [31]. BMI (Body mass index) of 25 kg/m2 was utilized to define obesity in the Asia-Pacific WHO recommendations [31].

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In order to get an accurate reading of body composition, test subjects had to wear loose-fitting clothes (exercise wear) and stand with their feet flat on the floor. While standing with your feet and hands behind your back, open the gap between your arms. When the equipment scans the body, measurements are taken while the body remains stationary [31]. For precise assessment, we requested that the participants wear the most straightforward clothing possible, take out any substances adhered to their bodies, and measured one hour after defecating.

Vital capacity

Utilizing the CSMI Spirometrics device, the respiratory parameters were measured. The subjects sat in a relaxed stance on a chair. They were instructed to inhale the mouthpiece of the spirometer thoroughly, and their noses were fitted with prongs to prevent air leakage. Three measurements were taken at the five-minute interval, and the highest score was recorded. This is the enormous volume of air exhaled during a forceful, quick, and profound expiration [32] forced vital capacity was reported in litres.

Resting Heart Rate

The measurements of resting heart rate or pulse (the frequency of heartbeats per minute) were obtained a few minutes after awakening while still laying in bed and were the frequency of heartbeats per minute. Before taking the subject's pulse, allow some time for the body to acclimate to the transition from sleeping (2-5 minutes). Before measuring a subject, they may be instructed to lie down for at least 10 minutes. After 10 minutes of supine relaxation, the resting heart rate was determined (Polar T31, Kempele, Finland) [33].

Mean Arterial Blood Pressure

Before performing a manual or automated mean arterial blood pressure assessment, ensure that the subject has either been comfortably lying on a bed or sitting on a chair with a backrest, position of feet on the floor and uncrossed legs, relaxed, not talking and should have been in position for a minimum of five minutes [34].

Breath Holding Time

The participant exhales completely, inhales deeply, and then holds his breath for as long as possible. As a reference for respiratory rates, manual counts were utilized. A single, trained medical staff member was assigned to manually observe and count respiration rates to maintain continuity and eliminate variances. For each individual, simultaneous electronic and manual records were initiated. At 60 seconds, when manual records were made, respiration rates were computed based on the electronic data. The benchmarks were then utilized for comparative analysis. Hospital professionals on case report forms recorded all manual counting and diagnoses.

Blood biochemistry

Sitting for 20 minutes following a fast of 12-hour overnight, blood has been taken from an antecubital vein between 7:00 and 9:00 a.m. at Week 0 and Week 12 for analysis. The sample size was 15 mL. To conduct a hematological analysis, blood has been transmitted immediately into tubes of Vacationer (Becton Dickinson, Rutherford, NJ, USA) contain or not contain 0.1% EDTA as an anticoagulant. Serum and plasma are separated using a centrifuge at 2500 rpm for 15 minutes at four °C, and the separated components are accumulated at 80 °C until assessment. Fasting glucose, total triglyceride levels, triglyceride, high-density lipid , and low-density lipid, have been examined with use of an automated biochemical analyzer [35].

Statistical Analysis

Means and standard deviations (±) were used to describe all the data, and the Kolmogorov-Smirnov and Shapiro-Wilk tests were used to see if the data were normal. To make sure there wasn't a big difference between the groups. Used intra class correlations (ICCs), test and retest accuracy for all tests was analysed. The effects of exercise were also looked at with a two-way analysis of variance (ANOVA) and repeated measurements (three groups, twice). If group by time connections were discovered to be important, Bonferroni post-hoc tests were done [36]. The statistical test was set to be significant if p0.05. [37].

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Results

There were no significant differences ($p > 0.05$) in any of the study groups (i.e., step aerobics exercise training, floor aerobics exercise training, and control) for age, weight, height, Body Mass Index, cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, body composition, vital capacity, mean arterial blood pressure, resting heart rate, respiratory rate, breath holding time, total cholesterol, triglyceride, high density lipoprotein and low density lipoprotein (Table 3). The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to evaluate whether the data were normal (Table 4).

Health Related Physical fitness

The main influences of time on some outcomes have been found to be CRE F value: 27.37; $p<0.001$ value, η_p^2 value: 0.32, and power value: 0.99; MS F value: 31.27; $p<0.001$ value, η_p^2 value: 0.35, and power value: 0.99; ME F value: 56.35; $p<0.001$ value, η_p^2 value: 0.49, and power value: 0.99); Flex F value: 1.40; $p<0.001$ value, η_p^2 value: 0.71, and power value: 0.99; BC F value: 35.95; $p<0.001$ value, η_p^2 value 0.38; power value: 0.99. Significant group (three) and time (2 pre & post) interactions were seen for CRE F value: 2.67; $p=0.078$ value, η_p^2 value: 0.086, and power=0.51; MS F value: 0.67; $p=0.515$ value, η_p^2 value: 0.23, and power value: 0.15; ME F value: 6.90; $p<0.002$ value, η_p^2 value: 0.19, and power value: 0.99, Flex F value: 11.82; $p<0.001$ value, η_p^2 value: 0.29, and power value: 0.99, BC F value: 2.06; $p=0.136$ value, η_p^2 value: 0.067, and power value: 0.40. A post-hoc analysis showed a considerable pre-to-post improved ($p<0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for cardiorespiratory endurance (η_p^2 value: 0.07; η_p^2 value: 0.20, respectively), muscular strength (η_p^2 value: 0.08; η_p^2 value: 0.15, respectively), and muscular endurance (η_p^2 value: 0.04; η_p^2 value: 0.12, respectively) compared to control group. A post-hoc analysis showed a considerable pre-to-post decreases ($p<0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for body composition (η_p^2 value: 0.04; η_p^2 value: 0.14, respectively) compared to control group. Participants engaged in step aerobics aerobic training and floor aerobics aerobic fitness showed no significant improvement in any of the training protocols tested in terms of cardiovascular endurance, muscular endurance, muscular strength flexibility, or body composition, while the control group showed no significant improvement in any of the training protocols tested (Table 5).

Table 3

Mean and SD (±) Characteristics of Participants

Characteristics	SAET	FAET	Control
Age (years)	18.65 ± 1.13	19.15 ± 1.98	18.95 ± 1.43
Height (cm)	170.7 ± 4.52	171.9 ± 4.78	174.7 ± 6.44
Weight (kg)	87.25 ± 4.60	88.80 ± 6.59	92.20 ± 6.96
BMI (kg/m^2)	29.94 ± 1.31	30.00 ± 1.22	30.18 ± 1.25

Notes: SAET - step aerobic exercise training; FAET - floor aerobic exercise training, BMI - Body Mass Index

Physiological variables

The main influences of time on some outcomes have been found to be VC F value: 1.84; $p<0.001$ value, η_p^2 value: 0.76, and power value: 0.99; resting heart rate F value: 91.30; $p<0.001$ value, η_p^2 value: 0.61, and power value: 0.99; mean arterial blood pressure F value: 0.01; $p=0.982$ value, η_p^2 value: 0.88, and power value: 0.50; breath holding time F value: 73.55; $p<0.001$ value, η_p^2 value: 0.56, and power value: 0.99; respiratory rate F value: 21.51; $p<0.001$ value, η_p^2 value: 0.27, and power value: 0.99. Significant group (three) and time interactions (2 pre & post) were seen for vital capacity F value: 18.33; $p<0.001$ value, η_p^2 value: 0.39, and power value: 0.51, resting heart rate F value: 9.60; $p<0.001$ value, η_p^2 value: 0.25, and power value: 0.97; mean arterial blood pressure F value: 1.87; $p=0.163$ value, η_p^2 value: 0.19, and power value: 0.62); breath holding time F value: 4.90; $p<0.011$ value, η_p^2 value: 0.14, and power value: 0.78, respiratory rate F value: 4.58; $p=0.014$ value, η_p^2 value: 0.139, and power value: 0.75.

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A post-hoc analysis showed a considerable pre-to-post decreases ($p<0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for resting heart rate (η_p^2 value: 0.08; $\eta_{p_2}^2$ value: 0.16, respectively), and respiratory rate ($\eta_{p_2}^2$ value: 0.07; η_p^2 value: 0.18, respectively) compared to control group. A post-hoc analysis showed a considerable pre-to-post improved ($p<0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for breath holding time (η_p^2 value: 0.04; η_p^2 value: 0.11, respectively) compared to control group. Neither training protocols showed significant improvement in was observed in terms of vital capacity, and breath holding time, decreases resting heart rate, mean arterial blood pressure and respiratory rate, in participants performing step aerobics exercise training and floor aerobics exercise training whereas no significant improvement was observed in control group (Table 6).

Table 4

Normality Test Calculation

Variables	Group	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
CRE (ml/kg/min)	CG SAET FAET	0.092	60	0.200	0.986	60	0.733
MS (numbers)	CG SAET FAET	0.111	60	0.063	0.971	60	0.163
ME (numbers)	CG SAET FAET	0.109	60	0.072	0.974	60	0.240
F (cm)	CG SAET FAET	0.108	60	0.076	0.972	60	0.178
BC (%)	CG SAET FAET	0.102	60	0.191	0.968	60	0.114
VC (mL)	CG SAET FAET	0.101	60	0.200	0.978	60	0.351
MABP (mmHg)	CG SAET FAET	0.101	60	0.200	0.969	60	0.127
RHR (bpm)	CG SAET FAET	0.098	60	0.200	0.964	60	0.072
RR (numbers)	CG SAET FAET	0.107	60	0.085	0.965	60	0.085
BHT (s)	CG SAET FAET	0.077	60	0.200	0.968	60	0.119
TC (mg/dl)	CG SAET FAET	0.076	60	0.200	0.966	60	0.091
TG (mg/dl)	CG SAET FAET	0.075	60	0.200	0.971	60	0.170
HDL (mg/dl)	CG SAET FAET	0.081	60	0.200	0.967	60	0.099
LDL (mg/dl)	CG SAET FAET	0.080	60	0.200	0.975	60	0.253

Notes: BMI, body mass index, CRE, cardiorespiratory endurance, MS, muscular strength, ME, muscular endurance, F, flexibility, SAET, step aerobic activity training, FAET, floor aerobic activity training, VC, vital capacity, MABP, mean arterial blood pressure, RHR, resting heart rate, RR, respiratory rate, BHT, breath holding time; Total cholesterol (TC); Triglyceride is TG; Low density lipoprotein is known as LDL, and high density lipoprotein is HDL.

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Table 5

Mean (± SD) values of health related physical fitness parameters for the 3 groups.

Variables	Group	Before	After	p (Cohen´s d)		
				Main effect group	Main effect time	Interaction group x time
CRE (ml/kg/ min)	SAETG	28.89 ± 2.13	30.95 ± 1.09 ac	0.162 (0.062)	<0.001 (0.324)	0.078 (0.086)
	FAETG	28.58 ± 0.84	30.54 ± 1.01 a			
	CG	28.97 ± 2.15	29.54 ± 1.64			
MS (numbers)	SAETG	19.10 ± 1.37	20.45 ± 1.43 a	0.401 (0.032)	<0.001 (0.354)	0.515 (0.023)
	FAETG	19.15 ± 2.18	20.90 ± 1.41 ac			
	CG	18.90 ± 1.86	19.95 ± 1.76			
ME (numbers)	SAETG	22.85 ± 2.30	25.40 ± 1.27 ac	0.797 (0.008)	<0.001 (0.497)	0.002 (0.195)
	FAETG	22.95 ± 1.82	25.00 ± 1.16 a			
	CG	23.55 ± 1.63	24.10 ± 1.51			
F (cm)	SAETG	22.85 ± 1.75	24.85 ± 1.26 ac	0.367 (0.035)	<0.001 (0.791)	<0.001 (0.412)
	FAETG	22.00 ± 2.55	24.25 ± 1.99 a			
	CG	22.80 ± 1.90	23.45 ± 1.70			
BC (%)	SAETG	39.33 ± 0.35	38.67 ± 0.60 a	0.239 (0.049)	<0.001 (0.387)	0.136 (0.067)
	FAETG	39.33 ± 0.61	38.72 ± 0.72 a			
	CG	39.33 ± 0.15	39.06 ± 0.43			

Notes: SAETG: step aerobic exercise trained group (n=20); FAETG: floor aerobic exercise trained group (n=20), CG: control group no training intervention (n=20). Different aerobics exercise programme. Before-pre test, After-post-test. Data are mean values (± SD), CRE: cardiorespiratory endurance, MS: muscular strength, ME: muscular endurance, F: flexibility, BC: body composition, a: significant variation between the training intervention before and after; c: significant interaction between: SAETG & FAETG

Table 6

Mean (± SD) values of physiological parameters for the 3 groups.

Variables	Group	Before	After	p (Cohen´s d)		
				Main effect group	Main effect time	Interaction group x time
VC (mL)	SAETG	3.07 ± 275.48	3.32 ± 228.49 ac	0.635 (0.016)	<0.001 (0.764)	<0.001 (0.391)
	FAETG	3.07 ± 233.73	3.29 ± 217.40 a			
	CG	3.07 ± 451.16	3.14 ± 425.99			
RHR (bpm)	SAETG	75.20 ± 3.73	72.40 ± 3.31 ac	0.288 (0.043)	<0.001 (0.616)	<0.001 (0.252)
	FAETG	75.25 ± 1.77	73.30 ± 2.69 a			
	CG	75.65 ± 3.01	74.90 ± 3.50			
MABP (mmHg)	SAETG	97.92 ± 2.61	96.76 ± 2.36 ac	0.712 (0.012)	<0.001 (0.982)	0.062 (0.163)
	FAETG	97.97 ± 2.59	97.87 ± 2.44 a			
	CG	97.16 ± 3.45	98.46 ± 4.57			
BHT (s)	SAETG	36.35 ± 3.03	38.40 ± 3.03 a	0.795 (0.008)	<0.001 (0.563)	0.011 (0.147)
	FAETG	36.90 ± 4.37	39.20 ± 3.86 ac			
	CG	36.95 ± 3.97	37.80 ± 3.83			
RR (numbers)	SAETG	17.00 ± 1.48	16.15 ± 1.26 a	0.444 (0.028)	<0.001 (0.274)	0.014 (0.139)
	FAETG	17.10 ± 1.11	16.15 ± 0.93 a			
	CG	17.00 ± 1.29	16.95 ± 0.94			

Notes: SAETG: step aerobic exercise trained group (n=20); FAETG: floor aerobic exercise trained group (n=20), CG: control group no training intervention (n=20). Different aerobics exercise programme. Before-pre test, After-post-test. Data are mean values (± SD), VC: vital capacity, RHR: resting heart rate, MABP: mean arterial blood pressure, BHR: breath holding time, RR: respiratory rate, SAETG: step aerobic exercise trained group FAETG: floor aerobic exercise trained group, CG: control group. a: significant variation between the training intervention before and after; c: significant interaction between: SAETG & FAETG

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Biochemical variables

The main influences of time on some outcomes have been found to be high density lipoprotein F value: 30.82; p<0.001 value: η_p^2 value: 0.35, and power value: 0.99; low density lipoprotein F value: 1.66; p<0.001 value, η_p^2 value: 0.74, and power value: 0.99; total cholesterol F value: 3.82; p=0.056 value, η_p^2 value:0.63, and power value: 0.48; triglycerides F value: 7.27; p=0.009 value, η_p^2 value: 0.11, and power value: 0.75. Significant group (three) and time interactions (2 pre & post) were seen for high density lipoprotein F value: 1.21; p=0.304 value, η_p^2 value: 0.41, and power value:0.25; low density lipoprotein F value: 25.11; p<0.001 value, η_p^2 value: 0.46, and power value: 0.99; total cholesterol F value: 3.51; p=0.036 value, η_p^2 value: 0.11, and power value: 0.63; triglycerides F value: 0.88; p=0.417 value, η_p^2 value: 0.30, and power value: 0.78. A post-hoc analysis showed a considerable pre-to-post improvement (p<0.001 value) in both step aerobic exercise training and floor aerobic exercise training for high density lipoprotein (η_p^2 value: 0.05; η_p^2 value: 0.14, respectively) compared to control group. A post-hoc analysis showed a considerable pre-to-post decreases (p<0.001 value) in both step aerobic exercise training and floor aerobic exercise training for total cholesterol (η_p^2 value: 0.09; η_p^2 value: 0.18, respectively) and triglycerides (η_p^2 value: 0.07; η_p^2 value: 0.19, respectively) compared to control group. Participants who engaged in step aerobics activity and floor aerobics aerobic training both showed no significant improvement in any of the training protocols when it came to of highly dense lipoprotein, decreased low density lipoprotein, lipid profile, and triglycerides, while no significant improvement was seen in the control group (Table 7).

Table 7.

Mean (± SD) values of biochemical parameters for the 3 groups.

Variables	Group	Before	After	p (Cohen´s d)		
				Main effect group	Main effect time	Interaction group x time
HDL (mg/dl)	SAETG	53.95 ± 3.83	55.60 ± 2.13 a	0.580 (0.019)	<0.001 (0.351)	0.304 (0.041)
	FAETG	52.60 ± 3.06	55.80 ± 2.06 a			
	CG	53.85 ± 2.96	55.95 ± 2.08			
LDL (mg/dl)	SAETG	123.78 ± 6.04	120.94 ± 5.63 a	0.898 (0.004)	<0.001 (0.745)	<0.001 (0.468)
	FAETG	123.96 ± 3.86	120.62 ± 3.51 a			
	CG	123.49 ± 9.98	122.96 ± 10.37			
TC (mg/dl)	SAETG	214.65 ± 5.19	212.70 ± 4.89 a	0.894 (0.004)	0.056 (0.063)	0.036 (0.110)
	FAETG	215.74 ± 5.93	212.85 ± 5.92 a			
	CG	214.12 ± 6.83	215.20 ± 11.57			
TG (mg/dl)	SAETG	181.52 ± 11.31	179.30 ± 10.23 a	0.793 (0.008)	0.009 (0.113)	0.417 (0.030)
	FAETG	183.88 ± 7.88	180.20 ± 10.09 a			
	CG	180.35 ± 11.79	179.42 ± 13.45			

Notes: SAETG: step aerobic exercise trained group (n=20); FAETG: floor aerobic exercise trained group (n=20), CG: control group no training intervention (n=20). Different aerobics exercise programme. Before-pre test, After-post-test. Data are mean values (± SD), HDL: high density lipoprotein, LDL: low density lipoprotein, TC: total cholesterol, TG: triglycerides, SAETG: step aerobic exercise trained group FAETG: floor aerobic exercise trained group, CG: control group.
a: significant variation between the training intervention before and after
c: significant interaction between: SAETG & FAETG

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Discussion

The main finding of the research was that different aerobic training of exercise had a variety of positive effects on physical strength, physiological, and biochemical parameters in obese men adults. After 16 weeks of randomized control trail undertaking aerobic and resistance training intervention, it was shown that on improving quality of life and physical fitness obese and overweight cancer patients [38]. These results was reliable with previous studies shows VO2 max improved [39,40] and HIIT exercise could reduce resting heart rate children with obesity [41]. Another one previous investigation it was 12 weeks isolated and combined randomized control trail undertaking aerobic, resistance and combined training shown that overweight and obese adults considerable improvement body percentage of fat and cardiorespiratory fitness [42]. While the exercise intervention 16 weeks follow up MLIP has been suggested to improve physical fitness and body composition in adolescents and obese children [31]. In the present study we found a significant improvement on selected health related physical fitness parameters of 12 weeks different types of aerobic exercise training. Importantly a reduction in body composition study reported 8 weeks HIIT aerobic exercise intervention has made improvements in the quality of life patients [43].

Our study findings agrees with previously related studies those shows decreases in blood pressure, after 12 weeks of combined training of exercise in young obese pre hypertensive men [44]. Our data indicate breath holding time and respiratory rate was significantly enhanced after 12 weeks interference in the current study. This may following another mechanism effectively improved breath holding time and respiratory rate due to neuromuscular training intervention [45].

The findings of the research have been in line of related studies suggested that aquatic exercise had a beneficial effects on forced vital capacity [46]. Komathi and Indira had previously investigated the effects of step aerobics, floor aerobics, and combination exercise on biochemical variables in female students [47]. After undertaking floor aerobics exercise for a period of twelve weeks, it was shown that women students showed considerable improvement in all of the selected biochemical variables. After participating in step aerobics for a period of twelve weeks, women students showed significant improvements in all of the selected biochemical variables. Women students in the combined training group performed better on biochemical variables than the other groups. Same outcomes have been obtained in present research in which the biochemical profile of the obese male adults was found to improve after twelve-week intervention of steps or floor aerobics.

Clary et al. looked into the effects of Ballates, walking on balance and step aerobics in women aged 50 to 75. When compared to the Ballates programme, walking programmes and step aerobics resulted in improved static balance and postural stability [48]. In our study however, similar results were obtained in case of steps aerobics and floor aerobics. Melam et al. examine the effects of aerobics and brisk walking on overweight people. For ten weeks, this programme was carried out five days a week [49]. Body mass index, hip and waist circumference, as well as the thickness of the skinfolds in the abdomen, subscapular region, biceps, and triceps, were all measured on the women throughout all three categories before and after the experiment. All of the values fell in women who did 10 weeks of brisk walking and aerobics. In present study also, the body composition was found to be improved significantly among adult obese male after twelve weeks of aerobic exercises. Maiyanga and Gunen investigated the effect of step aerobics on % body fat and visceral fat in obese female nurses in Bauchi's speciality hospital and discovered that step aerobics reduces percentage body fat [50].

Strengths and limitation of research

The outcome of the study being pilot in nature, present study has several limitations that should be considered on which future studies could be carried out. Main limitations of the research are that we take only the male respondent. Obesity is also prevalent in females and therefore future studies could be conducted by taking the female participants. Other limitation of the study is that present study is focused specific age group, future studies could be conducted by taking all age group. This will help in validating the result of current study for all age groups. Another limitation of the present study is the sample size itself. Because the small sample size of the research cannot be validated for general population. Moreover, present study is a single centric study; future study by taking the multicentric approach should be conducted to find the role of aerobic exercise in management of obesity among adults.

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Conclusion

Exercise, 12 weeks of step aerobic exercise training and floor aerobic exercise training improved health-related physical fitness, physiological, and biochemical parameters in obese male adults. These findings suggest that participating in an step aerobic exercise training and floor aerobic exercise training intervention on a regular basis can considerably improve the quality of their life in obese adults. More complex studies (e.g., different combinations of intensity, volume, and resistance-based aerobic exercise for adults) are required to determine the effect of a combined aerobic exercise intervention on body composition, physical and psychological health in obese adult individuals.

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Conflict of Interest

The authors declare no conflict of interest.

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The effect of 12-week step and floor aerobic exercise programs on physical and psychophysiological health parameters in obese men

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Wpływ 12-tygodniowych programów ćwiczeń aerobowych na fizyczne i psychofizjologiczne parametry zdrowotne otyłych mężczyzn

Streszczenie

Ćwiczenia aerobowe zalecane są w celu zapobiegania i kontrolowania nadwagi i otyłości. Niniejsze badanie miało na celu ocenę skuteczności dwóch 12-tygodniowych programów ćwiczeń aerobowych w poprawie stanu zdrowia fizycznego i psychofizjologicznego otyłych mężczyzn. Sześćdziesięciu dorosłych mężczyzn w średnim wieku 18,92 (SD 1,54 lat) i wskaźniku masy ciała (BMI) ≥ 30 kg/m^2 zostało losowo przydzielonych do trzech równych (n = 20) grup: trening aerobowy z wykorzystaniem stepów (SAET), trening aerobowy bez stepów (FAET) lub grupa kontrolna (która nie podejmowała aktywności fizycznej). Procedury treningowe SAET i FAET wykonywano trzy dni w tygodniu przez 12 tygodni. Wybrane parametry zdrowotne (fizyczne i psychofizjologiczne) oceniono na początku badania i po 12 tygodniach. Stwierdzono istotne różnice w zakresie parametrów zdrowia fizycznego i psychofizjologicznego u uczestników, którzy przeszli trening SAET i FAET w porównaniu z grupą kontrolną ($p < 0,05$). SAET i FAET okazały się pomocne w poprawie zdrowia fizycznego i psychicznego otyłych mężczyzn. Aby uzyskać lepsze perspektywy zdrowotne, szkoły i uczelnie wyższe powinny organizować sesje ćwiczeń aerobowych dla dorosłych.

Słowa kluczowe: aerobik, siła, wytrzymałość, ćwiczenia fizyczne, cholesterol.

Abstract

Aerobic exercise training is recommended to prevent and control obesity. The present study aimed to evaluate the effectiveness of a twelve-week step aerobics or floor aerobics exercise program in improving the physical and psychophysiological health of obese men. Sixty male adults of mean age 18.92 (SD 1.54 years) and Body Mass Index (BMI) ≥ 30 kg/m^2 were randomly allocated into three equal (n = 20) groups: Step Aerobics Exercise Training (SAET), Floor Aerobic Exercise Training (FAET), and a control group (which did not perform any exercise). The SAET and FAET training protocols were performed three days per week for 12 weeks. Health-related physical fitness, biochemical, physiological, and psychological variables were used as outcome measures and measured at baseline and at 12 weeks. There were significant differences in terms of physical and psychophysiological health parameters in participants who underwent SAET and FAET training compared with the control group ($p < 0.05$). SAET and FAET proved to be helpful in managing the physical and psychological health of obese adults. Schools and colleges should administer aerobic exercise sessions to adults for better health perspectives.

Keywords: aerobics, strength, endurance, physical exercise, cholesterol.

Introduction

Obesity is a chronic disease affecting food habits, exercise levels, and sleep schedules. Genetics, social factors of health, and the use of specific medications, all of them have an impact on body fat. Machines have changed human life and humans now enjoy a maximum level of physical comfort. Modern technology is

working hard to make our lives easier, more luxurious, and more pleasant while also reducing physical exertion. Consequently, humans are becoming increasingly inactive globally. People now ride instead of walking, sit instead of standing, and watch instead of participating. These lifestyle changes have reduced physical labor and increased mental stress and strain. As a result, it is critical to affect positive changes in today's lifestyles through involvement in sports and physical education programs. The development of physical fitness among the public or participants should be one of the major goals of every physical education and sports program. Physical education should try to make all child physically, cognitively, and emotionally healthy, as well as develop personal and social traits in them, allowing them to live happily with others and develop as good citizens. Consequently, an individual's physical fitness can be improved through a variety of programs or activities [7].

Obesity was once considered a developed world issue; nevertheless, its incidence is increasing in both developed and developing countries. It is a life-threatening condition caused by a sedentary lifestyle that affects millions of people in both developed and developing countries. Both obesity and overweight contribute the most to non-communicable disease morbidity and mortality [14]. In 2008, the World Health Organization estimated that over 1.4 billion adults were overweight, with more than half of them being obese [15]. According to the National Health and Nutrition Examination Survey, the prevalence of obesity was 39.6 percent among rural people in 2005–2008, compared to 33.4 percent among urban adults [1]. The prevalence of generalized obesity ranged from 11.8 percent to 33.6 percent among people in a recent ICMR-INDIAB study conducted in three Indian states: Tamil Nadu, Maharashtra, and Jharkhand, as well as in one Union Territory, Chandigarh [13]. The prevalence of obesity among Indian women has increased from 10.6% to 12.6 percent, according to a comparison of two major surveys conducted by the National Family Health Survey (NFHS-2) in 1998–1999 and NFHS-3 in 2005–2006 [5]. According to the Chennai Urban Rural Epidemiology Study, the age-standardized prevalence of generalized obesity is 45.9% [3].

Anaerobic exercise, which includes strength training and short-distance running, can be compared to aerobic exercise and fitness. The duration and intensity of muscular contractions as well as how energy is created within the muscle differ between the two types of exercise. Recent research on the endocrine functions of contracting muscles has found that both aerobic and anaerobic exercise promote the secretion of myokines, which has a variety of benefits, including new tissue growth, tissue repair, and anti-inflammatory functions, lowering the risk of developing inflammatory diseases. The quantity of muscle contraction, as well as the duration and severity of contractions, all influence myokine secretion. Count is used in floor aerobics. Floor aerobics was created to

eliminate the need for open-air exercise. Women took advantage of the opportunities presented to them daily. Many gyms and fitness facilities with a group workout program offer step-aerobic programs. Gin Miller introduced the concept of step aerobics in 1989. Gin visited an orthopaedic doctor after suffering a knee injury, who advised her to strengthen the muscles supporting the knee by stepping up and down on a milk crate, which she did, and from which she devised step aerobics [8]. The present study aimed to analyze the changes in physical and psychological health among obese adults after participating in 12 weeks of step-aerobic or floor-aerobic exercise protocols.

Methods

Participants and Study Design

Sixty obese male adults were recruited from the SRM Institute of Science and Technology (Kattankulathur, Tamil Nadu, India). The participants were randomly selected from various family backgrounds and participated in similar academic activities. The age range of the patients was 18–24 years. The following inclusion criteria were met by each participant for them to be part of this study: age of 18–24 years old, healthy sedentary obese men with a Body Mass Index (BMI) of ≥ 30 kg/m^2, and each participant had a sedentary lifestyle (less than 1 h of physical activity per week during the last year). The exclusion criteria were being female, having a BMI of less than 25–30 kg/m^2, undergoing any prior open surgery during the previous 8 months, having cardiovascular disease, and both the lower and upper extremities amputated. All the participants read and signed an informed consent form. Before the measurements started, the *SRM* Medical College Hospital and Research Centre (SRM CHRC, Kattankulathur, Tamil Nadu, India, Number 8484/IEC/2022) evaluated and approved the study procedures. The most recent revision of the Declaration of Helsinki was followed for all procedures.

Males with a BMI of 30 kg/m^2 or higher were considered obese for the purposes of this study. All participants were randomly divided into three groups, with 20 participants in each group: step aerobics exercise training (SAET), floor aerobics exercise training (FAET), and control group (CG). The aerobic and floor aerobic groups were subjected to respective exercises for 12 weeks, whereas the control group did not perform any exercise. Physical and psychological health were compared at baseline and endpoint in all groups. The requirements of the experimental procedures, testing, and exercise schedule were explained to the participants prior to the administration of the study to obtain full cooperation in the effort required on their part. The subjects completed training three

days a week, except for Saturdays and Sundays, from 6.30 to 7.30 a.m. The exercises were gradually introduced. A simple to complex procedure was used.

Outcome Measures

Health Related Physical Fitness Measures

Following a review of the literature and consultation with professionals and experts, the following variables were chosen as criteria for this study: cardiovascular endurance (CRE) was measured using Cooper's 12 Minute Run / Walk test [20]. Muscular flexibility (F) was measured through Sit and Reach test [21]. Muscular Strength (MS) was measured using push-ups [11]. Muscular Endurance (ME) was measured using the half-squat jump test [23]. Body Composition (BC) was calculated based on the following formula: percent body fat = 0.41563 x (sum of three sites) - 0.00112 x (sum of three sites) 2 + 0.36661 x (age) + 4.03653, where the sum of the three sites were skinfold caliber measures at the triceps, medial region of the navel part, and suprailium [22].

Physiological Measures

The vital capacity (VC) was measured using a Spirometer [6]. Resting Heart (RHR) rate was measured using a digital heart rate measuring machine (Model No. EW 243, National Company, Japan) [16]. Mean arterial blood pressure (MABP) was measured using systolic and diastolic blood pressure, as suggested by Mathews and Fox [4]. Breath-holding (BH) time was measured using a nose clip and a stopwatch, as suggested by Mathew [10]. Respiratory Rate (RR) was measured using a bio-monitor, as suggested by Saroja [19].

Biochemical Measures

To conduct a hematological analysis, blood was immediately transferred into tubes of Vacationer (Becton Dickinson, Rutherford, NJ, USA) with or without 0.1% EDTA as an anticoagulant. Serum and plasma were separated by centrifugation at 2500 rpm for 15 minutes at four °C, and the separated components were stored at 80°C until assessment. After sitting for 20 minutes, following a fast of 12-hour overnight, blood was taken from an antecubital vein between 7:00 and 9:00 a.m. at Week 0 and Week 12 for analysis. The sample size was 15 ml. Fasting glucose, total triglyceride levels (TG), total cholesterol (TC), high-density lipids (HDL), and low-density lipids (LDL) were examined using an automated biochemical analyzer and measured using standard laboratory methods [17].

Psychological Measures

Self-confidence (SC) scale used in the current study was to rate self-confidence levels within the selected sample using a 5-point Likert scale ranging from totally disagree (1) to totally agree (5), Emotional Adjustment (EA) was quantified using a 5-point Likert scale ranging from totally disagree (1) to totally agree (5). Assertiveness (A) 19-item scale version demonstrated good psychometric characteristic regarding reliability. Interpersonal Relationship (IR) 5-point scale ranged from "strongly agree" to "strongly disagree," and Stress Management (SM) was measured using Personality Development Index Questionnaire developed by Kaliappan [9].

Interventions

The investigator constructed a 12-week training schedule for FAET and SAET, with much focus on the progression of the training load. The FAET group was allotted to Experimental group I, SAET was allotted to Experimental group II, and another group called the control group was allotted no training except for their regular activities. The training period for the experimental groups was restricted to 12 weeks, thrice a week. The duration of each training session was 60 min, which included warm-up and cool-down. The investigator personally supervised and ensured the appropriate execution of training, along with assistance from a trained expert. The Floor Aerobic Exercise Training group performed for 60 minutes per session, 3 times per week for 12 weeks. Each session started with a 10-minute warm-up exercise for weeks 1–4 (32 counts, 8 sets), weeks 5–8 (32 counts, 10 sets), and weeks 9 – 12 (32 counts, 12 sets). The aerobic exercise training group performed for 60 min per session, 3 times per week for 12 weeks. For weeks 1- 4 (32 counts, 4 sets), weeks 5–8 (32 counts, 10 sets), and weeks 9 – 12 (32 counts, 12 sets), at the end of each training session, a 10-minute cool-down exercise was given.

Data analysis

Means and standard deviations (±) were used to describe all data, and Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine if the data were normal. We ensured that there was no significant difference between the groups. The intraclass correlations (ICCs) and test and retest accuracies for all tests were analyzed. The effects of exercise were also examined using a two-way analysis of variance (ANOVA) and repeated measurements (three groups, twice). If group-by-time connections were found to be important, Bonferroni post-hoc tests were performed. Statistical significance was set at $p<0.05$.

Results

There were no significant differences ($p > 0.05$) in any baseline parameters between groups (Table 1).

Table 1. Participant characteristics (mean ± SD)

Characteristics	SAET	FAET	CG
Age (years)	18.41 ± 1.61	18.72 ± 1.92	18.89 ± 1.40
Height (cm)	170.5 ± 4.51	172.8 ± 4.69	173.4 ± 5.19
Weight (kg)	88.26 ± 4.30	88.60 ± 5.49	90.20 ± 6.10
BMI (kg/m^2)	30.10 ± 1.11	30.00 ± 1.30	30.20 ± 1.41

SD: Standard Deviation; BMI: Body Mass Index; SAET: Step Aerobics Exercise Training; FAET: Floor Aerobic Exercise Training; CG: Control Group.

Health Related Physical fitness

The main influence of time on some outcomes has been found to be CRE ($F = 27.37$, $\eta p^2 = 0.32$, power value: 0.99, $p < 0.001$), MS ($F = 31.27$, $\eta p^2 = 0.35$, power value: 0.99, $p < 0.001$), ME ($F = 56.35$, $\eta p^2 = 0.49$, power value: 0.99, $p < 0.001$), Flex ($F = 1.40$, $\eta p^2 = 0.71$, power value: 0.99, $p < 0.001$), and BC ($F = 35.95$, $\eta p^2 = 0.38$, power value: 0.99, $p < 0.001$). Significant group (three) and time (pre and post) interactions were seen for CRE ($F = 2.67$, $\eta p^2 = 0.09$, power = 0.51, $p = 0.08$), MS ($F = 0.67$, $\eta p^2 = 0.23$, power value: 0.15, $p = 0.51$), ME ($F = 6.90$, $\eta p^2 = 0.19$, power value: 0.99, $p < 0.002$), Flex ($F = 11.82$, $\eta p^2 = 0.29$, power value: 0.99, $p < 0.001$), and BC ($F = 2.06$, $\eta p^2 = 0.07$, power value: 0.40, $p = 0.14$).

A post-hoc analysis showed considerable pre-to-post improvement ($p < 0.001$) in both step aerobic exercise training and floor aerobic exercise training for cardiorespiratory endurance ($\eta p^2 = 0.07$; $\eta p^2 = 0.20$, respectively), muscular strength ($\eta p^2 = 0.08$; $\eta p^2 = 0.15$, respectively), and muscular endurance ($\eta p^2 = 0.04$; $\eta p^2 = 0.12$, respectively) compared to the control group. The post-hoc analysis showed a considerable pre-to-post decrease ($p < 0.001$) in both step aerobic exercise training and floor aerobic exercise training for body composition ($\eta p^2 = 0.04$; $\eta p^2 = 0.14$, respectively) compared to the control group. The participants engaged in step aerobics aerobic training and floor aerobics aerobic fitness showed no significant improvement in any of the training protocols tested in terms of cardiovascular endurance, muscular endurance, muscular strength flexibility, or body composition, whereas the control group showed no significant improvement in any of the training protocols tested (Table 2).

Table 2. Mean (± SD) values of health-related physical fitness parameters for the three groups

Variables	Group	Before	After	Partial eta-squared (ηp^2)		
				Main effect group	Main effect time	Interaction group x time
CRE (ml/kg/min)	SAET	28.89 ± 2.13	30.95 ± 1.09 [ac]	0.06 (p = 0.16)	0.32 (p < 0.001)	0.09 (p = 0.08)
	FAET	28.58 ± 0.84	30.54 ± 1.01 [a]			
	CG	28.97 ± 2.15	29.54 ± 1.64			
MS (numbers)	SAET	19.10 ± 1.37	20.45 ± 1.43 [a]	0.03 (p = 0.40)	0.35 (p < 0.001)	0.02 (p = 0.52)
	FAET	19.15 ± 2.18	20.90 ± 1.41 [ac]			
	CG	18.90 ± 1.86	19.95 ± 1.76			
ME (numbers)	SAET	22.85 ± 2.30	25.40 ± 1.27 [ac]	0.01 (p = 0.80)	0.50 (p < 0.001)	0.19 (p = 0.002)
	FAET	22.95 ± 1.82	25.00 ± 1.16 [a]			
	CG	23.55 ± 1.63	24.10 ± 1.51			
F (cm)	SAET	22.85 ± 1.75	24.85 ± 1.26 [ac]	0.03 (p = 0.37)	0.79 (p < 0.001)	0.41 (p < 0.001)
	FAET	22.00 ± 2.55	24.25 ± 1.99 [a]			
	CG	22.80 ± 1.90	23.45 ± 1.70			
BC (%)	SAETG	39.33 ± 0.35	38.67 ± 0.60 [a]	0.05 (p = 0.24)	0.39 (p < 0.001)	0.07 (p = 0.14)
	FAETG	39.33 ± 0.61	38.72 ± 0.72 [a]			
	CG	39.33 ± 0.15	39.06 ± 0.43			

SAET: Step Aerobics Exercise Training; FAET: Floor Aerobic Exercise Training; CG: Control Group; CRE: Cardiorespiratory Endurance; MS: Muscular Strength; ME: Muscular Endurance; F: Flexibility; BC: Body Composition; [a]significant difference before and after the intervention; [c]significant interaction between SAET and FAET.

Physiological variables

The main influence of time on some outcomes have been found to be VC (F = 1.84, ηp^2 = 0.76, power value: 0.99, p<0.001), RHR (F = 91.30, ηp^2 = 0.61, power value: 0.99, p < 0.001), MABP (F = 0.01, ηp^2 = 0.88, power value: 0.50, p = 0.982), BHT (F = 73.55, ηp^2 = 0.56, power value: 0.99, p < 0.001), RR, (F = 21.51, ηp^2 = 0.27, power value: 0.99, p < 0.001). Significant group (three) and time (pre and post) interactions were seen for VC (F = 18.33, ηp^2 = 0.39, power = 0.51, p < 0.001), RHR (F = 9.60, ηp^2 = 0.25, power = 0.97, p < 0.001), MABP (F = 1.87, ηp^2 = 0.19, power = 0.62, p = 0.163), BHR (F = 4.90, ηp^2 = 0.14, power = 0.78, p < 0.011), RR (F = 4.58, ηp^2 = 0.14, power = 0.75, p = 0.014).

A post-hoc analysis showed a considerable pre-to-post decrease (p < 0.001 value) in both step aerobic exercise training and floor aerobic exercise training for resting heart rate (ηp^2 = 0.08; ηp^2 = 0.16, respectively), and respiratory rate (ηp^2 = 0.07; ηp^2 = 0.18, respectively) compared to the control group. The post-hoc analysis showed a considerable pre-to-post improvedment (p < 0.001 value)

in both step aerobic exercise training and floor aerobic exercise training for breath holding time ($\eta p^2 = 0.04$; $\eta p^2 = 0.11$, respectively) compared to the control group. No training protocols showed significant improvement in vital capacity, breath-holding time, and decreased resting heart rate, mean arterial blood pressure, and respiratory rate in participants performing step aerobics exercise training and floor aerobics exercise training, whereas no significant improvement was observed in the control group (Table 3).

Table 3. Mean (± SD) values of the physiological parameters in the three groups

Variables	Group	Before	After	Partial eta-squared (ηp^2)		
				Main effect group	Main effect time	Interaction group x time
VC (mL)	SAETG	3.07 ± 275.48	3.32 ± 228.49 [ac]	0.63 (p = 0.02)	0.76 (p < 0.001)	0.39 (p < 0.001)
	FAETG	3.07 ± 233.73	3.29 ± 217.40 [a]			
	CG	3.07 ± 451.16	3.14 ± 425.99			
RHR (bpm)	SAETG	75.20 ± 3.73	72.40 ± 3.31 [ac]	0.28 (p = 0.04)	0.61 (p < 0.001)	0.25 (p < 0.001)
	FAETG	75.25 ± 1.77	73.30 ± 2.69 [a]			
	CG	75.65 ± 3.01	74.90 ± 3.50			
MABP (mmHg)	SAETG	97.92 ± 2.61	96.76 ± 2.36 [ac]	0.71 (p = 0.01)	0.98 (p < 0.001)	0.16 (p = 0.06)
	FAETG	97.97 ± 2.59	97.87 ± 2.44 [a]			
	CG	97.16 ± 3.45	98.46 ± 4.57			
BHT (s)	SAETG	36.35 ± 3.03	38.40 ± 3.03 [a]	0.79 (p = 0.01)	0.56 (p < 0.001)	0.15 (p < 0.01)
	FAETG	36.90 ± 4.37	39.20 ± 3.86 [ac]			
	CG	36.95 ± 3.97	37.80 ± 3.83			
RR (numbers)	SAETG	17.00 ± 1.48	16.15 ± 1.26 [a]	0.44 (p = 0.02)	0.27 (p < 0.001)	0.14 (p = 0.014)
	FAETG	17.10 ± 1.11	16.15 ± 0.93 [a]			
	CG	17.00 ± 1.29	16.95 ± 0.94			

SAET: Step Aerobics Exercise Training; FAET: Floor Aerobic Exercise Training; CG: Control Group; VC: Vital Capacity; RHR: Resting Heart Rate; MABP: Mean Arterial Blood Pressure; BHR: Breath Holding Time; RR: Respiratory Rate; [s]significant difference before and after the intervention; [c]significant interaction between SAET and FAET.

Biochemical variables

The main influences of time on some outcomes have been found to be HDL (F = 30.82, ηp^2 = 0.35, power value: 0.99, p < 0.001), LDL (F = 1.66, ηp^2 = 0.74, power value: 0.99, p < 0.001), TC (F = 3.82, ηp^2 = 0.63, power value: 0.48, p = 0.056), TG (F = 7.27, ηp^2 = 0.11, power value: 0.75, p = 0.009). Significant group (three) and time (pre and post) interactions were seen for HDL (F = 1.21, ηp^2 = 0.41, power = 0.25, p = 0.304), LDL (F = 25.11, ηp^2 = 0.46, power = 0.99,

$p < 0.001$), TC ($F = 3.51$, $\eta p^2 = 0.11$, power = 0.63, $p = 0.036$), TG ($F = 0.88$, $\eta p^2 = 0.30$, power = 0.78, $p = 0.417$).

A post-hoc analysis showed considerable pre-to-post improvement ($p < 0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for high density lipoprotein ($\eta p^2 = 0.05$; $\eta p^2 = 0.14$, respectively) compared to the control group. The post-hoc analysis showed a considerable pre-to-post decrease ($p < 0.001$ value) in both step aerobic exercise training and floor aerobic exercise training for total cholesterol ($\eta p^2 = 0.09$; $\eta p^2 = 0.18$, respectively) and triglycerides ($\eta p^2 = 0.07$; $\eta p^2 = 0.19$, respectively) compared to the control group. The participants who engaged in step aerobics activity and floor aerobics exercise training both showed no significant improvement in any of the training protocols when it came to highly dense lipoprotein, decreased low density lipoprotein, lipid profile, and triglycerides, while no significant improvement was seen in the control group (Table 4).

Table 4. Mean (± SD) values of the biochemical parameters in the three groups

Variables	Group	Before	After	Partial eta-squared (ηp^2)		
				Main effect group	Main effect time	Interaction group x time
HDL (mg/dl)	SAETG	53.95 ± 3.83	55.60 ± 2.13 [a]	0.02 ($p = 0.58$)	0.35 ($p < 0.001$)	0.04 ($p = 0.30$)
	FAETG	52.60 ± 3.06	55.80 ± 2.06 [a]			
	CG	53.85 ± 2.96	55.95 ± 2.08			
LDL (mg/dl)	SAETG	123.78 ± 6.04	120.94 ± 5.63 [a]	0.04 ($p = 0.89$)	0.74 ($p < 0.001$)	0.47 ($p < 0.001$)
	FAETG	123.96 ± 3.86	120.62 ± 3.51 [a]			
	CG	123.49 ± 9.98	122.96 ± 10.37			
TC (mg/dl)	SAETG	214.65 ± 5.19	212.70 ± 4.89 [a]	0.04 ($p = 0.89$)	0.06 ($p = 0.056$)	0.110 ($p = 0.04$)
	FAETG	215.74 ± 5.93	212.85 ± 5.92 [a]			
	CG	214.12 ± 6.83	215.20 ± 11.57			
TG (mg/dl)	SAETG	181.52 ± 11.31	179.30 ± 10.23 [a]	0.008 ($p = 0.79$)	0.11 ($p = 0.009$)	0.03 ($p = 0.42$)
	FAETG	183.88 ± 7.88	180.20 ± 10.09 [a]			
	CG	180.35 ± 11.79	179.42 ± 13.45			

SAET: Step Aerobics Exercise Training; FAET: Floor Aerobic Exercise Training; CG: Control Group; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; TC: Total Cholesterol; TG: Triglycerides; [a]significant difference before and after the intervention.

Psychological variables

The main influences of time on some outcomes have been found to be SC ($F = 24.80$, $\eta p^2 = 0.42$, power value: 0.99, $p < 0.001$), EA ($F = 1.66$, $\eta p^2 = 0.74$, power value: 0.99, $p < 0.001$), A ($F = 3.82$, $\eta p^2 = 0.63$, power value: 0.48,

p = 0.056), IR (F = 7.27, ηp^2 = 0.11, power value: 0.75, p = 0.009). Significant group (three) and time (pre and post) interactions were seen for SC (F = 1.21, ηp^2 = 0.41, power value: 0.25, p = 0.304), EA (F = 25.11, ηp^2 = 0.46, power value: 0.99, p < 0.001), A (F = 3.51, ηp^2 = 0.11, power value: 0.63, p = 0.036), IR (F = 0.88, ηp^2 = 0.30, power value: 0.78, p = 0.417).

A post-hoc analysis showed considerable pre-to-post improvement (p < 0.001 value) in both step aerobic exercise training and floor aerobic exercise training for self-confidence (ηp^2 = 0.05; ηp^2 = 0.14, respectively) compared to the control group. The post-hoc analysis showed a considerable pre-to-post decrease (p<0.001 value) in both step aerobic exercise training and floor aerobic exercise training for assertiveness (ηp^2 = 0.09; ηp^2 = 0.18, respectively) and interpersonal relationships (ηp^2 = 0.07; ηp^2 = 0.19, respectively) compared to the control group. The participants who engaged in both step aerobics activity and floor aerobics exercise training showed no significant improvement in any of the training protocols in terms of self-confidence, decreased emotional adjustment, psychological profile, interpersonal relationships, and stress management, while no significant improvement was seen in the control group (Table 5).

Table 5. Mean (± SD) values of psychological parameters in the three groups

Variables	Group	Before	After	Partial eta-squared (ηp^2)		
				Main effect group	Main effect time	Interaction group x time
SC (scores)	SAETG	21.22 ± 1.41	22.16 ± 1.80 [a]	0.02 (p = 0.67)	0.421 (p<0.001)	0.04 (p = 0.310)
	FAETG	20.60 ± 1.82	21.23 ± 1.20 [a]			
	CG	21.86 ± 1.16	21.40 ± 1.45			
EA (scores)	SAETG	46.52 ± 4.31	47.10 ± 1.35 [a]	0.04 (p = 0.84)	0.654 (p <0.001)	0.51 (p<0.001)
	FAETG	45.17 ± 4.15	46.23 ± 2.34 [a]			
	CG	45.70 ± 3.50	45.14 ± 1.30			
A (scores)	SAETG	23.17 ± 2.40	24.40 ± 4.89 [a]	0.05 (p = 0.87)	0.06 (p = 0.06)	0.21 (p = 0.04)
	FAETG	22.43 ± 1.19	23.18 ± 2.80 [a]			
	CG	23.10 ± 1.10	23.10 ± 1.15			
IR (scores)	SAETG	21.34 ± 3.46	22.32 ± 2.14 [a]	0.08 (p = 0.78)	0.11 (p = 0.09)	0.03 (p = 0.42)
	FAETG	20.16 ± 2.31	21.34 ± 1.42 [a]			
	CG	20.35 ± 3.40	20.96 ± 2.17			
SM (scores)	SAETG	35.19 ± 2.15	36.23 ± 3.16	0.06 (p = 0.85)	0.065 (p = 0.06)	0.13 (p = 0.036)
	FAETG	34.16 ± 1.75	35.16 ± 4.40			
	CG	35.80 ± 1.10	34.12 ± 2.34			

SAET: Step Aerobics Exercise Training; FAET: Floor Aerobic Exercise Training; CG: Control Group; SC: Self-Confidence; EA: Emotional Adjustment; A: Assertiveness; IR: Interpersonal Relationship; SM: Stress Management; [a]significant difference before and after the intervention.

Discussion

The main finding of this study was that different aerobic training exercises had various positive effects on physical strength and physiological and biochemical parameters in obese men. After 16 weeks of a randomized control trial undertaking aerobic and resistance training intervention, it was shown to improve the quality of life and physical fitness of obese and overweight cancer patients [24]. These results were consistent with previous studies showing that VO2 max improved [25,26] and that HIIT exercise could reduce resting heart rate in children with obesity [27]. Another previous study showed that 12 weeks of isolated and combined randomized control trials undertaking aerobic, resistance, and combined training showed that overweight and obese adults had considerably improved body percentage of fat and cardiorespiratory fitness [28]. Exercise intervention at 16 weeks follow up MLIP has been suggested to improve physical fitness and body composition in adolescents and obese children [29]. In the present study, we found a significant improvement in selected health-related physical fitness parameters after 12 weeks of aerobic exercise training. Importantly, a reduction in body composition study reported that eight weeks of HIIT aerobic exercise intervention improved the quality of life of patients [30].

Our study findings agree with those of previous studies showing a decrease in blood pressure after 12 weeks of combined exercise training in young obese pre-hypertensive men [31]. Our data indicate that breath-holding time and respiratory rate were significantly enhanced after 12 weeks of intervention in the current study. This may follow another mechanism that effectively improves breath-holding time and respiratory rate due to neuromuscular training intervention [32].

The findings of this study are in line with related studies suggesting that aquatic exercise has a beneficial effect on forced vital capacity [33]. Komathi and Indira previously investigated the effects of step aerobics, floor aerobics, and combination exercises on biochemical variables and psychology in female students [34]. After undertaking floor aerobic exercise for a period of 12 weeks, it was shown that female students showed considerable improvement in all selected biochemical and psychological parameters. After participating in step aerobics for a period of twelve weeks, female students showed significant improvements in all selected biochemical and psychological variables. Women in the combined training group performed better on biochemical variables than did those in the other groups. Similar outcomes were obtained in the present study, in which the biochemical profile of obese male adults was found to improve after twelve-week intervention of steps or floor aerobics. Clary et al. examined the effects of ballate, walking on balance, and step aerobics in women aged 50–75 years. Compared to the Ballates program, walking programs and step aerobics

result in improved static balance and postural stability [3]. In our study, similar results were obtained in steps aerobics and floor aerobics. Melam et al. examined the effects of aerobics and brisk walking in overweight individuals. For ten weeks, this program was carried out five days a week [18]. Body mass index, hip and waist circumference, and the thickness of the skinfolds in the abdomen, subscapular region, biceps, and triceps were measured in all three categories before and after the experiment. All values fell in women who performed 10 weeks of brisk walking and aerobics. In the present study, body composition was found to be significantly improved among adult obese male after 12 weeks of aerobic exercise. Maiyanga and Gunen investigated the effect of step aerobics on percentage of body fat and visceral fat in obese female nurses in Bauchi's specialty hospital and discovered that step aerobics reduced percentage body fat [19].

Limitations

Being pilot in nature, the present study has several limitations that suggest a lacune on which future studies could be conducted. One limitation of this study is that we only included male participants in the current study. Obesity is also prevalent in females; therefore, future studies should be conducted with female participants. Another limitation of the study is that it focused on specific age groups, and future studies could be conducted by considering all age groups. This will help validate the results of the current study for all age groups. Another limitation of this study was the sample size. Because the sample size of the present study was small, the results of the present study cannot be validated for the general population. Moreover, the present study was a single-centric study, and future studies using a multicentric approach should be conducted to determine the role of aerobic exercise in the management of obesity among adults.

Conclusion

The present study revealed significant improvement in adult obesity in terms of body composition, muscular strength and endurance, cardiovascular and respiratory parameters, biochemical parameters, and psychological domains after practising steps and floor aerobics. Aerobic exercise proved to be helpful in managing the physical and psychological health of obese adults. It is recommended that schools and colleges administer aerobic exercise sessions to adults for better health perspectives.

STATEMENT OF ETHICS

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the SRM Medical College Hospital and Research Centre (SRM CHRC, Kattankulathur, Tamil Nadu, India, Number 8484/IEC/2022). All participants provided written informed consent to participate in this study.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interests with respect to the research, authorship, and/or publication of the article *The effect of 12-week step and floor aerobic exercise programs on physical and psychophysiological health parameters in obese men*.

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Hedonic Shopping Experience in Malls: A Scale Development Study

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ABSTRACT: The evolving retail sector, rising customer expectations and competitive landscape have emphasized the need for hedonic ingredients to enrich the shopping experience of consumers. Malls being a prime destination for hedonic shopping in India, this study aims to develop a practical hedonic shopping experience scale encapsulating the various types of hedonic experiences offered in malls. The study employed qualitative research using in-depth interviews to thoroughly investigate the shopping experiences of mall consumers and to generate the initial scale items. A structured questionnaire comprising these items was designed for the quantitative study. The data collected (n = 224) using mall intercept survey were subjected to exploratory and confirmatory factor analyses which yielded a 26-item hedonic shopping experience scale consisting of seven dimensions: window shopping experience, social experience, entertainment experience, gratifying experience, bargain shopping experience, status shopping experience and aesthetic experience. The potential applications of the proposed scale are discussed along with its limitations and directions for future research.

KEYWORDS: Shopping experience, Hedonic consumption, Malls, Scale development

I. INTRODUCTION

Shopping in India has witnessed a transformation with the evolution of the retail industry and specifically, the expansion of the organized retail sector. Shopping malls constitute a significant part of the Indian organised retail format which has developed dramatically in major tier 1 and tier 2 cities over the past decade (Pani, 2015; Dungarwal, 2016). Malls have revolutionized the shopping experience of consumers by influencing their shopping habits, preferences, and behaviour.

In the past, shopping was primarily about making need-based purchases. This can be termed as utilitarian shopping which is directed towards satisfying a functional or economic need and its value weighed on its success or completion (Holbrook and Hirschman 1982; Babin et al., 1994). Utilitarian shoppers are believed to be more task-oriented, efficient and rational who are concerned with 'expectations of consequences' i.e. means-ends type (Batra and Ahtola, 1991; Fiore and Kim, 2007). However, in recent times, consumers do not just shop for purchasing goods and services, but also for experiential and emotional reasons that go well beyond the traditional shopping paradigm. These multisensory, fantasy and emotive aspects of one's experience with products or services represent the hedonic consumption (Holbrook and Hirschman 1982). This hedonic view explores consumption experience not as a purely cognitive or information processing event, but via a phenomenological or experiential perspective.

Malls are the common destination for shoppertainment in urban India, which offer a wholesome shopping experience, specifically in the hedonic sense which includes shopping, entertainment and leisure. Visitors can not only purchase and consume various products and services, but the mall itself offers experiences which are consumable (Bloch et al., 1994). For the discerning modern consumers, malls are proving to be a panacea to all their shopping woes (Mohan and Tandon, 2015). Hence, malls have become increasingly popular among Indian

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consumers with an average weekday footfall of 30,000 - 50,000 that further spikes during weekends in case of the large city malls (Largest malls of India, 2013; Srivastava, 2017).

Despite the boom in mall culture and success stories of some popular malls, industry experts state that 60-90 percent of shopping malls in major cities across India are performing lamentably and face a bleak future owing to their non-adaptation and competition from new shopping malls offering sophisticated shopping experience to their customers (Khare and Rakesh, 2010; Shopping Malls dying in India, 2016; Survival Crisis, 2017). It is easier to get people to the mall once, but to get them to return and spend money depends on the mall's ability to offer hedonic shopping experience. Urban consumers in India and especially youth visit malls primarily for the hedonic shopping experience rather than just utilitarian purpose (Kaur and Singh, 2007). Most visitors are attracted to malls for varied experiential reasons such as aesthetics, luxury, safe environment, good ambience, entertainment, leisure, and best hang-out place for families and friends (Dungarwal, 2016). Malls which failed to offer such experiences have witnessed dipping footfalls and sales with some even forced to shut down (Shah and Bose, 2012; Nair and Maheshwari, 2017).

Since hedonic constituents have become the unique selling proposition of malls, it is essential to gain a comprehensive understanding of the hedonic shopping experience offered by malls to their consumers.

II. LITERATURE REVIEW

Shopping research in the past has generally focussed on the utilitarian aspects of the shopping experience, which are characterized as task-oriented and means-end type (Batra and Ahtola, 1991; Arnold and Reynolds, 2003). However, consumers are not just logical decision-makers who focus on functional benefits; they are also emotional human beings who are concerned with gaining hedonic experiences (Schmitt, 1999; Sadachar, 2014).

This shift from the traditional information processing approach to a more hedonic, experiential view of consumption was initially recognized by Tauber (1972) who found that shoppers have numerous psychological shopping motives other than just purchase of products and services. Holbrook and Hirschman (1982) presented the experiential view of consumption experience which emphasizes the importance of pleasure and happiness for a satisfying shopping experience. In a widely cited study, Pine and Gilmore (1999) proposed the concept of "Experience Economy" which contends that consumers are no longer interested in just purchasing goods and services; they desire engaging and entertaining experiences during shopping. They presented four dimensions of experience: educational, entertainment, escapist and esthetic experiences. Thus, to run a successful business in the retail space, retailers must offer enchanting shopping experiences that stimulate the consumers' senses and touch their hearts and minds (Pine and Gilmore, 1999; Sadachar, 2014).

Hedonic shopping experience in the context of malls

Past studies have highlighted the importance of hedonic attributes such as entertainment and leisure in drawing consumers to a mall. According to Bloch et al. (1994), malls are not just strictly purchase sites, but a centre for many hedonic activities. Wilhelm and Mottner (2005) found that consumers in developed countries prefer malls with experiential features rather than a typical status quo mall. Similarly, in recent times, Indian consumers largely shop from a hedonic perspective which involves getting product ideas, meeting friends, alleviating stress or breaking the monotony of everyday life (Kaur and Singh, 2007; Khare, 2011). Hence, urban Indian consumers desire to visit malls which offer an entertaining shopping experience (Srinivasan and Srivastava, 2010).

Recognizing the importance of hedonic aspect in retailing, most studies focused on incorporating it as one of the dimensions of various constructs such as consumer attitude (Batra and Ahtola, 1991), shopping value (Babin et al., 1994), shopping motivations (Tauber, 1972; Kaur and Singh, 2007; Farrag et al., 2010) and shopping orientations (Sinha, 2003). Very few studies concentrated on analyzing the shopping experience of consumers, specifically from the hedonic perspective. Pandey & Darji (2011) and Srinivasan & Srivastava (2010) qualitatively explored the concept of experience economy; while Sadachar et al. (2014) empirically examined the applicability of the 4Es (Pine and Gilmore, 1999) to understand the shopping experience of consumers in the context of Indian malls. These studies analyzed shopping experience within Pine and Gilmore's Experiential Realms. Singh and Prashar (2013) analyzed the composition of shopping experience in the view of Dubai mall shoppers and they found that mall experience can be conceptualized as a mix of five factors i.e. ambience, physical infrastructure, marketing focus, convenience, and safety and security. In a similar study, Singh and Prashar (2014) explored the anatomy of shopping experience with respect to malls in Mumbai. They identified ambience, convenience, marketing focus, safety and security and physical infrastructure as the important components defining shopping experience.

It is a fact that with the evolving consumer expectations and competitive market, the composition of shopping experience offered by Indian malls has been changing. Also, the existing studies focus on the overall shopping

experience and not specifically on the hedonic perspective. This necessitates the study of consumer perception of hedonic shopping experience offered in malls.

III. OBJECTIVE OF THE STUDY

Given the growing significance of hedonic experiences during mall shopping, this study aimed at investigating the hedonic shopping experiences of consumers in malls. Specifically, the objective of the study was to develop a scale representing the wide range of hedonic shopping experiences offered in malls.

IV. RESEARCH METHODOLOGY

To achieve the research objective, a qualitative study was conducted followed by a quantitative study involving exploratory factor analysis and confirmatory factor analysis to develop a scale summarizing the comprehensive range of hedonic shopping experiences in malls. In-depth interviews were conducted with regular mall going consumers as well as mall administrators to qualitatively explore the shopping experience of mall consumers. Based on these qualitative inputs and literature review, 42 scale items were generated which were validated by two marketing professors for content adequacy and representativeness. Finally, 37 items were retained after content validity.

A structured questionnaire was used as the data collection instrument for the quantitative study. The 37 items obtained from qualitative research was used to construct the questionnaire. The items were evaluated using the 5 point Likert scale (1 - strongly disagree and 5 - strongly agree). The sampling sites for the study were three prominent shopping malls in Chennai city, India. The data were collected using the mall intercept survey (Bush and Hair, 1985) where respondents were selected through convenience sampling technique. The respondents were asked to think about their shopping experiences in malls, the activities they indulged in while visiting malls and the feelings and level of satisfaction experienced during shopping. A total of 300 questionnaires were administered of which 224 filled questionnaires were found usable for further data analysis. The demographic analysis of the data revealed that the sample was diverse in terms of gender, age and income. It comprised approximately 41 percent men and 59 percent women between 18 to 60 years of age and varied income levels.

V. EXPLORATORY FACTOR ANALYSIS

The 37 items were subjected to exploratory factor analysis (EFA) using principal components method and varimax rotation to determine the number of distinct factors/dimensions and to categorize the generated items under these dimensions. A seven-factor solution was estimated and 6 items with factor loadings less than 0.5 were discarded for further iterations (Hair et al., 2006). The grouping of the items was examined for domain representation and 3 items were removed since they theoretically did not match other items in the factors they were grouped into. The remaining items were subjected to EFA which yielded a seven-factor solution with 26 items. The solution explained 63 percent of the total variance and the KMO measure of sampling adequacy of 0.762 indicated the fitness of data for factor analysis. The factor loadings ranged from 0.633 to 0.853. The Cronbach alpha coefficients, average variance extracted (AVE) and composite reliability (CR) estimates were above the prescribed threshold signifying good reliability and validity of the factor structure (Fornell and Larcker, 1981; Nunnally and Bernstein, 1994).

VI. CONFIRMATORY FACTOR ANALYSIS

The confirmatory factor analysis (CFA) was carried out for thorough examination of the scale's psychometric properties (Anderson and Gerbing, 1988). The 26 items obtained from EFA were subjected to CFA using maximum likelihood (ML) method in SPSS AMOS 22. The results revealed a 26-item seven-factor measurement model which was consistent with the EFA factor solution. The measurement model showed an adequate fit as the fit indices above the acceptable thresholds ($\chi 2_{(303)} = 354.72$, p = .001; GFI = .901; AGFI = .875; CFI = .954; NFI = .823; IFI = 0.955; standardized RMR = .073; RMSEA = .035) indicating a good model fit with the data (Schermelleh-Engel et al., 2003; Vandenberg and Grelle, 2009). The CFA results showed that the standardized factor loadings of all items ranging from 0.558 to 0.859 were significant and above the prescribed limit of 0.5 (Hair et al., 2006). The item SMCs ranged from 0.312 to 0.738 and all modification indices were low and insignificant. Hence, no items were removed. Table 1 presents the 26-item factor structure obtained from the confirmatory factor analysis (Refer Appendix Figure A1 for the measurement model obtained from SPSS AMOS).

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Table 1: Confirmatory Factor Analysis Results

Dimension	Items	Factor Loadings	Squared Multiple Correlations
Window shopping experience	This mall helps me explore the latest products/designs/brands available.	0.728	0.548
	I enjoy browsing and trying different products in this mall.	0.693	0.436
	Shopping in this mall keeps me up with the new fashion and trends.	0.698	0.437
	This mall offers the best window shopping experience.	0.621	0.428
Social experience	This mall is a great place to hang-out with family.	0.698	0.421
	I enjoy visiting this mall with my friends.	0.666	0.401
	This mall is the best place to socialize.	0.759	0.312
Entertainment experience	I enjoy visiting this mall since it has a variety of food and entertainment services.	0.699	0.738
	This mall offers first-class movie experience.	0.594	0.488
	This mall is entertaining with play areas, adventure games, health clubs and salons/spas.	0.611	0.535
	I like this mall as it is a one-stop destination for fashion, fun, food and films.	0.795	0.519
Gratifying experience	I visit this mall to break the monotony of my daily routine.	0.665	0.500
	Shopping in this mall feels like self-gratification for a hard day's work.	0.742	0.462
	When I am in a bad mood or stressed, I visit this mall to make me feel better.	0.680	0.550
	When I am alone and bored, this mall is a good place to go.	0.707	0.442
Bargain shopping experience	I like visiting this mall when there is an end of season sale or festive offers.	0.720	0.632
	I enjoy browsing different stores in this mall for good discounts.	0.731	0.374
	This mall is a convenient place to hunt for bargains.	0.699	0.352
Status shopping experience	Shopping in this mall is a sign of status and prestige.	0.859	0.488
	I prefer to shop in this mall just like my peers do.	0.558	0.576
	I feel more socially accepted when I visit this mall as my friends/colleagues do.	0.634	0.443
	Shopping in this mall helps make a good impression on others.	0.649	0.487
Aesthetic experience	I love shopping in this mall because of the artistic and pleasant interiors.	0.654	0.385
	The mall facilities (escalators, restrooms, parking) make the shopping experience convenient and pleasurable.	0.661	0.487
	I like the ambience (lighting, music, hygiene, aromas, and temperature) of this mall.	0.660	0.480

	I prefer this mall for shopping since it is peaceful and spacious.	0.740	0.530

Reliability and Validity

The scale reliability was assessed using composite reliability (CR) estimates. As shown in Table 2, CR values of the dimensions ranged from 0.751 to 0.792 which were above the prescribed limit of 0.7 (Fornell and Larcker, 1981; Nunnally and Bernstein, 1994). The convergent validity was examined using factor loadings and average variance extracted (AVE) estimates. The standardized factor loadings of all 24 items were significant and ranged from 0.558 to 0.859. As presented in Table 2, the AVE values of the dimensions ranged from 0.462 to 0.514 which were closer to the acceptable threshold of 0.4. Thus, the scale was considered to have adequate convergent validity (Fornell and Larcker, 1981; Hair et al., 2006). The discriminant validity was tested by comparing the AVE estimates of the dimensions and the correlations between them (Fornell and Larcker, 1981). As shown in Table 2, the AVE estimates of all dimensions ranging from 0.462 to 0.514 were greater than the squared correlation coefficients ranging from 0.00 to 0.269; hence the scale possessed adequate discriminant validity.

By analyzing the content of the items grouped together, the seven dimensions were labelled appropriately symbolizing the different hedonic shopping experiences offered in malls i.e. window shopping experience, social experience, entertainment experience, escapist experience, bargain shopping experience, status shopping experience and aesthetic experience. Table 2 presents the reliability and validity results obtained from confirmatory factor analysis.

Table 2: Confirmatory Factor Analysis - Reliability and Validity Results

Dimensions	Composite Reliability	Discriminant Validity - Comparison of AVE and squared correlations						
		WS	SO	EE	GE	BS	SS	AE
WS	0.780	**0.471**						
SO	0.751	0.078	**0.502**					
EE	0.772	0.003	0.173	**0.462**				
GE	0.792	0.206	0.269	0.120	**0.489**			
BS	0.760	0.015	0.061	0.004	0.027	**0.514**		
SS	0.774	0.000	0.023	0.008	0.004	0.000	**0.468**	
AE	0.774	0.179	0.007	0.031	0.019	0.091	0.004	**0.462**

*Note: Diagonal values in **bold** are AVE estimates and off-diagonal values are squared correlation coefficients*

WS-window shopping experience; SO-social experience; EE-entertainment experience; GE-Gratifying experience; BS-bargain shopping experience; SS-status shopping experience; AE-aesthetic experience

VII. RESULTS AND DISCUSSION

The data analysis yielded a reliable and valid scale for hedonic shopping experience with seven dimensions. Each of these hedonic experiences is discussed taking into account the qualitative study findings, theoretical background and literature.

1. Window shopping experience

The first dimension was labelled as 'window shopping experience' which consisted of items such as exploring latest products, trying different products and being up-to-date with new trends. Thus, window shopping experience refers to the feeling of pleasure obtained from browsing and examining various merchandise in a mall. During window shopping, consumers derive fun from exploring and seeking information, but they may not necessarily make a purchase. They regard the fashion updates they gain and the pleasure they experience from exploring as their main drive, irrespective of them making a purchase or not.

Tauber (1972) identified that learning about new trends is one of the personal shopping motives where people are interested in keeping track of the up-to-date trends in fashion and styling. This concept of window shopping/exploration corresponds with Arnold and Reynold's (2003) hedonic motivation of idea shopping which signifies shopping as a means to be cognizant with current vogue and popular designs and products. It is roughly

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similar to the 'educational experience' dimension of the 4Es concept (Pine and Gilmore, 1999) which comprises consumers' active participation with mind and/or body actively engaged to improve their skills and knowledge (Sadachar, 2014). Indian malls are generally focussed on captivating customers through shopping experience rather than educating them through events or classes. Since shopping is regarded as fun rather than an educational experience, this dimension is termed as window shopping which is one of the common hedonic experiences offered in malls.

2. Social experience

The second dimension was named as 'social experience' which consisted of items such as malls being a hang-out place for family and friends and a place to socialize offering good bonding experience. Thus, social experience refers to the pleasure derived from socializing with others. In urban India, malls have become a one-stop destination for shopping, fun and leisure. Hence, a majority of Indian consumers prefer mall as a happening and safe place to hang-out with family and friends. Malls have now become a desired place for working professionals to conduct unofficial business meetings, corporate events, lunch and dinner get-togethers and colleagues' birthday, promotion or farewell parties.

Malls are an expedient place for socialization which implies going out, meeting and hanging out with friends, family or colleagues. Past research has unearthed different shades of socialization while shopping. Stone (1954) first identified 'personalising' shopper as a distinct shopper type who tends to personalize and have close relationships with shop personnel. Tauber (1974) recognized the social motives of shopping i.e. having social experiences outside the home and communicating with other people. While these researchers solely focused on socializing with outsiders, Arnold and Reynold (2003) recognized social shopping as a hedonic motive which represents the pleasure of shopping with friends and family as well as bonding with outsiders. Social experience is a significant hedonic shopping experience desired by Indians since they are intrinsically embedded in their socio-cultural society characterized by social interdependence, deeper involvement with others and desire for social acceptance and support (Jacobson, 2004). Thus, malls are popular destinations to socialize and interact with others while shopping.

3. *Entertainment experience*

The third dimension was labelled as 'entertainment experience' which consisted of items such as malls offering a variety of food and entertainment services, movie experience and a one-stop place for fashion, food, fun and films. Thus, entertainment experience refers to the feeling of enjoyment and adventure derived from the various entertainment services such as movies, bowling alleys, video game arcades, kids' play areas and food courts offered in malls. Recent surveys found that nearly 50 percent of the mall visitors use entertainment services compared to a mere 20 percent who go shopping which emphasizes consumer preference for entertainment (Khare and Rakesh, 2010). Hence, all new-age malls are designed with a significant share of mall space for entertainment services to improve their customer footfalls and revenue.

Bloch et al. (1994), Anuradha and Manohar (2011) and Sadachar (2014) identified that the entertainment experience offered by mall services such as movies, cafes, food courts, arcades, health clubs, salon/spa, pubs and recreational services help attract consumer traffic to the malls. The hedonic motives of gaining enjoyment, fun and adventure have boosted the consumer demand for entertainment consumption (Sit et al., 2003). Hence, entertainment has now become a common hedonic shopping experience offered by malls.

4. Gratifying experience

The fourth dimension was identified as 'gratifying experience' which consisted of items such as visiting malls to break the monotony, self-gratification and to feel better. It refers to the pleasure obtained from recreation, relaxation and relief from the monotony of daily life. With the changing and demanding lifestyle, not many places offer both leisure and peace to people and malls are one such space which offers these along with shopping. For most people, mall atmosphere helps rejuvenate mood and shopping relieves stress. Thus, shopping in malls to gratify oneself is regarded as truly fun and stress buster.

The concept of gratification during shopping has been emphasized in past research. Hirschman (1983) introduced the escapism as one of the four hedonic behaviours to escape unpleasantness. Tauber (1972) was one of the first to recognize the self-gratifying benefits of shopping which are motivated not by the consumption value, but by the utility of the buying process. Similarly, Arnold and Reynolds (2003) found gratification as a hedonic shopping motive that helps alleviate stress, negative mood and as a way to unwind. Thus, malls offer a feeling of gratification which is a notable hedonic experience desired by customers.

5. Bargain shopping experience

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The fifth dimension was labelled as ' bargain shopping experience' which consisted of items such as visiting mall for sale and offers, enjoy browsing for discounts and mall being a convenient place for bargain hunting. Thus, bargain shopping experience refers to the pleasure derived during the process of bargain hunting i.e. searching for sale, offers and best deals on purchases. Consumers in India rarely make purchases in malls since they are regarded as luxurious and expensive place for purchasing merchandise. However, in case of offers such as end-of-season sale and festive discounts, Indian consumers desire to visit malls, browse various stores and hunt for the best deals irrespective of them making a purchase.

The concept of pleasure from bargaining was formerly recognized by Tauber (1974) who posited that the ability to seek bargains makes one a sensible shopper. Similarly, Arnold and Reynolds (2003) identified value shopping as a hedonic motive which signifies customers' tendency to hunt for best deals at low prices. Though it can be contended that seeking bargains is a utilitarian behaviour, the process itself offers an adventure and emotional satisfaction which is inherently pleasure-driven or hedonic. Thus, malls can be regarded as a convenient spot with numerous shops and brands in one place to easily compare and hunt for bargains.

6. Status shopping experience

The sixth dimension was termed as 'status shopping experience' which consisted of items such as shopping in mall as a sign of status and prestige, to feel more socially accepted and to make a good impression. Thus, status shopping experience refers to the pleasure obtained from mall shopping owing to the status it confers. In this age, especially youngsters and middle class consumers who believe in display of wealth generally prefer shopping in malls since it is a matter of prestige. According to them, mall shopping enhances the way they are perceived by others and helps gain social approval. These conspicuous consumers buy some products and services in malls just as a status symbol to advertise how wealthy and classy they are.

Past studies have highlighted the significance of status-driven shopping and the proclivity of Indian consumers towards prestige over rationality while making purchases (Bullis, 1997; Kaur and Singh, 2007). Thus, malls offer pleasure through status shopping which is an intrinsic hedonic experience.

7. Aesthetic experience

The last dimension was labelled as 'aesthetic experience' which consisted of items such as mall ambience, interior design, architecture, facilities and spaciousness. Aesthetic experience refers to the pleasure obtained from the sensory appeal, comfort and opulence of the mall. In recent times, the rising customer expectations along with competitive market have compelled mall administrators to focus on mall atmospherics and customer service. Customers expect captivating and hygienic environment to make their shopping experience convenient and mesmerizing.

The concept of mall aesthetics has been highlighted in past research. Tauber (1972) recognized that sensory stimulation is one of the consumer shopping motives wherein the shopping environment may be an influencer of the consumer's decision to visit and shop in a store. Wakefield and Baker (1998) established that perceived physical environment of the mall is a vital determinant of consumers' excitement and desire to stay at the mall. According to Haytko and Baker (2004), physical comfort and atmospheric features of malls influenced the purchase patterns and favouritism of adolescent girls. Atmospherics comprising the mall interior design, layout, lighting, and music create an esthetic experience, which is one of the four experiential relams (4Es) identified by Pine and Gilmore (1999). Thus, aesthetic experience is one of the fundamental hedonic experiences that malls need to offer to improve the customer satisfaction and repatronage behaviour.

These seven types of hedonic shopping experiences were conceptualized and defined based on the qualitative study findings, review of literature and experts' opinion.

VIII. CONCLUSION

This study demonstrates the development of a practical hedonic shopping experience scale consisting of 26 items across seven types of hedonic shopping experience offered in malls. The hedonic experience dimensions are: window shopping experience, social experience, entertainment experience, gratifying experience, bargain shopping experience, status shopping experience and aesthetic experience.

For the scale development process, this study employed a qualitative study followed by a quantitative study consisting of data collection and analysis. In-depth interviews with mall consumers and administrators were conducted to qualitatively explore the various hedonic shopping experiences offered in malls. Initial scale items were generated using qualitative study results and literature review. A questionnaire consisting of these items were used for data collection through mall intercept survey. The data were subjected to exploratory and

confirmatory factor analyses which yielded a 26-item seven-dimensional hedonic shopping experience scale with adequate reliability and validity.

IX. RESEARCH IMPLICATIONS

The hedonic shopping experience scale summarizes a wide range of hedonic experiences offered in malls which has a broad array of applications for researchers, retailers and mall administrators. The scale can function as a tool to measure the degree of hedonism offered by malls as perceived by its customers. This will indicate the extent to which the mall offers various hedonic shopping experiences. It can help the mall administrators in identifying the hedonic features prominently appealing to their customers and those missing in their mall. This information can facilitate in making better strategic and marketing decisions which include designing mall interiors, selection of retailers and entertainment services, allocation of mall resources and facilities.

The scale developed in this study can be used as a base to analyze hedonic experiences offered by other retail formats such as supermarkets, hypermarkets, grocery stores, e-tailers and street bazaars. Researchers and retailers can use this scale to test the level of hedonism provided by other retail settings. Based on the results indicating the customer perception of various hedonic experiences, the retailers can appropriately plan and strategize to improve their business model.

X. LIMITATIONS OF THE STUDY

The study has certain limitations which ought to be mentioned. First, the hedonic shopping experience scale is specific to malls in India. Hence, researchers and retailers must be cautious while applying the scale to other shopping contexts and regions. Secondly, the seven types of hedonic experiences are based on the qualitative research performed in this study which might not be the exhaustive list of hedonic shopping experiences offered in malls. Finally, the study was limited to Chennai city in India due to time and financial constraints. Besides, data was collected through mall intercept survey using convenience sampling which is a non-probability sampling technique. These limitations in terms of the sampling method affect the generalizability of results.

XI. FUTURE RESEARCH DIRECTIONS

This study provides considerable scope for future research. The hedonic shopping experience scale developed in this study can be further validated using a larger, geographically diverse sample for better generalizability of results. Besides, the applicability of the scale can be tested by adapting it for other retail formats such as supermarkets, hypermarkets, chain stores and e-tailers. In future, researchers can conduct an in-depth analysis of each of the hedonic shopping experiences found in this study. Further, the scale can be used to investigate the impact of various hedonic shopping experiences on customer satisfaction, loyalty and repatronage behaviour.

XII. APPENDIX

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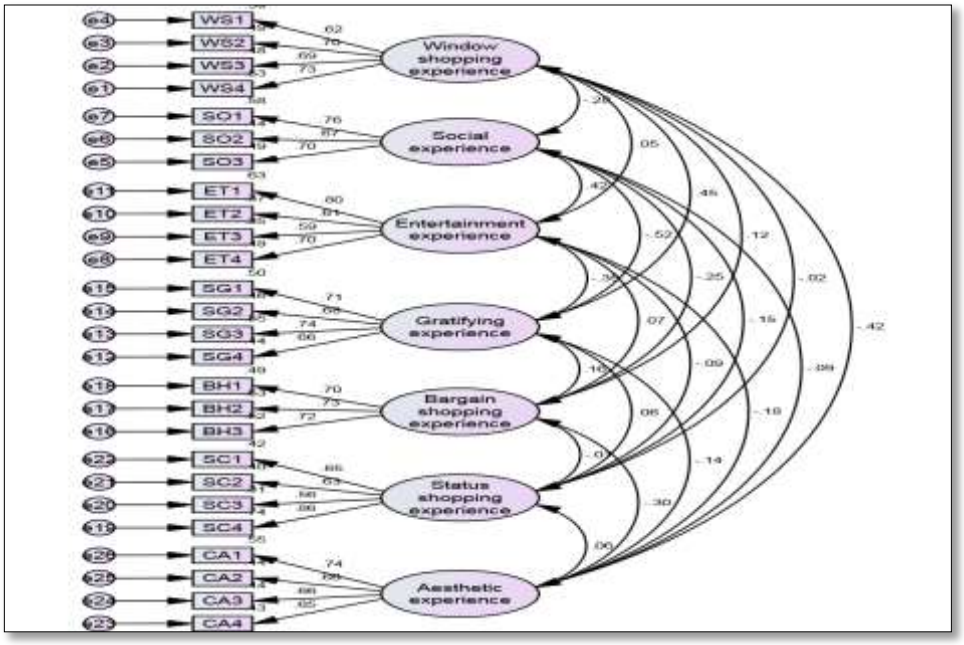

Figure A1 - Measurement Model from Confirmatory Factor Analysis

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Impact of recent developments in fabrication of auxetic materials on safety and protection in sport

G. Nallavan

Avoiding injury and increasing the safety and protection of the athletes and sports enthusiasts is the driving force for the development of protective equipment (PE) and personal protective equipment (PPE). In addition, as opposed to medical intervention, employing sports safety equipment is the cost effective solution. However, the implementation of sports safety equipment involves several challenges with lack of standard for the protective gear being the principal challenge. In order to overcome the competition in the market for sports safety equipment, manufacturers try to achieve higher standards (or overdesign). In the domain of materials development for sports safety equipment, one important candidate that cannot be overlooked is auxetic materials. Auxetic materials have a negative Poisson ratio (NPR) that gives them high tolerance to indentation and resilience to fractures. Recent advances in the manufacturing of auxetic materials give more influence over the cell framework created by the producers, thereby enabling the production of auxetic materials with outstanding characteristics and improved safety standards. Specific manufacturing techniques used to generate auxetic foams and textiles have been studied, while also discussing the effect of combining finite element analysis (FEA) and additive manufacturing (AM) on auxetic materials manufacturing

Study on Magnus effect of the different sports ball in the wind tunnel

G. Nallavan

Tamil Nadu Physical Education and Sports University (TNPESU) had a wind tunnel facility to study the forces and moments acting on the different balls in the rotation through a six-axis strain gauge. In this paper, the effect of the Magnus on the Cricket ball, Tennis ball, Baseball, Hockey ball and Golf ball is studied. The variation of Coefficient of Lift [CL], Coefficient of Drag [CD], Coefficient of Side force [CS], Coefficient of Roll moment [CRM], Coefficient of Pitch moment [CPM] and Coefficient of Pitch moment [CPM] of the static and rotational in both Clockwise and Anti-Clockwise condition. This data will give an insight into the ball performance in the spin and can be used in the sports effectively.

Hardware Implementation of PV fed boost converter with quasi resonant voltage doubler and snubber circuit

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A. Thiagarajan, M.Tech (PED) , BIHER - BIST, Chennai,

Abstract— In this article, hardware implementation of PV fed boost converter with quasi resonant voltage double and snubber circuit is presented. This method clarifies the improvement of a boost half-bridge (BHB) DC-DC converter with high power transformation efficiency and a wide voltage range for photovoltaic smaller scale inverter. The improvement is accomplished by presenting an isolation Transformer, interfacing the BHB DC-DC converter on the essential side of the transformer and including a voltage doubler with a snubber capacitor on the auxiliary side. Quasi Resonance (QR) strategies are utilized to accomplish zero-voltage exchanging (ZVS) turn-on for the switches, just as ZVS turn-on for the diodes. Furthermore, the new improved converter has no DC-charging current for the transformer because of the DC blocking capacitor, and it duplicates the voltage increase through the voltage doubler and snubber capacitor to diminish spikes Further, an extensive hardware validation show the effectiveness of the system.

Keywords— Photo voltaic Systems, Micro Inverter, DC-DC Converter, Quasi Resonance, Power Conversion.

I. INTRODUCTION

Lately numerous nations satisfy the power need, so the age of renewable power source is expanded, for example, photovoltaic, wind, fuel and so on. The sun gives all that anyone could need vitality to meet the entire world's vitality needs, and not at all like petroleum products, it won't run out at any point in the near future [1-2]. As a sustainable power source, the main impediment of sun oriented force is our capacity to transform it into power in a proficient and savvy way. No ozone depleting substance emanations are discharged into the environment when you utilize sun powered boards to make power. Also, on the grounds that the sun gives more vitality than we'll ever require, power from sun based force is a significant vitality source in the transition to clean vitality creation. After sun based boards have been introduced, operational expenses are very low contrasted with different types of intensity age. Fuel isn't required, and this implies sun based force can make huge sums of power without the vulnerability and cost of verifying a fuel supply. The progression up DC-DC converter for a smaller scale inverter must have a high voltage gain G (V_O/V_{IN}) of a few tens or more [3-4]. In this manner, if a traditional DC-DC help converter is utilized for a small scale inverter, the switch must have an incredibly high duty ratio. Be that as it may, this outcomes in huge current flows, losses due to conduction, and losses due to switching losses of the electric influence segments in the converter. Non-isolated DC-DC converters have been concentrated to defeat these issues in Step-up DC-DC Converters above [5-7].

To accomplish high voltage gain without an amazingly high duty ratio of the principle switch, non-isolated converters utilize detached and dynamic parts rather than a transformer. In any case, non-isolated DC-DC Converters have complex structure, electro-attractive obstruction, grid current contortion, and extra misfortunes because of the spillage current produced by the galvanic association between the PV module and grid [8-9]. The traditional flyback converter has the littlest circuit parts and circuit size. In any case, it has burdens of the low voltage increase, high voltage worry of the rectifier diode, and high voltage spike issue of switch[10-11]. To take care of these issues, the dynamic clamp flyback converter with a voltage doubler was presented.

The proposed converter utilizes the quasi-resonance among C_1 and L_{lk}. Contrasted with the past converter it can decrease the turn off current of S_1 and obligation loss of the circuit in view of the quasi-resonance among C_1 and L_{lk}. Along these lines, this converter of has the littler turn off misfortunes and more extensive voltage at the input side run than that of past converter

PROPOSED SYSTEM

In proposed system shown in Fig 1 the PV panel input voltge is fed to the DC load with the help of half bridge boost converter which converts the DC voltage with AC voltage with some boost ratio and then it converted AC voltage is stepped up using turns ratio of transformer and then voltage doubler circuit converts the doubles the AC voltage to DC voltage which drives the load.

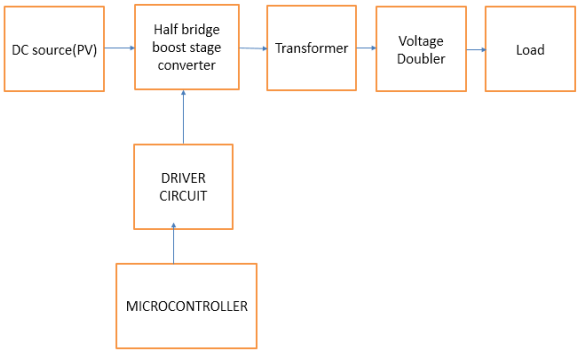

Fig 1. Block Diagram of Proposed System

The siwtching pulses to the switch is given by microcontroller which is amplified by the driver circuit.

II. MODELS

A. PROPOSED CONVERTER

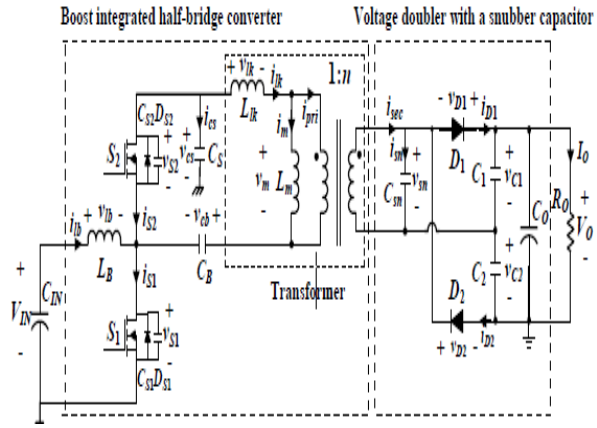

Fig 2. Circuit Diagram of Quasi Z source inverter

The proposed converter has a combined structure of a boost integrated half-bridge converter on the primary side of the transformer and a voltage doubler with a snubber capacitor on the secondary side. The boost integrated half-bridge converter consists of a boost inductor (L_b), two switches (S_1, S2), a storage capacitor (C_s), a blocking capacitor (C_b), and a transformer with a leakage inductance (L_{lk}), turn ratio of 1:n, and a magnetizing inductance (L_m). It performs the operation of the boost converter of stepping up the input voltage (V_{in}) to the higher voltage (V_{Cs}) of C_s. It then performs the operation of the half-bridge converter of transferring the electric energy from Cs to the load (R_0). An Isolation Transformer is used to step up the Voltage of BHB Converter. The voltage doubler with a snubber capacitor consists of two diodes (D_1, D_2), a snubber capacitors (C_{sn}), two capacitors(C1, C_2), and an output capacitor (C_O). It generates a DC output voltage (V_O) of twice the secondary voltage of the transformer and reduces the voltage stresses of D_1 and D_2 to V_O. The simple PWM circuit has been used to give the switching pulses to the switches. The swithces S_1 and S_2 works complemetary for giving the AC like signals. The circuit diagram of proposed converter is shown in Fig 2.

The operation includes when switch S_1 is in ON condition the positive cycle is generated, switch S_2 is responsible for the negative cycle generation. The input boost inductor L_b charges and discharges linearly with respect of switching condition of switches S_1 and S_2.

B. DRIVER CIRCUIT

A driver is an electrical circuit or other electronic component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), and numerous others. They are usually used to regulate current flowing through a circuit or to control other factors such as other components, some devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. Typically the driver stage(s) of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier circuit, typically the driver circuit requires current gain often the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

C. MICROCONTROLLER(PIC16F877A)

The term PIC, or Peripheral Interface Controller, is the name given by Microchip Technologies to its single – chip microcontrollers. PIC micros have grown to become the most widely used microcontrollers in the 8- bit microcontroller segment. The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features 200 ns instruction execution, 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire SPI or 2-wire I2C bus, a USART, and a Parallel Slave Port.

III. RESULTS

Fig 3 shows the overall hardware setup of proposed converter for the measurement and acquisition of Input & Output Waveforms.

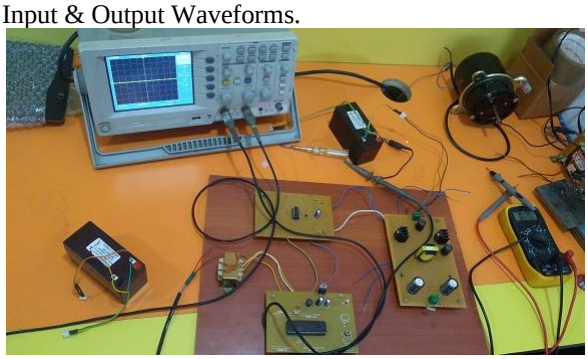

Fig 3. Overall hardware setup

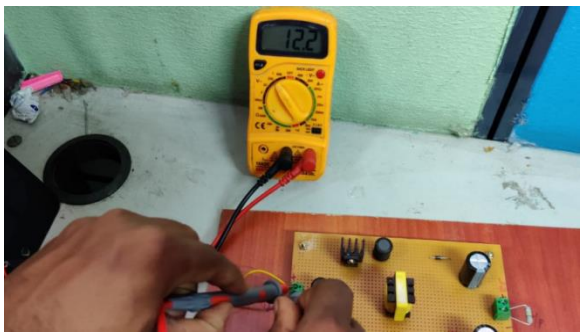

Fig 4. Input voltage of 12V

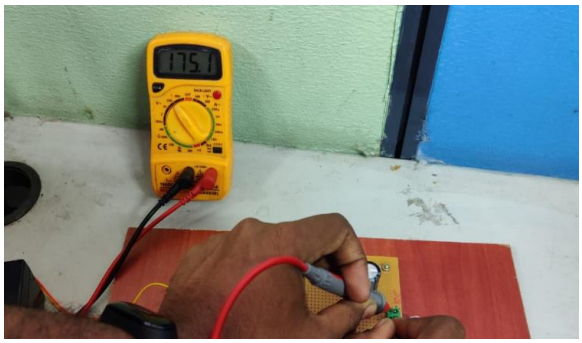

Fig 5. Output voltage of 175V

Fig 4 & 5 show the input and output voltage of proposed converter

IV. OUTPUT WAVEFORMS

The Input and Output Waveforms were captured in Digital Storage Oscilloscope (DSO). Fig 6 shows the the Input DC voltage fed from a Solar Panel or any DC source (12.5 Volts).

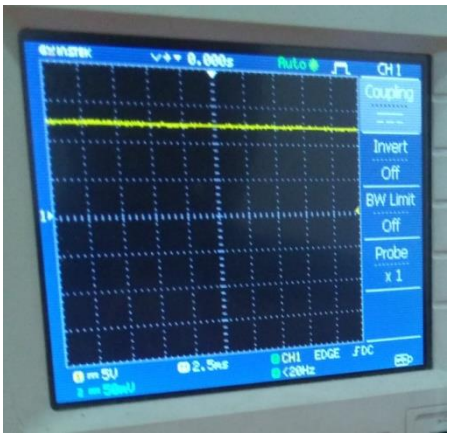

Fig 6. DC Input to BHB Converter

Fig 7 shows the Switching Pulse to MOSFET so that the DC input given to the BHB Converter Switches ON and OF the S1 & S2 pair of MOSFETS.

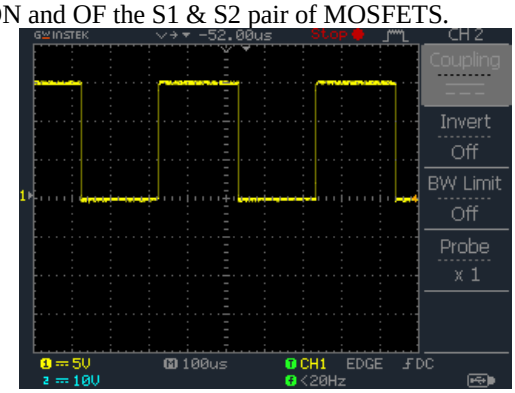

Fig 7. Switching Pulse to MOSFETs S1 & S2

The Output of BHB Converter and input to primary of the Transformer is shown in Fig 8.

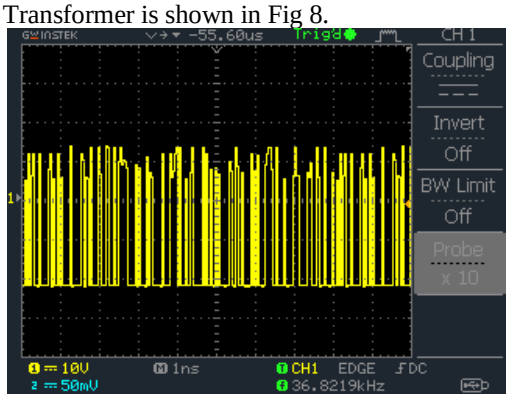

Fig 8. Input to Primary of Transformer

Fig 9 shows the waveform available in the secondary of the Transformer. The voltage is stepped up here and is fed to the Voltage Doubler.

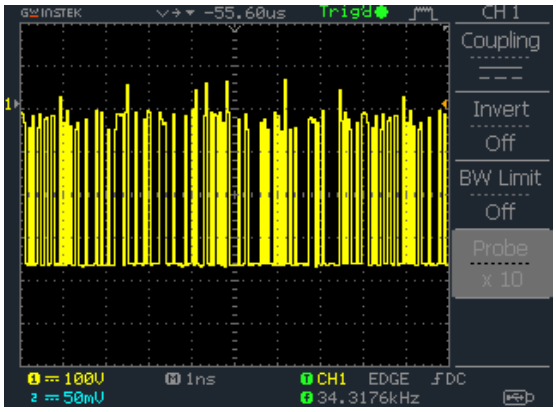

Fig 9. Voltage avaialbe at Transformer Secondary

The Voltage Doubler doubles the Voltage and then to eliminate the spikes Snubber Capacitors are introduced. Fig 10 shows the Output wave form of the Voltage Doubler and Fig 11 shows the final DC output after Snubber Circuit.

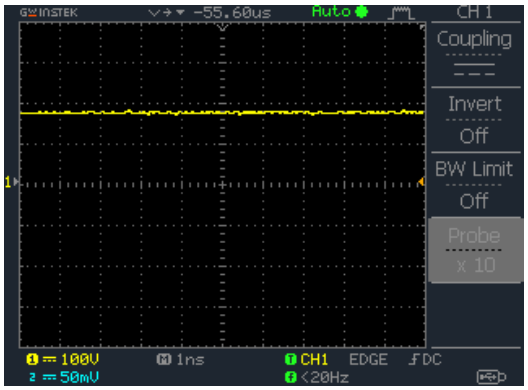

Fig 10. Output after Voltage Doubler.

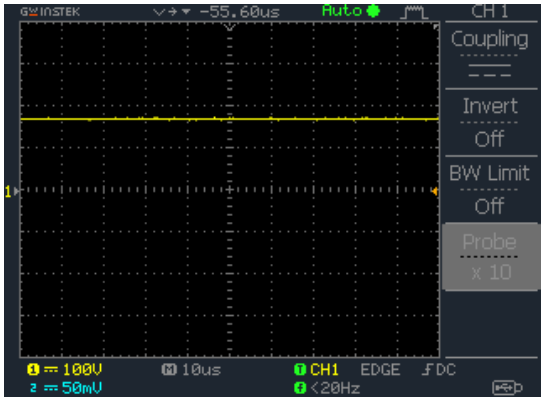

Fig 11. Final DC Output after Snubber Circuit

V. CONCLUSION

This paper presented a hardware implementation quasi-resonant boost half-bridge (BHB) DC-DC converter with high power conversion efficiency (η%) and a wide input voltage range. Moreover, the proposed converter had no DC-magnetizing current of the transformer, and the voltage gain was increased by using the voltage doubler with a snubber capacitor to reduce spikes.

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Hardware Implementation of Improvement in Power Quality by using Advanced Reactive Power Compensation

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Abstract

In this paper it is decided to improve the power quality of power supply. When the power quality is poor at load side which can cause other equipment malfunction even damages the associated devices. Therefore, a reactive power compensation method is suggested to improve the power quality in a distribution power system. To improve the power quality by using the facts device is one of the conventional methods; in our paper we inject the reactive power by using same real power supplying system.

1. Introduction

The power quality (PQ) problems and solutions to theseproblems have gained much importance in recent years.The main causes for poor power quality are: extensive use ofnonlinear loads in distribution system for efficient andcontrolled use of energy, integration of distributed generatorsbased on the renewable power (such as, solar and wind) andthe occurrence of frequent faults on the electrical network.Under the generic name of custom power devices [2] a newgroup of compensators like dynamic voltage restorer (DVR),the distribution static synchronous compensator(DST A TCOM) and unified power quality conditioner (UPQC)have been developed and used for improving power quality inthe distribution system. Some of the critical loads like dairyfood industry, chip manufacturing industry, large computer networks etc. are very sensitive to supply related powerquality problems. Voltage sags, swells, transients, unbalanceand harmonic distortion are major power quality problems in the supply voltage. These power quality problems can beeffectively compensated using a DVR.The DVR is a voltage source converter (VSC) based powerelectronics device connected in series between the supply andsensitive loads through a series transformer. It can protectsensitive loads from supply side voltage quality problems byinjecting the compensating voltage into the distribution line.When the injected voltages by DVR are in quadrature with thefeeder currents, it does not require any active power forcompensation. A small amount of active power to overcomethe DVR system losses however should be supported toachieve a self-supporting DC bus.

The disadvantage ofquadrature voltage injection is that in case of a voltagesag/swell event the restored voltage may not be in-phase withpre-sag/swell voltage and, the compensation range is highly dependent on load power factor [15].The different topologies of DVR and its protection arediscussed in [9-10]. The analysis, design and voltage injectionschemes of a self-supported DVR are explained in the [2, 11].In [11-24], different control strategies have been developed forthe control of the DVR. Some of the popular techniques are:the instantaneous reactive power theory (IRPT) [4],synchronous reference frame theory (SRFT) [12, 24], adalinebased fundamental extraction [13], instantaneous symmetrical component theory (ISCT) [14, 15], and space vectormodulation [19].The frequent unsymmetrical faults in the power systemgenerally cause the unbalanced voltage sags. To compensatefor such unbalanced voltage sags, DVR needs to injectcompensating voltages with both positive and negativesequence components. These can be achieved using twoseparate proportional-integral (PI) controllers, each for positive and negative-sequence voltages, in d-q synchronousframe [24]. The approach proposed in [24] is computationallyintensive due to the transformation from stationary frame tosynchronous frame and vice-versa.In this paper, a new control algorithm is developed based onestimation of instantaneous load reactive power for generationof reference load voltages in the stationary reference frame.The load voltages are controlled to its reference values usingPR controller in the stationary reference frame. A PR controller achieves good positive and negative-sequencefundamental voltage regulation simultaneously as it has highgains around both positive and negative-sequence fundamentalfrequencies [23]. Then implementation of DVR using VSCwith PWM control is discussed in this paper. The extensivesimulations are performed using MATLAB with its Simulink and Sim Power System (SPS) tool boxes for verifying theproposed control algorithm for DVR.

2. Materials and Methodology

In the system consists of ac source and PV panel, DC-DC converter, voltage source converter, and filter used for supplying real and reactive power without using external facts device.AC source provide the real power to the system, when there is consumption real power increase in load side to compensate the power by feed the reactive power by the voltage source inverter with use of capacitor bank.Voltage source converter, convert the dc into ac to the distribution line

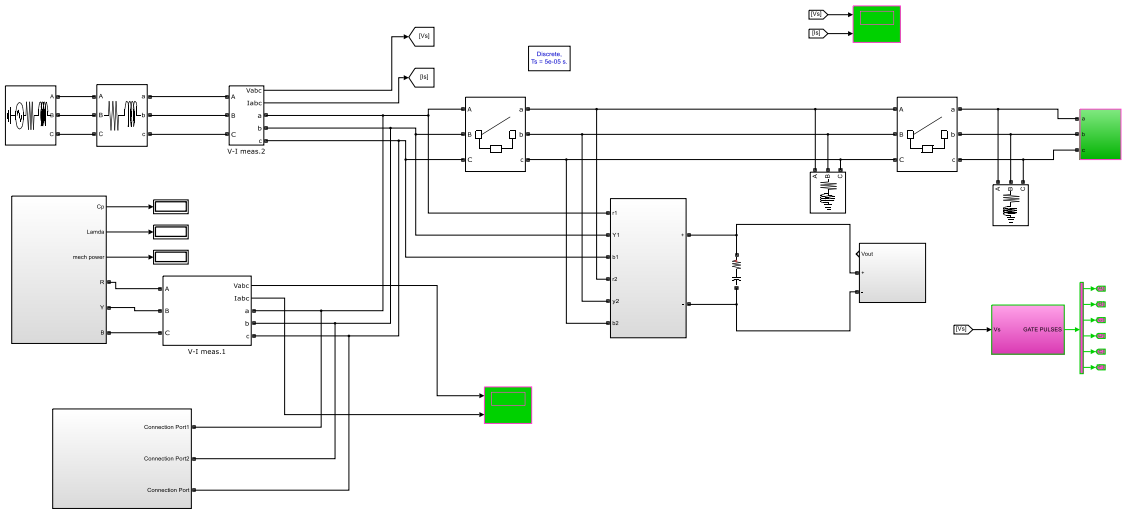

Fig.1.Simulation Diagram of the proposed system

3. Results and Discussion

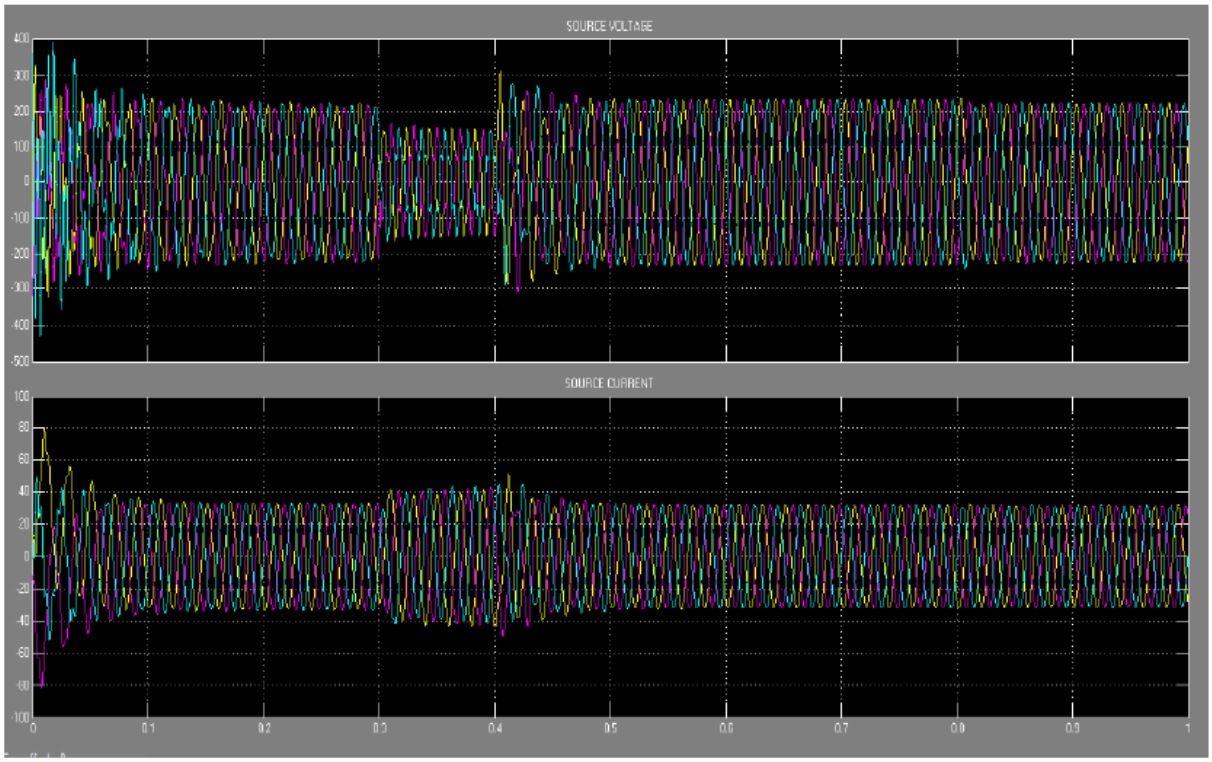

Fig.2.Source voltage before and after reactive power compensation

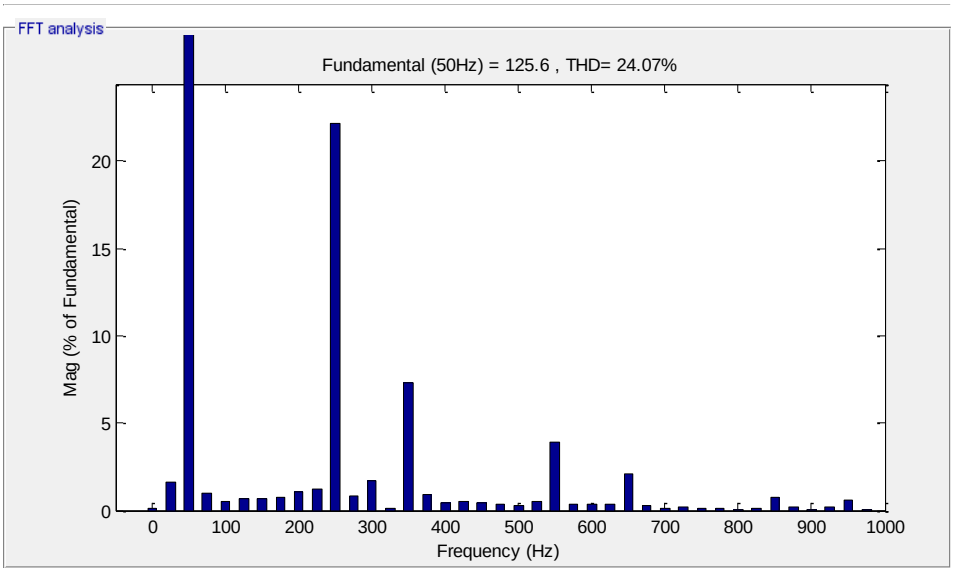

Fig.3. THD before reactive power compensation

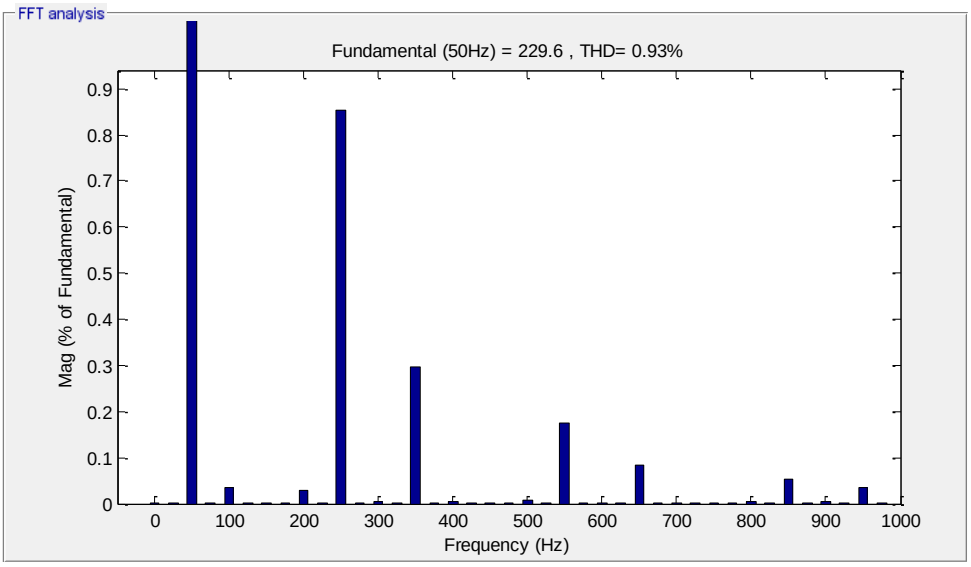

Fig.4. THD after reactive power compensation

4. Hardware Implementation

To repay the reactive power misfortunes in the transmission line and any place in the electrical influence framework, we have completed the writing survey of the different papers and embraced the distinctive procedures to defeat this issue. We have utilized the shunt and series arrangement strategies, in which the compensator like capacitor will be given in parallel and in series to the

inductive load. Since there is dependably a voltage and current transient upon the changing the capacitor steps. Henceforth we adopted the FACTS (Flexible AC Transmission Systems) gadgets to beat the responsive force remuneration issue. The studies for the different FACTS gadgets were completed and we discovered the STATCOMs (Static Synchronous Compensators) is the present day and the most productive approach to conquer the responsive force pay. The different strategies were done for the STATCOMS.

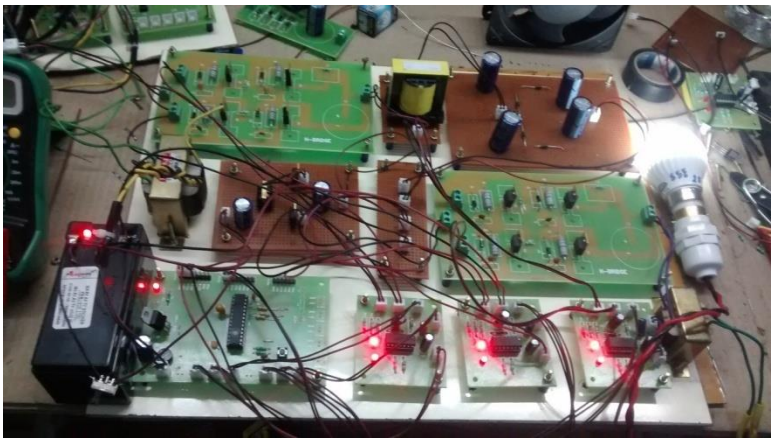

Fig.6.Hardware circuit

To compensate the reactive power in three phase AC system by using STATCOM Static Synchronous Compensator is one of the static component device and comes under the family of FACTS devices. It can absorb or supply reactive power in the single or three phase AC systems. A transmission network reactive power can be compensated using Static Synchronous Compensator. It also helps in preventing fluctuations in the transmission system like sudden voltage increase (voltage sag), sudden voltage decrease (voltage sag), transients etc. A STATCOM comprises of a three phase inverter utilizing SCRs, MOSFETs or IGBTs, a DC capacitor (which when charging will absorb reactive power and while discharging will supply 17 reactive power), a connection reactor whose purpose is to link the inverter output to the AC supply side, channel parts to channel out the high recurrence segments because of the PWM inverter. From the DC side capacitor, a three stage voltage is produced by the inverter. This is synchronized with the AC supply. The connection inductor interfaces this voltage to the AC supply side. This is the essential standard of operation of STATCOM.

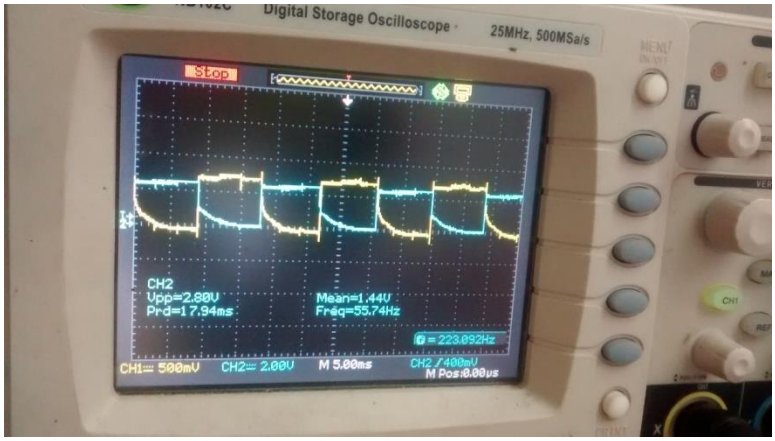

Fig.6.Before Reactive Power Compensation

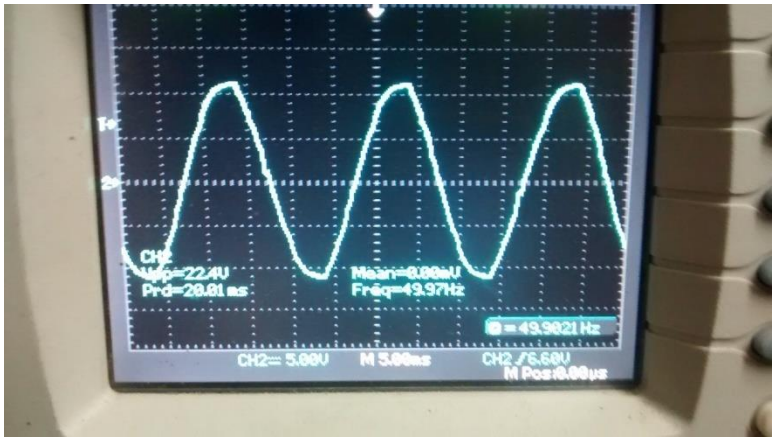

Fig.7.After Reactive Power Compensation

5. Conclusion

The reactive power compensation has been done using Renewable energy based dynamic voltage restorer and static compensator. The results of total harmonic distortion(THD) have been utilized to verify the simulation results. In this article PV based FACTS device has been successfully applied for reactive power compensation, the THD level before compensation is 24.07%, and after reactive power compensation it has been improved to 0.93%.

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Study on Intelligent Data Algorithms Implemented in Wearable for Sports Applications

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Abstract: Technological transformation is unlocking new opportunities in wearable devices used in sports application. Nowadays training the sports involves the use of integrating smart sensors, cameras, internet of things and intelligent data algorithms into a device which is wearable making the players to achieve their maximum performance. These smart devices replace the coach and manage all aspects of technical training except for the physical training given by the real coach. This paper provides a comprehensive study on the intelligent data analysis made on the data acquired from sensors to give a meaningful sense to it. The smart training methods employed currently in various sports are identified and presented. The future directions in this area of research are also presented.

Keywords: Wearable devices, intelligent data algorithms, sensors, technical training, sports

1. Introduction

The technological boom has influenced in all areas of human life. Smart devices have changed the way of looking the world. Sports field is not an exception. Wearables take new dimension in monitoring sports activities of the player. These devices incorporated with smart algorithms help the player to understand his performance and help him to compete to next level. Due to developments in internet and cloud services the collected data from sensors can be worked in a detailed manner. Here clever algorithms can be applied which extracts the features, train the data set and can be tested to verify its accuracy. With these resources the devices now become smart Artificial Intelligent (AI) devices which will help the player to train himself and achieve better results. Section 2 discusses the role of wearables in smart training. Section 3 briefs the sensors that are commonly used in devices. Section 4 summarizes the intelligent approach used in the sports wearables and the results obtained. Section 5 lists the challenges faced and section 6 concludes with the limitations and identifies the scope of futureresearch.

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2.Wearables in SportsTraining

The role of coach for a player is very important. Unfortunately all aspirant players do not get their dream coach. Sometimes financial support also poses some problem. So, wearable technology could reduce this burden by providing solution to the above problem. Intelligent algorithms incorporated in these devices gives clues to the player so that he can understand his game profile and take necessary steps to correct and achieve histarget.

Two important sections in wearable device are,

1. Hardware

a. Sensor selection
b. Noise removal
c. Communication to the decision making subsystem

2.Software which takes decision based on acquired signals.

The tasks performed during training require physical effort and it is a continuous process where the ultimate goal is to improve the perfection in the game played. The various stages involved in sports training are,

- Data acquisition
- Intelligent dataanalysis
- Assessment
- Targetrealization

The flow diagram for the sports training is shown in figure 1,

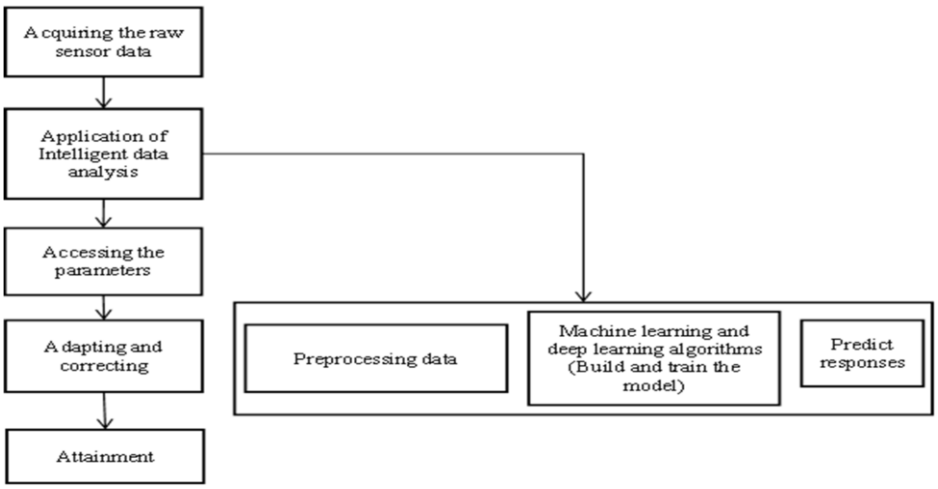

Figure 1. Flow diagram for sports training

3. Sensors

The important consideration for developing a wearable device is the selection of sensors. The sensors should be reliable, small in size, light in weight and durable. The data's from sensors can be used in activity recognition i.e. understand the body kinematics and movement parameters. The machine learning algorithms can be applied on the collected data's to bring out predictions. To get best results the user has to select the suitable algorithm to get the desired insight. The algorithm can be supervised or unsupervised. But all data processing algorithms cannot run on the device itself due to lack of its computational capacity, memory constraints and power back up. So with Bluetooth or wireless module the data's can be transported to a mobile or cloud services where intelligent algorithms can be performed to aid the player in decision making. This virtual coach assists the player in his training replacing the actual trainer. The various sensors deployed in sports wearables are inertial measurement unit which involves accelerometer, gyroscope and magnetometer, pressure sensor array, force sensor, motion sensor etc.

4. Intelligent data algorithms in sports

Intelligent data algorithms and data set can provide a method to analyze the performance parameter of an athlete and can improve his training plan to achieve the best results. Table 1 summarizes the information such as the name of the sport, the sensors used, the features detected, the goal, the classification algorithm and the accuracyobtained.

Table 1. Studies identified in sports wearable sensors with intelligent approach

Ref	Sport	Sensor	Features	Aim	Approach	Result
[1]	Basket ball	Motion sensor	Body acceleration , Gesture	Automatic recognition of basketball training type	Support Vector Machine (SVM)	99.5% accuracy with SVM algorithm or activity recognition
[2]	Basket ball	Accelerometer and Gyroscope	Arithmetic mean and Standard deviation	Classify the action of players	k-Nearest Neighbours (k-NN),Random Forests	Random Forests was more accurate than k-NN
[3]	Fitness	Multiple acceleration sensor on several parts of body/distributed across body	Mean, Maximum, Minimum, Range, Standard deviation, Root mean square	Examine the participant performance on collected data set from a smart wrist wearable device	k-NN, Linear SVM, Naïve Bayes with Gaussian kernel & Bernoulli(NB),SVM polynomial, Decision Tree (DT), Long Short-term Memory (LSTM)	LSTM is best with an accuracy of 92.5%

[4]	Fitness	Accelerometer and Gyroscope, Pulse rate sensor	Mean, Standard Deviation	Classify the indoor exercise activity such as biceps curl, Row, Pushup, Sit up, Squat and Triceps curl	k-NN,SVM, DT	95.3% accuracy for activity recognition and 99.4% for repetition count
[5]	Running	Wireless sensor network deployed in the area of training. MTS 400 sensor board, Crossbow MOTE2 IPR 2400	Mean, Standard Deviation	Develop a prototype to support athlete with ambient intelligent algorithms	k-NN, SVM, Spline Interpolation	Classification system achieves and accuracy of 80% in spline interpolation
[6]	Soccer	Data form video recordings	Mean, Maximum, Minimum, Standard deviation	Classify athlete position and predict the number of goals scored in the game	SVM, RF, Linear Regression (LR)	82% accuracy is achieved in RF and LR
[7]	Football	Data from data set at Tottenham Hotspur Football club	Maximum, Minimum	To predict the recovery time after injury without official diagnosis	SVM Radial basis function (RBF) kernel and polynomial kernel, Gaussian process with RBF and Laplace kernel, Artificial Neural Network (ANN)	Accuracy for SVM-98.43%, Gaussian process-97.4%,ANN –98%
[8]	Table Tennis	IMU sensor	Mean, SD, Skewness, Kurtosis	To detect and classify the stroke in table tennis	SVM linear, SVM RBF, RF, k-NN	SVM linear-95.6%, SVM RBF-96.7%, RF-95.7%, kNN-94.7%
[9]	Tennis	Video recordings	3 layer LSTM network	Classifies the activities in tennis shots	LSTM	81.23% to 88.16%
[10]	Volley ball	IMU, EMG sensors and video cameras	Mean, SD	Identifying and classifying the not allowed moves and providing feedback in training sessions	LSTM	F1 score of 0.74 for labels with 2 classes

[11]	Weight lifting	IMU	Mean, Variance, SD	Classifying the weight lifting exercises	SVM, Linear Discriminant Analysis (LDA)	94.36% accuracy in SVM
[12]	Cricket	Recorded videos	-	Develop AI training system to be used as a coach for trainees to become expert in batting, bowling and fielding	Fuzzy, ANN	Good classification accuracy
[13]	Cricket	Data form IPL matches	Mean, SD	To identify the best set of attributes in the player in the match played	SVM	81%
[14]	Golf	Strain gauge sensor, 3-axis accelerometer and 3-axis gyroscope	-	Investigate Golf swing data classification method	Convolutional Neural Network (CNN), SVM	95% of accuracy is achieved in deep CNN than SVM which is 86.8%

5. Challenges

Plenty of research is open in the field of sports training. Some of the challenges to be addressed are:

1. The authors have shown results conducted with certain method and approach and tabulated their findings. But they are not aware whether these methods will be adopted by all athletes over long term. So the researchers can share their views and results with the real world. Can interact with professional athlete and conduct more experiments and provide a wider scope to researchers.
2. Every player is unique, so integrating intelligent algorithms might not provide expected results for all as the body and thinking are different foreveryone.
3. All most all the design of wearables with intelligent algorithms is still in development phase, it means they are available in prototypes only. So with only proper validation these prototypes can be brought out as a commercialproduct.

6. Conclusion

This paper studies the various intelligent data algorithms proposed and implemented in the field of sports training. With technology the minute details of the game can be perceived. The accuracy and complexity of the models involved in this research vary due to the different classification problems that each model is tasked with. The study observes only few sports are concentrated and research should focus on the design and

implementation of wearable in other sports also. Moreover the security issues in data handling also have to be considered.

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CFD analysis of the generic isolated indoor stadium: Impact of wind direction and roof configuration for wind drift in badminton

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Abstract. Indoor stadiums are built to minimise the effects of the environment and weather on sporting events. The shuttlecock in badminton is extremely vulnerable to a slight wind gust caused by ventilation in the indoor stadium. It is critical in elite tournaments to design the driftless court area stadium without compromising player and spectator ventilation comfort. CFD simulation is used to study two roof structures widely used in indoor stadium construction: barrel and gable roofs with two ventilation openings in opposite directions for lateral and longitudinal airflow. The simulation is carried out in 3D steady Reynolds-averaged Navier-Stokes (RANS) using the Shear-Stress Transport (SST) k- ω model. Grid independency is carried out to compare the results with wind tunnel measurement data from the literature. The non-dimensional velocity and coefficient of pressure contour are obtained in the vertical centre plane and horizontal plane (H=0.06m and 0.02m) from the ground. Finally, the gable roof configuration with longitudinal wind direction volume flow rate increased to 26% and the average velocity in the horizontal (H=0.02m) is 0.19 leading to low wind drift near the ground. There is no huge impact on the roof configuration (barrel and gable) compared to the wind direction (longitudinal and lateral) of the opening in the model.

1 Introduction

Badminton is a racket sport played with a shuttlecock made up of feathers surrounded by a hemispherical cork. Due to its lightweight and bluff body shape, it will easily deviate from the actual trajectory even for small wind gusts known as wind drift. The indoor stadium is built to avoid environmental or weather disturbance in sports but in the case of badminton, the indoor ventilation (natural or air-conditioning) wind alters the actual trajectory of the shuttlecock in the tournament [1-3]. This problem is a huge challenge because the reduction of wind drift needs to be achieved without compromising the ventilation for the player and spectator. The lack of ventilation leads to dehydration for the player and discomfort for the spectator. Most of the International tournaments are conducted in a Multi-purpose arena / indoor where no special attention is given to badminton drift [4]. The elite player started

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complaining about the drift which became a huge controversy during the tournaments [1-6]. There were a lot of studies that have been carried out on the cross ventilation effect in low-rise buildings like the effect of roof types, inlet-outlet openings ratios, opening location and building size ratios. The research works in the cross ventilation set up trends in both generic and real-time stadium studies [7-16]. In the case of cross ventilation on generic buildings [7-10], the effect of grid generation, opening size and location, sheltered and unsheltered, numerical and geometrical parameters has been carried out by the researcher through field measurement [11-16], wind tunnel and CFD. From the literature of review, it's evident that almost no studies have been conducted in the generic stadium to understand the influence of wind drift related to ventilation for badminton stadium construction or design. In this paper, we are going to study the impact of roof configuration and opening wind direction in the different roof stadium configurations through Computational Fluid Dynamics (CFD) to understand the best design for less wind drift near the ground and effective ventilation in the stadium. From the ventilation point of view, this paper is not only trying to understand the volume flow rate, but also the mean velocity on the given area of the flow of the indoor air to eliminate the drift. This paper deals with a couple of approaches to understanding indoor and outdoor interaction. The simulation results are validated with a literature paper [17] which provides detailed wind tunnel PIV data for an isolated building with a flat roof with opposite openings.

2 Wind Tunnel Experiment

The wind tunnel experiment is conducted by Karava et al [17] for the isolated generic wind-induced cross-ventilation building model for a flat roof for different configurations of opening location and size. The experiment is conducted in the boundary layer wind tunnel with a test section 180 X 308 X 96m^3 at Concordia University, Canada. The experiment is conducted in the nine-configuration model with three different porosity (opening area-to-wall area) of 5%, 10% and 20% respectively. In the experiment, a reference velocity of 6.6m/s at the building height. In this paper, the CFD investigation is carried out on the rectangle opening located on the opposite side (top region) at a height of 57mm from the ground at 10% porosity for validation purposes. For more detail on the experiment refer [17].

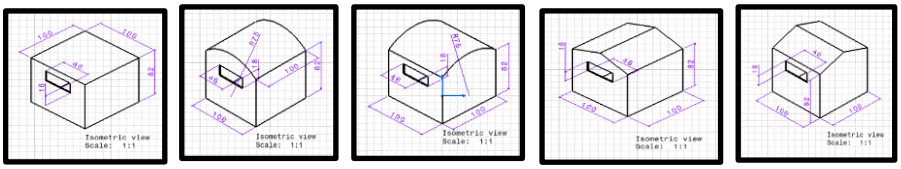
3 Indoor stadium and CAD development

The indoor stadium generally uses two types of roof configurations:- Barrel roof and Gable roof. The flat roof configuration is developed as per the dimensions of Karava et al to compare the CFD simulation results with the wind tunnel data. The validating model is developed for the dimensions 100 X 100 X 180 mm^3 which is a reduced model of the 20 X 20 X 16 m^3 full-scale dimension at a 1:200 ratio. The models are with top opposite rectangle opening configurations with 10% porosity (18 X 46 mm^2). The same dimension as the validating model with a barrel and gable roof is designed for the CFD simulation. For the roof dimension for all configurations refers to Figure 1.

4 CFD simulation

CFD gains importance in urban physics research like aerodynamics studies for buildings and stadium infrastructures. CFD is used in studying natural ventilation, wind loads, pedestrian comfort, and pollution dispersion. Also, play a huge role in designing the sports stadium with ventilation efficiency and low wind disturbance in the play area. In this

paper, CFD is going to be employed based on the literature research carried out by Blocken et al for the cross-ventilation studies for generic isolated buildings.

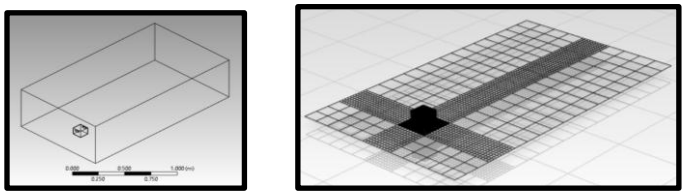


(a) (b) (c) (d) (e)

Fig 1. (a). Isometric view of the Karava et al [17] reduced-scale model with an opposite opening at the top (in mm). (b). Isometric view of barrel roof with longitudinal wind direction opening at the top (in mm). (c). Isometric view of barrel roof with lateral wind direction opening at the top (in mm). (d). Isometric view of gable roof with longitudinal wind direction opening at the top (in mm). (e).Isometric view of gable roof with lateral wind direction opening at the top (in mm).

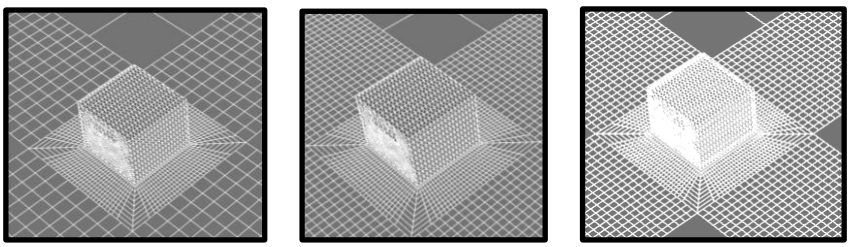
4.1 Domain and grid generation

The cuboidal computational domain is constructed at the ratio 1:200 scale of the wind tunnel. The domain size and the grid generation technique are adopted based on the work carried out by Perén et al. The distance between the front of the building and a domain is three times the height of the building, the distance between the side and top wall is five times the height of the building and the rear to the domain is fifteen times the building height as shown in Figure 2a. The mesh generation is focused on all directions of the building and concentrated meshing in the building and surroundings shown in Figure 2b. The grid sensitivity study is carried out for the validating simulation and is shown in Figure 3 - (a). Course mesh with 2,09,796 elements, (b). Reference mesh with 4,31,796 elements and (c). Fine mesh with 6,92,521 elements. This analysis is carried out to improve the simulation accuracy and optimize computational timing. For grid analysis results refer to section 4.4.



(a) (b)

Fig 2. (a). Isometric view of the computational domain. (b). Isometric view of meshed model and ground



(a) (b) (c)

Fig 3. Grid independency analysis (a). Course mesh model with 2,09,796 elements. (b). Reference mesh model with 4,31,796 elements (c). Fine mesh model with 6,92521 elements.

4.2 Boundary Condition

In the domain the front wall is the inlet plane and the rear is the outlet plane. Symmetry condition is applied to the top and both lateral walls of the domain. In the inlet, ABL is imposed based on the wind tunnel measurement. The inlet wind velocity profile is defined based on the logarithmic law given in Eq. (1) below.

$$U(z) = \frac{U*}{\acute{k}} ln\left[\frac{Z+Z_0}{Z_0}\right] \qquad (1)$$

Where, Z_0 is from the experiment [17], $U*_{ABL}$= 0.35m/s, $\acute{k}$ is von Karman constant (0.42) and Z is the height of the domain. The turbulent kinetic energy [k], turbulence dissipation rate [$\boldsymbol{\varepsilon}$] and specific dissipation rate [ω] is calculated based on the reference [7,8]. In the outlet pressure, zero static pressure is applied and in the symmetry condition, zero normal velocity and gradient are imposed.

4.3 Solver setting

The ANSYS-Fluent commercial CFD code is used, 3D steady Reynolds-Averaged Navier-Stroke (RANS) solved with shear-stress transport (SST) k-ω model as per the recommendation of Perén, Ramponi and Blocken. The second order is used for the discretization scheme, pressure interpolation and pressure coupling with the SIMPLE algorithm. The convergence is obtained in scaled residuals with a minimum of 10^{-6} for x and y momentum, 10^{-5} for z momentum, 10^{-4} for k, ω and continuity [7-10]. To obtain a reliable value, the iteration is monitored till 10,000 iterations to reach a stationary solution.

4.4 Grid independence analysis and Validation

The non-dimensional length (X/D) horizontal measurement line is created between the inlet and outlet opening to measure the non-dimensional velocity for grid analysis and validation. In all three mesh cases, the simulation is carried out on a flat roof and mean velocity (V/Uref) is compared along the measurement line between the opening. The reference mesh results argue to be a better choice of selection over a course mesh due to the large deviation from the actual and fine mesh compared to the reference mesh model shows almost the same result by costing high computational timing. We conclude that the reference mesh model is suitable for this study and same is used for the remaining model in this paper. The obtained CFD results of the reference mesh model are compared with the Karava et al V/Uref measurement along the horizontal line between the opening which shows the agreeable result of accuracy, refer to Figure 5.

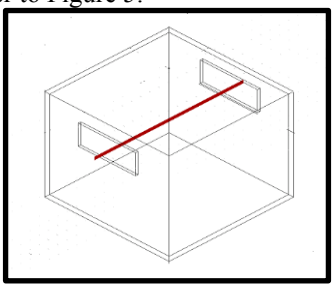


Fig 4. Indication of the horizontal measurement line in the model to measure the non-dimensional velocity between the inlet and outlet opening.

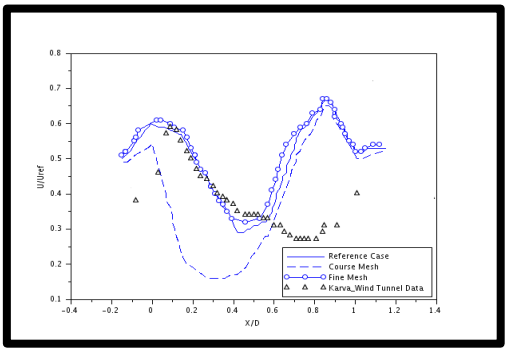


Fig 5. Comparison of mean velocity across the horizontal line between the opening for Reference Case, Course Mesh, Fine Mesh and PIV Measurement.

5 Impact of the roof configuration and wind direction opening type

To understand the roof impact on the ventilation and wind drift in badminton stadiums, two roof configuration with two wind directions (Longitudinal and Lateral) is considered in the study. To understand the influence, the same inlet and outlet opening type with the same dimension is used in all models. The non-dimensional velocity and coefficient of pressure contour are obtained in the vertical centre side plane and the horizontal plane at heights 0.06m and 0.02m from the ground as shown in Figure 6.

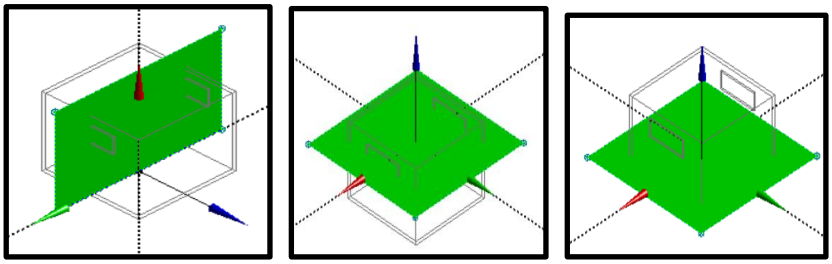


Fig 6. Contour measurement plane (a). Side plane at the model centre (b). Top plane at height from the ground is 0.06m and (c). Top plane at height from the ground is 0.02m

In general, the longitudinal wind flow opening has a much high volume flow rate compared to the lateral as shown in Figure 7. The Cp and |V|/Uref contour for flat roof and other roof configurations is shown in Figures 8, 9, 10, 11 and 12. The longitudinal gable roof has lower wind drift and better volume flow rate compared to other configurations. The lateral barrel roof also accounts for good ventilation and decent wind drift near the ground. The high Cp is found on the leeward side (inside the rooftop) of both roofs in the lateral wind direction. The longitudinal wind direction holds a high Cp inside compared to the lateral wind direction in both roof cases (barrel and gable). In the longitudinal direction, the roof can only accommodate low volume on the top side between the opening for the exchange of airflow but in the lateral direction having a uniform volume at the top between the opening gains the advantage. From non-dimensional velocity (V/Uref) measurement along the horizontal line

between the inlet and outlet opening refer to Figure 3, for both roofs lateral wind non-dimensional velocity drops largely in the centre compared to the longitudinal wind opening location which impacts the volume flow rate and wind drift.

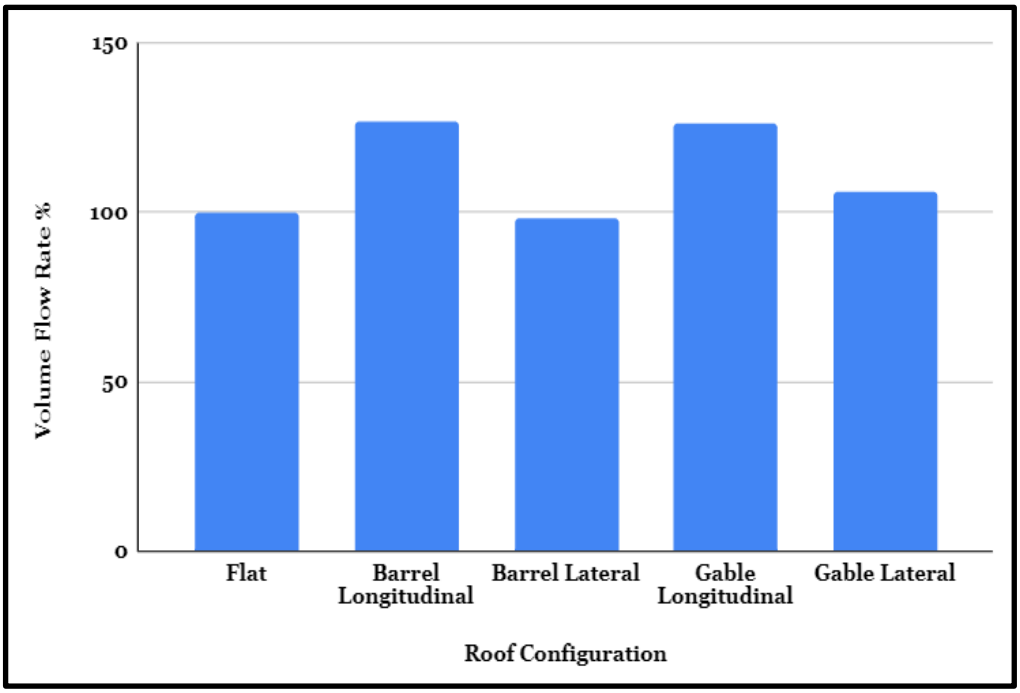


Fig 7. Influence of roof type on volume flow rate

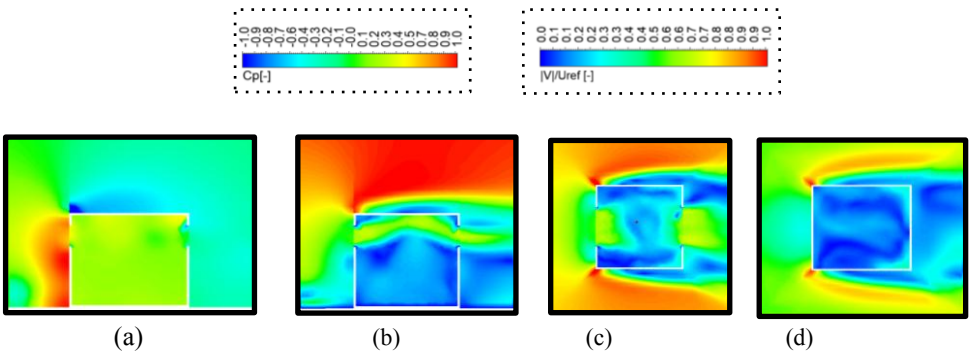


Fig 8. Flat roof Contours (a) Pressure coefficient C_p at side plane (b) non-dimensional velocity |V|/Uref at side plane (c). Non-dimensional velocity |V|/Uref at the top plane (H=0.06m) and (d). Non-dimensional velocity |V|/Uref at the top plane (H=0.02m)

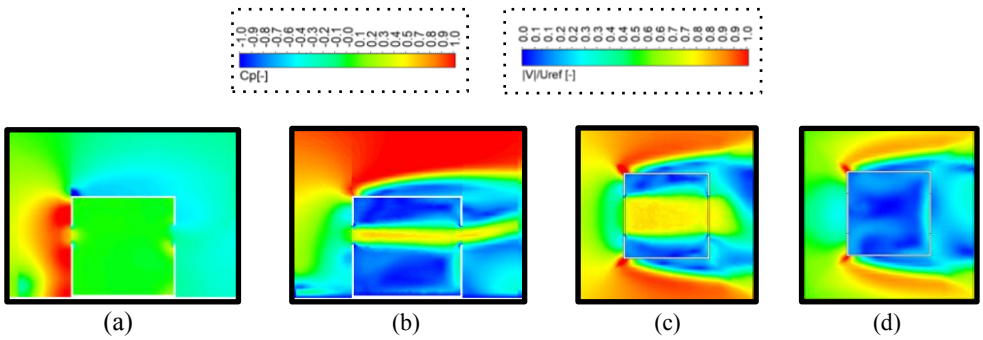


Fig 9. Barrel roof - longitudinal wind direction Contours (a) Pressure coefficient C_p at side plane (b) non-dimensional velocity |V|/Uref at side plane (c). Non-dimensional velocity |V|/Uref at the top plane (H=0.06m) and (d). Non-dimensional velocity |V|/Uref at the top plane (H=0.02m)

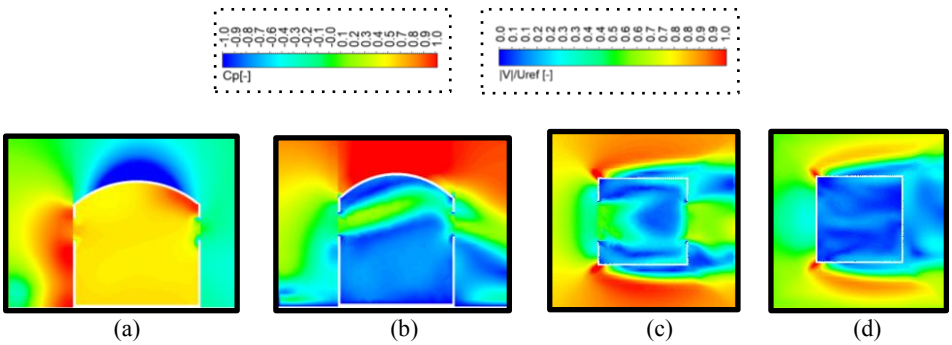


Fig 10. Barrel roof - lateral wind direction Contours (a) Pressure coefficient C_p at side plane (b) non-dimensional velocity |V|/Uref at side plane (c). Non-dimensional velocity |V|/Uref at the top plane (H=0.06m) and (d). Non-dimensional velocity |V|/Uref at the top plane (H=0.02m)

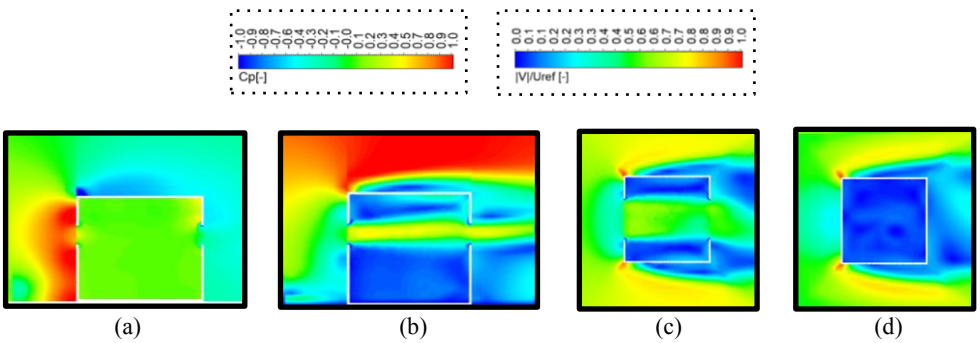


Fig 11. Gable roof - longitudinal wind direction Contours (a) Pressure coefficient C_p at side plane (b) non-dimensional velocity |V|/Uref at side plane (c). Non-dimensional velocity |V|/Uref at the top plane (H=0.06m) and (d). Non-dimensional velocity |V|/Uref at the top plane (H=0.02m)

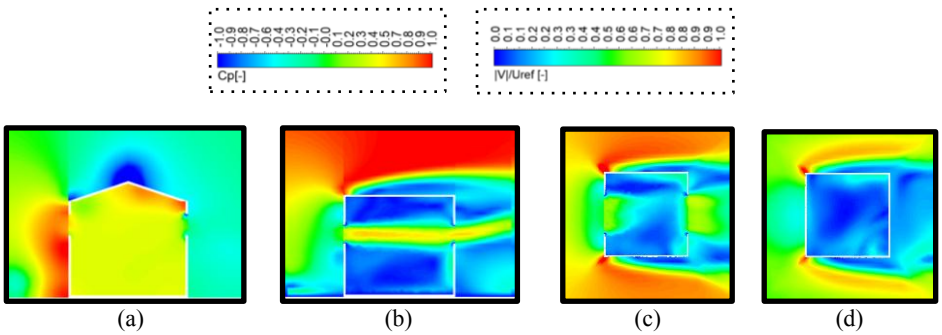
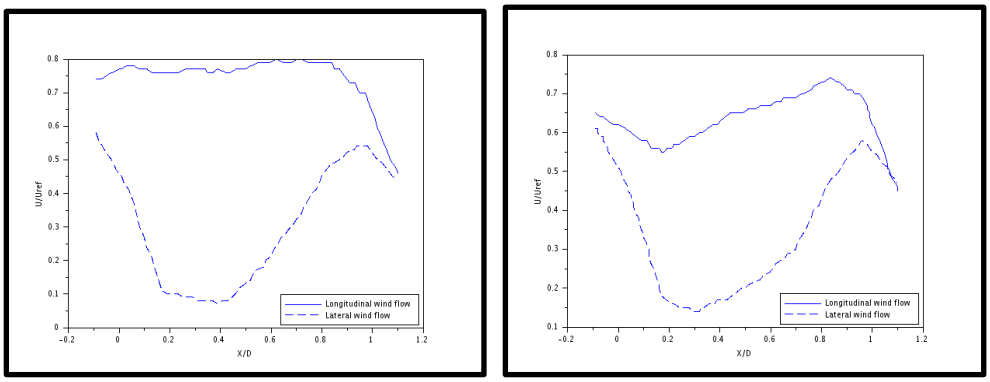


Fig 12. Gable roof lateral wind direction Contours (a) Pressure coefficient C_p at side plane (b) non-dimensional velocity |V|/Uref at side plane (c). Non-dimensional velocity |V|/Uref at the top plane (H=0.06m) and (d). Non-dimensional velocity |V|/Uref at the top plane (H=0.02m)

Table 1. Non-dimensional area-averaged magnitude (|V|/Uref) in the different plane

Model Name	Vertical Plane at the centre of the stadium model	Horizontal Plane at the centre of ventilation opening (0.06m)	Horizontal Plane near the ground (0.02m)
Flat roof (reference case)	0.24	0.34	0.18
Barrel roof Longitudinal wind direction	0.22	0.46	0.22
Barrel roof Lateral wind direction	0.24	0.36	0.20
Gable Longitudinal wind direction	0.23	0.42	0.19
Gable Lateral wind direction	0.29	0.36	0.22

Table 1 shows the non-dimensional average velocity on the different planes in flat and other roof configurations. The non-dimensional average velocity ranges from 0.18 to 0.46, the 0.46 is highest found in the barrel roof configuration in the longitudinal wind opening at the horizontal plane (H=0.06m). and 0.19 is lowest in the gable roof configuration in the longitudinal wind opening at the horizontal plane (H= 0.02m). To understand the wind drift, the horizontal plane (H=0.02m) is studied in all roof configurations, the gable roof in the longitudinal direction has a lower average non-dimensional velocity of 0.19 among other roof configurations and followed by the barrel roof in the lateral direction is 0.20. Both barrel longitudinal and gable lateral directions account for the same average non-dimensional velocity of 0.22. It can be concluded that the Gable roof in the longitudinal direction accounts for the best ventilation with low wind drift in the ground for a badminton stadium. We have found that rather than a roof type (Gable or Barrel), the wind direction opening in the stadium will contribute more impact on ventilation and wind drift effect in the stadium.



(a) (b)

Fig 13. Comparison of mean velocity across the horizontal line between the opening (a) Barrel roof - longitudinal and lateral wind flow (b). Gable roof - longitudinal and lateral wind flow.

6 Limitations and future study

Our main goal in this paper are to understand the influence of ventilation and wind velocity flow pattern near the ground. Based on the obtained results, we could suggest the roof configuration and wind direction opening for the stadium with less wind drift near the ground but without compromising the ventilation. There is some limitation based on other parameters and external factors in our study but can be addressed in future research.

- In all configurations internal building layout is not considered (like stadium gallery) but must be studied.
- All CFD analyses done in the isolation environment, surrounding buildings and other surroundings infrastructure will affect the obtained results.
- Only two majorly used roof configuration for the indoor stadium is taken into account for the study, maybe other new configuration can perform better than an obtained conclusion.
- Parameters like ABL, thermal effect, buoyancy, building height, ventilation opening size, the internal volume of the stadium and other inclined wind direction in the opening will have a huge impact on the ventilation and wind drift in the stadium.

7 Conclusion

The paper presents the CFD simulation results of cross ventilation study for the flat, barrel and gable roof with longitudinal and lateral wind direction. A grid independency study is performed on a flat roof validated with wind tunnel data. Based on the non-dimensional velocity in the horizontal centreline between the opening, non-dimensional velocity contour and Coefficient of pressure contour. We found that the gable roof configuration in a longitudinal direction and barrel roof configuration in a lateral direction is better than other models with efficient ventilation with less wind drift area for badminton.

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Validity and reliability analysis on video-based self-learning of yoga in children

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Abstract

The ongoing pandemic situation has affected almost everyone in some way. Particularly, children were very much affected mentally and physically due to continuous lockdowns imposed in several countries. Furthermore, they are in a position to sacrifice their useful period of learning new things from school or skill development centers or both. However, with the rising availability of an enormous number of educational videos on video-based websites like YouTube, it seems self-learning of new skills is not a big problem anymore. To examine the validity and reliability of one such assertion, five popular yoga training videos from YouTube were taken and experimented with children to test the possibility of self-learning of yoga. Two-dimensional video analysis of virtual yoga instructors and children from two different age groups practicing yoga poses were executed by using advanced smartphone cameras and video analysis software tool kinovea. The extracted key-frame images were subjected to semi-automated annotations of various angles between the body parts of the instructors and the participants. And mathematical modeling was usedthrough comparison of angle measurements with statistical MAE (Mean Absolute Error) calculation of angle variations, differences in annotated body shape features, side-by-side time/frame rate measurements, and minor errors identification to conclude that self-learning of yoga is only partly valid and is less reliable for children.

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Monitoring Biometric Data of a Player Using a Wearable Device in Real Time for Sports Applications

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Abstract
On-field heart rate and physiological fitness makes the player more active on the ground if his fitness level is maintained from beginning till the last. This is the current demand in the modern sports field. For this reason researchers are developing devices to be incorporated in training sessions to monitor the health parameters and the physical fitness of the players. The aim of the research paper is to present a wearable device to obtain the biometric information that is, the muscle contractions, temperature and pulse rate of a player during his training session. Strain gauges are used to predict the muscular contractions in non-invasive way to forecast the muscle strain for every shot during sports activity. The designed wearable system includes the integration two strain gauge sensors placed on human arm, along with the temperature and pulse sensor encapsulated into a separate module. The developed system measures the strain, temperature and pulse rate in real time and updates the player with these details instantly. A dedicated user interface is developed so that the player and the coach can review the health details instantly in his mobile or laptop. The prototype is powered with a 10,000 mAh rechargeable battery.

Keywords Wearable device · Biometric data acquisition · Sports training · Strain gauge sensor · Non-invasive

1 Introduction

Sports always play a major role in human life and with the advent of new technology it is gaining importance in recent years. Low cost and miniaturization of devices led embedded system to monitor the sports activities and biometric applications. In [1] sensors are used to monitor the physiological variables such as strain, force, vibration, muscle activity, temperature and heartbeat rate. Monitoring the real time details of a player helps to improve his performance and access his physical parameters instantly as in [2]. Sometimes

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overstrain might lead to injuries to the player. Early signs of injury to soft-tissues are readily detected, letting coaches relieve players before serious problems arise. A muscle contraction sensor was developed to measure muscle contractions in a non-invasive way [3]. It was implemented and tested by analyzing the values in time domain with the actual force developed by the muscle. Connaghan et al. [4] the vital signs of the player such as temperature, heart beat are captured in real time to know the fatigue and endurance of the player during his practice sessions. The wireless communication has enabled wearable devices embedded with sensors and wifi to easily communicate the physiological information to the user via smartphone or his laptop [5].

A wearable system was designed that can detect a particular movement or they support only the fitness metrics like heart rate, calories burnt, etc., but do not provide information on the muscle force that cause strain [6]. But the proposed wearable device measures the arm strain encountered in a particular stroke and also measures the on field body temperature and heart rate of the player during the training sessions. So this would help to understand the mechanics of human movement and motor control. The physiological responses like heart rate, oxygen uptake, respiratory exchange ratio, energy expenditure of batsmen were determined during a simulated One day International century match [7, 8]. The pulse rate variation and blood oxidation content were measured by a wrist wearable device without disturbing the user in any way [9]. Monitoring the physiological parameters like respiration rate and volume changes is possible with low power piezoelectric sensors like resistive strain gauge [10]. These sensors can be combined with Bluetooth units in wearable device and measure the parameters continuously.

A methodology was proposed to measure strain using strain gauge sensor where the data acquisition is done by low cost microcontrollers [11]. The results obtained were satisfactory and was verified by using finite element analysis software. The strain gauges were used to detect muscle contractions and showed a better result compared with electromyography sensors [12]. Continuous excessive strain in ankle joints will lead to tear in ligaments. The strain was measured by applying various degrees of stress to the ankle joint and stated the maximum strain rate [13]. The strain gauge sensors were used to find the muscle contractions, which were directly related to change in length of the sensor during muscle contractions [14].

Based on above related work discussed, this paper focuses on developing a wearable device which measures the strain encountered by a cricket player while playing various strokes during his training session and also measuring other basic parameters like heart beat rate and temperature.

2 System Architecture

The magnitude of vibration on the muscles during various strokes may lead to strain and overload the players. In games such as cricket the delivery speed of the ball is greater than 150 kmph for fast bowling. The batsman has to release a proper shot to encounter the ball coming with such high velocity. There are possibilities for the arm to get strained. Measuring the muscle activity at this point gains importance. A system is proposed to measure the strain, temperature and heart beat rate of a cricket player. From these details the information about the physical state of the player can be derived. Figure 1 shows the design of the proposed system.

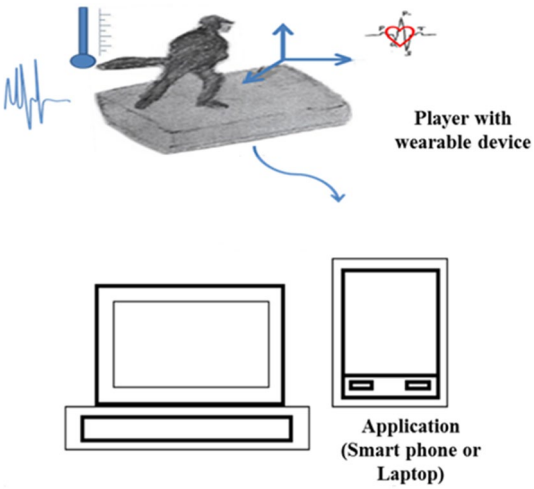

Fig. 1 Architecture of the wearable system for biometric data acquisition

The proposed system consists of three modules: (1) Wearable sensor module for recording strain, temperature and heart beat rate. (2) Processor module and (3) User Interface module to access real time details. All complex process is performed in the processor. The individual modules are presented in detail.

2.1 Hardware Design

The system hardware is designed to measure the player's biometric information. The wearable device is placed on the players gloves to acquire the data. Strain gauge sensors are to be placed on the either side of the elbow for recording muscle contraction while playing various shots.

The heart beat sensor is placed on the fingertip and temperature sensor is placed on the wrist of the player. The sensor placement does not disturb the player's performance. Figure 2 shows the placement of wearable device on the players arm. This data acquisition module operates solely measuring biometric data of the player in real time. The strain gauges which are well known for their accuracy, light weight, flexibility and low sampling frequency are considered a great interest for strain measurements on the human body. Basically the training lasts for 2–4 h, so the module is powered by Lipo rechargeable battery with a specification of 10,000 mAh battery which can lasts for 2 days and it is easily rechargeable so it can be used for prolonged time. Figure 3 depicts the block diagram representation of the proposed wearable device hardware.

The processor employed is a 64 bit RISC ARM cortex A-53 processor. Since the input from the strain sensor is too low it is amplified by HX711 amplifier and is connected to the processor via I2C bus. Also the temperature and pulse sensor is the other input to the processor and they are connected through ADS 1115 an analog to digital converter (ADC). External memory can be connected to the processor. With the inbuilt wifi module data can be transferred to the user form the processor. The strain gauge sensor along with its amplifier, heart rate sensor and temperature sensor are integrated into a separate module to avoid misplacement and can be easily replaced in case of damage. The module is fabricated separately to hold the sensors. Conductive tracks for ADC, amplifier, resistors and interface with the processor are designed and laid out on

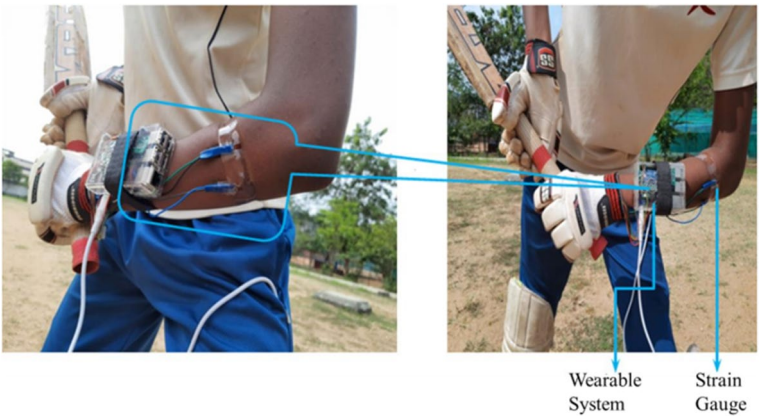

Fig. 2 Biometric data acquisition device position

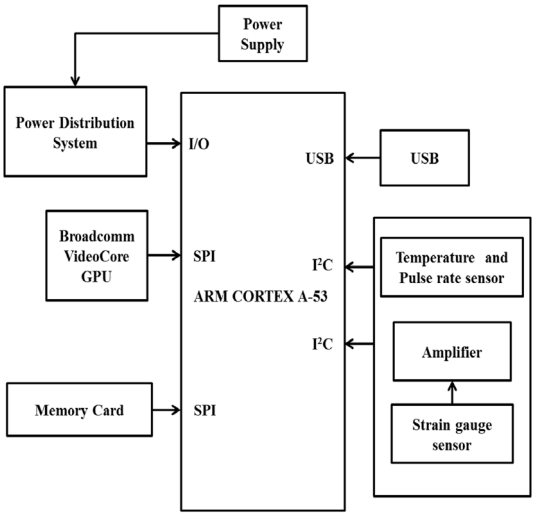

Fig. 3 Block diagram representation of the proposed wearable device

the printed circuit board. This board is then interfaced with the processor. So the circuit remains undisturbed and the sensors can be replaced easily in case of impairment.

Figures 4 and 5 shows the hardware setup and the fabricated printed circuit board.

3 Biometric Data Acquisition

This section discusses the details regarding acquiring biometric data like strain, temperature and heart beat rate. The performance of the proposed system was tested on cricket players. Figure 6 shows the workflow model.

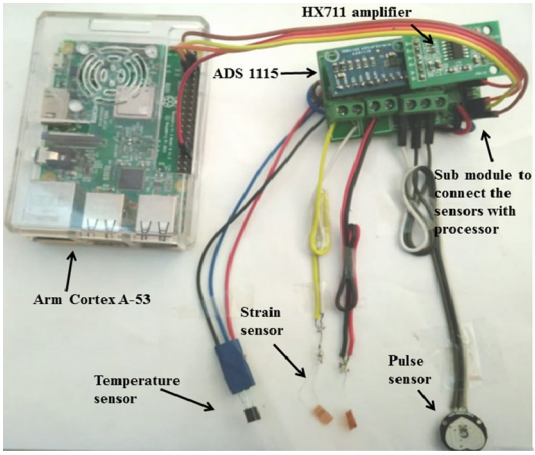

Fig. 4 Hardware setup of the wearable device

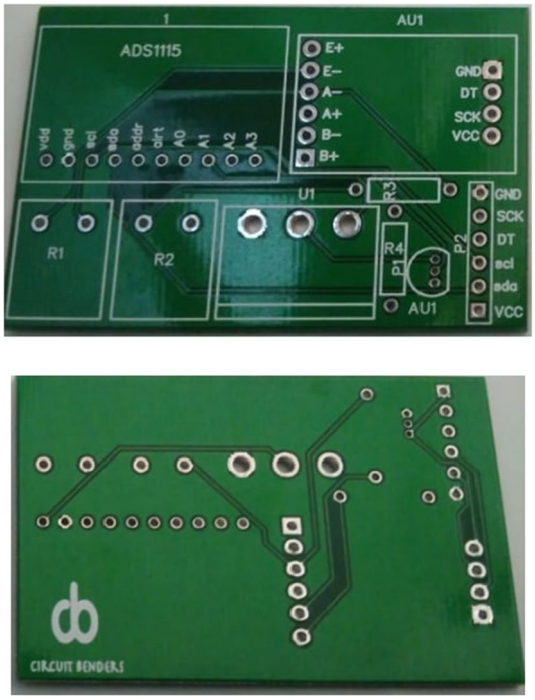

Fig. 5 Submodule -fabricated PCB front and back view

Strain in muscles might happen due to repeated activity in a particular portion of the body. During training sessions due to eagerness and involvement the player might over-strain his muscles without knowing that his body is strained too much.

It is now essential to concentrate on the health aspects of the player during their sports activity. So the system aims to measure the temperature and heart rate of the player. Table 1 gives the characteristics of the wearable prototype system.

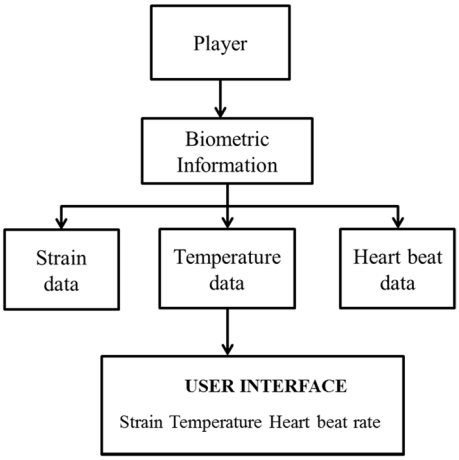

Fig. 6 Work flow model of Biometric data acquisition

Table 1 Characteristics of moniotring system

Sensors used	Strain gauge sensor—350Ω, Gauge factor—2 Pulse sensor—+3 V/+5 V Temperature sensor—−55 to 150 °C
Sensed parameter	Strain in arm muscles, Heart beat rate, Body Temperature
Connectivity	Wifi
Dedicated user application	Yes
Real time bio-feedback	Yes
Method	Non-invasive
Battery	Lipo rechargeble battery—10,000mAh
Wearable	Wrist worn
Easy replacement of in case of sensor damage	Yes, a separate hardware for the sensor module

3.1 Strain Measurement

Strain gauge sensor can measure strain in human arm. These low-powered piezo-resistive sensors can be integrated with the processor and Wi-Fi units, and thereby can be useful in monitoring the strain in sports activity, in everyday training sessions. Strain measurements can predict the location of injury and the performance of the safety wear being used by the batsman etc. In this paper, we demonstrate that it is possible to measure strain in arm using a wearable strain sensor placed directly on the arm of the player. Strain in the arm is increased when the elbow was moved into greater degrees of rotation and inversion.

This paper presents a method for measuring strain by using a strain gauge sensor and data acquisition is performed by a low power 64-bit processor with RISC architecture. Figure 7 shows the signal conditioning is done by Wheatstone bridge and discretized by HX711, which is an analog to digital converter (ADC) connected external to the processor. Figure 8 shows the strain for three different cricket shots obtained from the proposed wearable device.

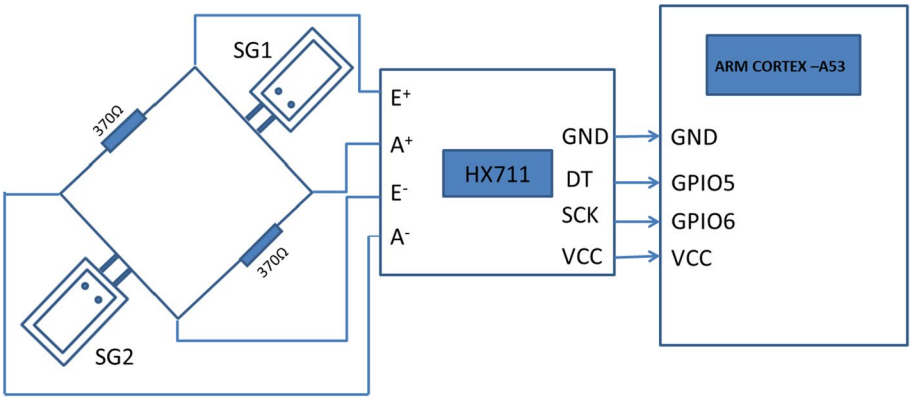

Fig. 7 Interfacing diagram of strain gauge with the processor

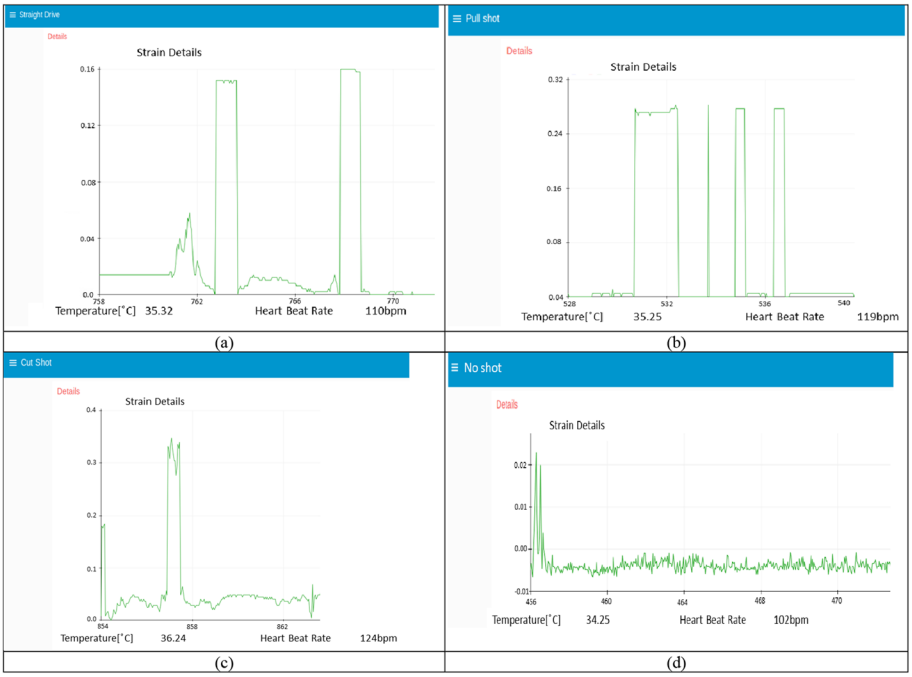

Fig. 8 Strain, temperature and heart beat rate seen in application for **a** straight drive, **b** pull shot, **c** cut shot and **d** no shot respectively

3.2 Heart rate Measurement

The pulse sensor has a light sensor on one side and an amplifier circuit on the other side. The LED on the front side of the sensor is placed on the wrist of the player. The emitted light will fall on the vein directly and the rate of blood flow can be monitored form which the heart beat can be calculated. The analog output form pulse sensor is interfaced

Table 2 Heart beat values of the players

Heart beat rate	Time (s)	Heart beat rate	Time (s)
118	200	120	1000
119	400	118	1200
119	600	112	1400
121	800	114	1600

Table 3 Skin temperature measurements

Skin temperature (°C)	Time (s)	Skin temperature (°C)	Time (s)
35.25	200	36.03	1000
35.42	400	35.52	1200
36.26	600	36.41	1400
36.44	800	36.43	1600

to the processor through ADS1115 ADC module via I2C communication since the processor accepts only digital inputs. Table 2 gives the heart beat rate values of player at different time intervals.

3.3 Temperature Measurement

Skin temperature is important in many research and applied settings and using sensors affixed directly to the skin surface is common for this purpose. LM35 temperature sensor provides a good support for direct skin contact continuous temperature measurement and measures the body temperature (in °C). The scale factor is 0.01 V/°C.

LM35 sensor which is placed on the wrist is connected to the processor through one of the channels of ADS1115 ADC module and the output format is adjusted to get a working thermometer in Celsius. Since continuous temperature output is not necessary, the temperature was recorded for every 10 s. Table 3 gives the temperature changes of a player at various time instances. The main finding of this study is, the skin temperature readings were changing constantly, as batting is performed for extended period. The reasons for such temperature variations are different levels of activity during practice, sweating rate, stress level etc.

4 Results and Discussion

4.1 Software Design

An interface between the system and the user is made and the app is designed using Tkinter and Node-RED supported by python. The strain details along with temperature and heart beat rate of the player is monitored and the updates are given instantly. The recorded data can be accessed both by the player and the coach. Figure 8 shows the strain details of shots like straight drive, pull shot and cut shot in cricket, the temperature and heartbeat of the player in his mobile or laptop.

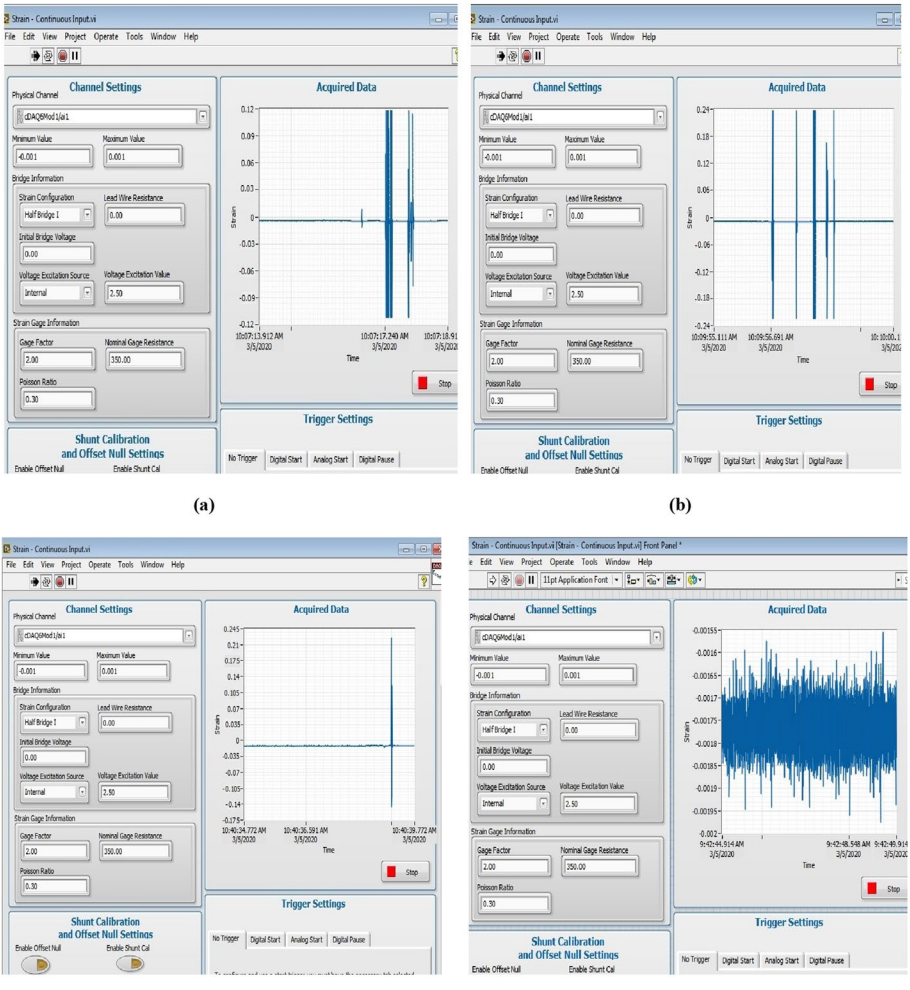

Fig. 9 Strain measurements from data acquisition device **a** Straight drive, **b** Pull shot, **c** Cut shot, **d** Still pose

Table 4 Comparison of strain measurements

Shots	Wearable device	Data acquisition device	Error
Straight drive	0.15	0.12	0.03
Pull shot	0.27	0.24	0.03
Cut shot	0.32	0.2	0.12

Table 5 Comparison of proposed system with other existing systems

References	Sensor	Objective	Physiological parameters	Application(general/sports)	Real time bio-feedback	Dedicated user interface	Result
[15]	Carbon nanotube Strain sensor	To measure the knee flexion and knee extension muscle strength	Muscle strain in knee	Sports	No	No	The torque– angle graph of the CNT sensor may be more informative in knee assessment than that of the dynamometer
[16]	Strain gauge sensor	To develop a wearable bio-instrument for detecting the contractions of subject's biceps muscle	Muslce contractions for the movement	General	Yes	No	Detection of the small skin deformations by strain gauge sensors
Proposed	Strain guage sensor, Pulse and Temperature Sensor	To introduce a wearable device to measure the biometric information of a player during his training session	Strain in the arm muscle while playing, heart beat rate in bpm and body temperature in degree celcius	Sports	Yes	Yes	The wearable prototype acquires the biometric information in a non-invasive manner and with an interactive user interface provides instant updates about the physiological information of the player

4.2 Strain Measurement Accuracy

In order to verify the results obtained using the wearable device, a verification of the same is done using LabVIEW and NI data acquisition devices. For the hardware, the half bridge strain gauge which is placed on the human arm is connected to NI 9236 module that includes the necessary signal conditioning to perform the strain measurement including, applying excitation voltage and completing the half bridge strain gauge. It's then connected to the computer using USB.

Figure 9 shows the strain measurements of the batsman for straight drive, pull shot, cut shot and still pose obtained from NI data acquisition devices. Still pose is recorded when the batsman is not performing any shot. The results obtained from wearable device are in agreement with the results obtained from NI data acquisition devices and demonstrate that the proposed system has satisfactory accuracy.

Table 4 gives the comparison on the performance of the wearable and data acquisition device. It is inferred from the table that the wearable device performs in a better way with a maximum strain error of only 12%. Table 5 shows the comparison of the proposed system with the existing system.

5 Conclusions

A wearable miniature device to find the strain encountered by the player along with measuring heart rate and temperature is developed. The designed wearable prototype acquires the biometric information in a non-invasive manner. The interactive user interface provides instant updates about the physiological information of the player.

With required break and relaxation the player might know when it's time to push for athletic activity. In future intelligent data algorithms can be developed to predict the strain while playing. Extensive collection of input data is required to predict the internal forces generated during dynamic movements. The prototype developed should be realized as a miniaturized commercial market available wearable device. These are challenges which have to be addressed in the upcoming research.

Author Contributions The authors have equal contribution.

Funding No funding received.

Data Availability All data generated or analysed during this study are included in this article itself.

Code Availability No.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Informed Consent Sensors such as strain gauge, temperature and pulse sensor were just placed on the body and it is a total non- invasive placement. The participants were well informed about the sensors.

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