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DESIGN TRACKING SYSTEM FOR ATHLETES USING GPS BASED-BLAND ALTMAN ANALYSIS

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DESIGN TRACKING SYSTM FOR ATHLETES USING GPS BASED-BLAND ALTMAN ANALYSIS

by

Zahraa Talib Hussein

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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Zahraa Talib Hussein

DEDICATION

I would like to dedicate this work to my very first teacher, my mother, my first supporter and role model, my father and my companion throughout the journey. Without you, this dream would never come true and my brothers and my sisters.

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I might want to offer my thanks to every one of the individuals who have upheld me all through the regularly extended periods of this voyage. I might want to thank my advisors, Assoc. prof. Dr. Oguz Bayat and Asst. Dr. Adil Deniz Duru for being my compass notwithstanding when I believed I was lost and being in extraordinary part in charge of the zenith of this work. I might likewise want to thank my supervisors for their supportive exhortation, which incredibly enhanced the nature of this work. Finally, I thank this institution for hosting me during these years, securely earning its place as my home. I am very thankful to my mom and dad, whose values and education motivate me to keep asking questions; to my siblings and family for their infinitely appreciated love and to my country which, although inanimate, keeps me anchored and offers me an example of resiliency.

ABSTRACT

DESIGN TRACKING FOR ATHLETES USING GPS BASED-BLAND ALTMAN ANALYSIS

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The fundamental purpose of this study is to assess the accuracy of the Global Positioning System data collected during the tracking of athletes in professional sports and athletes. The research will utilize an automatic system that will analyze the position of athletes in a football video. The algorithm will create the heatmaps and in-time snapshots of the athletes. The system is aimed at collecting statistics such as speed, accelerations, shots, the distance covered and percentage possession of the players in a match. The data collected in the system was analyzed via the use of root mean square error (RMSE). The results collected were also compared with an existing system such as the local positioning system (LPS) and video technology, and there were distinctive differences between these systems. Considering the distance, the LPS was more accurate with a mean average of 23±7 cm, GPS with an average of 46±23 cm and VID with an average of 56±16 cm. alternatively, regarding acceleration, the GPS has an error of 2.2. % while LPS and VID have errors of 4.0% and 2.7% respectively. The proposed system simulated and hardware designed using PROTEUS program. The result of the study illustrated a significant difference in the validity of the tracking systems utilized today in the field of athletics.

Keywords: Global Positioning System, Sports, Validity, Reliability, Bland-Altman, Root Mean Square Error, Local Positioning System, Velocity, Speed, Acceleration,

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1 INTRODUCTION

Sports is an extremely unpredictable where, so as to turn into an effective Athlete, one needs to create diverse execution properties. There are two fundamental parts in this game: mental and physiological. While the mental capacities of an Athletes are the hardest part to prepare and build up, the physiological segments are something that has been accounted for in a few research papers. Subsequently, there are currently a few rules on how an Athletes must be prepared to have the most ideal presentation during an official match. The round of Sports places special requests on its Athletes; Sports is an open circle sport where Athletes need to change their strokes in any event (aside from serve, the main close circle activity), hence, they have to build up an alternate arrangement of capacities and limits that enable them to perform taking care of business. In the course of the last a quarter century, Sports has drastically changed: Athletes are more grounded, quicker and fitter and the physical segment is the thing that can have a gigantic effect during a match and a competition. Explicit physical preparing that is all around arranged and executed has turned into a key factor in being fruitful on the court or not. It is principal for mentors and coaches to know about these changes, perceiving what is essential to actualize during the planning with the objective of streamlining wellness gains.

1.1 STATEMENT TO THE PROBLEM

Until this point in time, there is impressive inquiry with respect to the precision or legitimacy and dependability of utilizing GPS innovation to decide the physical requests of Sports. A few investigations have been directed which look at GPS inferred separations secured by Athletes with basis separations. These examinations commonly think about the separation secured by a competitor moving along a paradigm pathway to that recorded by the GPS unit. This methodology can be tricky if the competitor does not pursue the foundation pathway precisely. For instance, the separation of within path of a 400m runningtrack is estimated along a line 0.3m outside of within path line. At the point when a competitor's way falters during running in this path, the separation gone by the GPS unit will shift. For this situation, mistakes in separation between the GPS unit and the paradigm separation mirror a failure of the competitor to precisely pursue the assigned course. Likewise, in games, for example, Sports, developments of the middle are not constantly reflected in developments of the feet. For instance, horizontal influencing before accepting a serve may make the GPS unit record "separation" while the Athlete's feet have not moved. Further, going after a shot by sidelong inclining or forward bowing can bring about the middle moving a more noteworthy separation than the feet. Likewise with track running, changeability between the GPS unit and Athlete separations can be presented.

No investigation has thought about separations secured by the GPS units to a "highest quality level" estimation, for example, an aligned trundle wheel. This is especially valid for the new 15 Hz GPS units and the GPS sports gadget. This methodology would evacuate a significant part of the inconstancy initiated by trunk developments that are autonomous of foot developments. Also, the legitimacy and unwavering quality of GPS innovation has by and large been resolved utilizing connection draws near and not been assessed utilizing the more fitting Bland-Altman investigation [1].

1.2 RESEARCH QUESTION

Is the GPS Sport unit a valid and reliable tool to measure distances and tracking of athletes during simulated Sports movements?

1.3 SPECIFIC AIMS

- Aim 1: To determine the validity of the SPI HPU GPS units to determine distances covered during simulated Sports person or athletes movements. This was done by comparing GPS recorded distances to distances determined with a calibrated trundle wheel using Bland-Altman analysis.
- Aim 2: To determine the reliability and tracking of athletes using GPS units to determine distances covered during simulated Sports movements. Reliability and tracking was determined by comparing GPS distances between paired units simultaneously following the same path.

1.4 OPERATION A DEFINITIONS

- Validity: The extent to which an instrument measures what it is designed to measure. For this study, validity is the agreement between distances simultaneously determined by GPS units and the trundle wheel.

- Reliability: The extent to which similar instruments are consistent in their measurements. Inthis study, reliability is the agreement in recorded distances by two GPS units simultaneously attached to the trundle wheel.

- Bias: Determined from Bland-Altman analysis. It is the average difference between distances simultaneously measured by the trundle wheel and GPS units.

- LPS (Local Positioning System): The LPS represents the 95% confidence interval of the mean difference between measures of the same variable (X ± 1.98*SD).

- Root Mean Square (RMS) Error: The RMS error is the root of the squared differences between two measures of the same variable :

$$R(error) = \sum_{i=0}^{n} \sqrt[2]{(Trundle\ Wheel_i - \ GPS\ Unit_i)^2} \quad (1.1)$$

1.5 LIMITATIONS

The following limitations were intrinsic in this study:

- Trundle Wheel Movements: During the preliminaries, the trundle wheel may have executed in reverse developments. This would bring about separation being subtracted by the counter and think little of the real separation gone by the wheel.

- Trundle Wheel Calibration: During use, alignment of the trundle wheel could fluctuate, modifying the recorded separations.

- GPS Unit Placement: The two SPI HPU GPS Units were set one over one another, 7cm separated.

- GPS Unit Movement: Movement of the trundle wheel handle could cause mediolateral and anterio-back development of the GPS units that may not be reflected in wheel developments.

- Weather Conditions: Cloud spread and cloudy sky can debase GPS execution. All examinations were led on days with no or negligible overcast spread.

- Environmental Conditions: Buildings and trees can influence GPS signal quality. All examinations were directed on Sports or a running track that is free of checks.

- Dilution of Precision (DOP): DOP reflects to direction of GPS satellites as for the GPS unit. SPI HPU GPS sports units don't create DOP values.

- GPS separations were registered by restrictive programming given by GPS sports.wee two

1.6 DELIMITIONS

The following delimitations were set by the investigator:

- Criterion paths and distances were set by the investigator to simulate Sports movements.

- The GPS sports SHI HPU GPS units were selected for use as was the Meter-Man MK45M trundle wheel.

- A total of 20 GPS units were utilized in the study.

- A hard surface Sports was used in the study.

2 BACKGROUND

2.1 SPORTS MATCH CHARACTERISTICS

There are numerous factors that can impact a Sports coordinate. In games a match can keep going for an hour or, in certain conditions, over three hours. In this manner, a competitor must most likely run, stop and recuperate actually rapidly and, simultaneously, must be fit enough to keep up a pinnacle physical movement level all through the entire match.

A solitary point in Sports more often than not endures in the middle of 6 – 10 seconds, trailed by a short recuperation (10 – 20 sec) with longer times of rest during the changeover (90 – 120 sec). In his investigation, Kovacs (2017) proposed that abnormal state matches have a work to rest proportion of 1:2 to 1:5 Points have a normal length of three seconds on a portion of the quicker surfaces (grass, cover, and indoor) and near 15 seconds on more slow. Figure 2.1, taken from demonstrates the normal occasions of single focuses as revealed by a few investigations[1]. As can be seen, the time can shift extensively however by and large a point keeps going around 8 seconds.

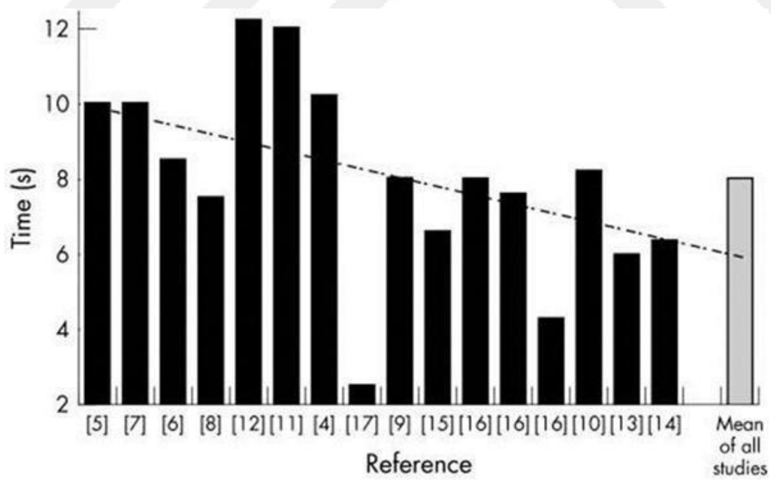


Fig. 2.1: Average time in seconds per point during competitive Sports [2].

[2]

There are several important variables that can influence the duration of a Sports match: the surface of the court and the playing style. In Table (2.1), [3] shows how the average duration of a point is less on grass compared to both hard and clay courts. Unfortunately, there are few studies about Sports played on grass court because this surface is not common to most matches and tournaments and there are few opportunities to monitor Athlete movements during grass court matches.

Table 2.1: Duration of a point and average rest interval between the points. [3]

Length	Men	Women
Average duration of a point on grass	2.7s	5.4s
Average duration of a point on hard	6.5s	6.6s
Average duration of a point on clay	8.3s	10.7s
Rest interval between points	25.6s	19.4s

As appeared in Table2.1, there is a generous and significant contrast among people regarding point term and rest period. Spans of focuses played by ladies are commonly more and the rest interim between focuses is shorter. The ladies' down tends to keeps going more than men's on the grounds that the speed of each shot is "slower". Likewise, aces and ground stroke champs are less regular in the ladies' down[4]. These kinds of shots can extraordinarily diminish the span of a point.

Another parameter to take in thought when assessingthe physiological requests of a Sports match is the Athlete's down style. Distinguished three unique styles: assaulting, entire court and gauge Athlete. From their examination obviously assaulting (Athletes who want to go to the net) have shorter energizes or focuses (4.8s) than baseliners (Athletes who incline toward remain on the back) who normal the longest encourages (15.7s). In this examination, the specialists additionally found that the level of the playing time as for the absolute time of the match is around 21% for the assaulting Athletes, 28.6% for entire court Athletes, and 38.5% for benchmark Athletes. Along these lines, the physical interest is impacted by playing styles and strokes utilized which at last how a long an Athlete spends on the court in play. As every Athlete has his own preferred style, mentors must almost certainly perceive which one is the best for his abilities and, at that point, program an ideal arrangement to be progressively effective during a match.

2.2 PHYSICAL COMPONENTS

A Sports match is characterized by quick starts and stops, with many accelerations and decelerations and the involvement of many motor skills (e.g. power, speed and duration). From a physiological point of view, Sports is considered an intermittent sport, combining low – high intensity activity periods. The ATP – creatine phosphate and glycolytic systems are the main producer of energy over the oxidative system, with a major emphasis on glycolysis and glycogenolysis[5]. However, Athletes, considering the fact that a Sports match is never predictable from a duration point of view, must be aerobically fit enough to last for more than three hours. In fact, [6]states that focusing on incomplete physiological recovery between points, as well as between matches and tournaments, high cardiorespiratory capacity might be crucial, in order to avoid or postpone 'fatigue'.

In a review conducted by [4]two parameters have been analyzed: VO2max (marker of aerobic and cardiorespiratory fitness), and exercising heart rate (HR). VO2max is a parameter that measures the maximal oxygen consumption per minute. In Sports, as shown in Table(2.2), the average VO2max range is between 44ml/kg/min and 69ml/kg/min. These values demonstrate a good aerobic status but not as great as aerobic sports men like marathon runners or cyclists. Actually, even if a match can last for more than three hours, the effective time of playing is usually not over the 40% of the total time. Thus, the aerobic metabolism is not used as much as during a long distance sport. Moreover, [7]suggests that it is fascinating to understand that Athletes who were considered to be aggressive (attacking Athletes) had lower hear rates (HR) and lower VO2 levels during a match than baseline Athletes. An Athlete's playing style is definitely a factor to take in consideration when evaluating training and physical performance. Every Athlete has different Sports skills, and a coach need to plan practices that can help him to develop a good physiological level for how he will perform on the court.

Table 2.2: Comparison of maximal oxygen consumption (VO2max) values in elite Sports Athletes.

Study (year)	**No.**	**VO2max (mL/kg/min)**
Bergeron et al. (2009)	10	58.5 ± 9.4
Elliot et al. (2011)	8	65.9 ± 6.3
Bernardi et al. (2012)	7	65 ± 4
Christmass et al.	8	54.25 ±1.9
Smekal et al. (2014)	20	57.3 ± 5.1
Faff et al. (2014)	72	62.3 ±4.8

Heart Rate (HR) is one of the most common variables monitored and is useful when determining the physiological demands placed on an Athlete. Since HR is a response to the movements executed during the match, it is considered an "internal" load[6]. States that during match play, the average HR of a collegiate athlete is 144.6 ± 13.2 beats per minute. [6]Also suggests that HR remains to a moderate level throughout the whole match, despite Sports is an intermittent sport with quite long recovery periods. Table(2.3) shows the percentage of maximal heart rate (%HRmax) collected in several studies and the average is 86.2% ± 1.0%. However, HR by itself, cannot be used to establish Sports metabolism values. Maximal HR is determined by both age and training. And %HRmax is a function of fitness level. Exercising HR is also a parameter that can be influenced by many factors (such as weather, daily physical conditions, opponent skill, playing style). Thus, in order to have a full understanding of the physiological load in Sports, it is better to have other data to compare with it. For example, both internal and external loads.

Table 2.3: Mean %HRmax in male Athletes.

Study (year)	**No.**	**Level**	**%HRmax**
Christmass et al. (1995)	8	Regional	86
Bernardi et al. (1998)	7	Regional	63.6–82.5
Therminarias et al. (1991)	19	Elite	87
Bergeron et al. (1991)	10	Elite	86.2
Elliott et al. (1985)	8	Elite	79

As emphasized before, a Athlete has to be able to adjust his game style and his tactic in order to have success at the same time on slower and faster surfaces. The type of surface a Athlete is competing on plays a key role on physical demands as the surface represents one of the most important variables to take in consideration when determining the physiological load in Sports.

Clay court is considered the slowest surface because it slows down the speed of the ball and causes a high bounce of the ball. Moreover, in order to move correctly, Athletes often slide to reach the ball. Due to these characteristics, clay reduces the speed of the whole game, and Athletes have much more time to return each shot. Athletes who prefer to give a lot of spin to the ball and who prefer run side to side on the court, have the major benefits on playing on this surface. On the other hand, hard courts are usually made from asphalt or concrete and are the most commonly available courts. There are different types of hard courts but, usually, they provide a surface where the ball travels at a speed faster than clay, the bounce of the ball is very predictable as the surface is flat and easy to maintain. Athletes who are successful playing on hard surfaces are usually "aggressive" on the court. Thus, serve and volley or Athletes with big shoots have a higher chance to win on hard courts. Given this, one would expect a clay court match to be characterized by longer movements and greater distance covered whereas a hard court match would be characterized by short movements, more changes in direction and less distance covered. As a result, HR responses could vary between play on these surfaces.

In a more specific study it is better explained how playing on hard court is less expensive from a metabolic point of view. Noted that total distance travelled and high intensity running distances were 24 and 30% greater on clay court than hard court matches.

Table 2.4: Distances covered in different velocity ranges in clay and hard courts matches (Mean ± SD,

Velocity Range	**Clay**	**Hard**
0 – 5.5 km/h	2054.5 ± 139.9 m	1651.3 ± 220.9 m*
5.5 – 7 km/h	244.6 ± 83.3 m	156.6 ± 68.5 m*
7 – 10 km/h	211.1 ± 38.9 m	117.8 ± 36.3 m*
10 – 15 km/h	122.3 ± 32.6 m	66.3 ± 18.7 m*
15 – 18 km/h	18.6 ± 13.3 m	13.0 ± 7.9 m*
>18 km/h	5.8 ± 5.8 m	7.2 ± 9.3 m
Total Distance	2656.9 ± 220.2 m	2012.3 ± 295.8 m*

Table(2.4) shows how the court characteristics influence a Sports match; total distance and distance covered at different speeds are the most influenced factors. At each speed, Athletes who are on a clay court, must cover more distance during the whole match (the only inference not clear is the one above 18km/h). This is likely ascribable to the surface because, as explained before, ball speed is slower giving much more time to Athletes to reach the ball. This could in turn, lead to longer rallies. [9] Also point out that the hard and clay courts elicit different physiological and psychological responses. Hence, these data suggests that playing on a hard court, where the ball is faster and rallies shorter, influences the physical demand required from Athletes.

2.3 COLLEGE SPORTS

College Sports is controlled by the Intercollegiate Sports Association (ITA). Matches general have the same rules as pro tournaments. However, the ITA introduced two uniques rules. First, “No Let” for men’s matches. Athletes continue the point when the service hits the net cord but lands in the service court. Second, “No Advantage” for both men and women. When the score is 40/40, only one point is needed to win the game rather than two. ITA decided to introduce these two rules to make a college match faster and more spectacular. Another important characteristic of college Sports is that matches are played only on hard courts. This has a huge impact on the physical demand of a Athlete because different papers showed how playing on hard courts makes matches shorter, with less rallies. [10] Note that a typical point during a collegiate Sports tournament lasts 6.36s. Thus, this suggests that there is a bigger contribution of the aerobic system compared to matches played on slower surfaces. Lastly, college Athletes often play more than one match during a day’s competition. Often a doubles match is immediately followed by a singles match. Given the above rule changes by the ITA, it is likely that college match play results in different total distances covered and different heart rate responses compared to professional matches.

2.4 GLOBAL POSITIONING SYSTEM

The global positioning system (GPS) is a tracking system originally introduced by the Department of Defense for military use (www.gps.gov). This system works thanks to 27 satellites spread outside the atmosphere around the earth, which send signals to the GPS receiver allowing theunit to calculate the position of the user. To record a correct position, a GPS receiver must lock onto at least 4 satellites which can give accurate information on latitude, longitude and altitude. [1 1]

Emphasizes the fact that satellites signals can be affected by weather conditions such a cloud cover which can negatively affect the GPS ability to track a position. [11]Also notes that environmental conditions such as buildings, trees, etc can interfere with the GPS signal and can reduce the number of satellites used to determine position. While the total number of satellites is a fundamental parameter for a correct position measurement, another crucial aspect is the orientation or positioning of the satellites interacting with the receiver. This value is called the Dilution of Precision (DOP). [12] State that DOP value is high with poor precision when satellites are bunched together, while, on the other hand, DOP value is low with great precision when satellites are spread out across the horizon. This DOP variable can have a value from 0 to 50, with 1-2 considered very well and <1 considered excellent condition. In an ideal scenario, one satellite would be placed right above the receiver with the others equally spread across the horizon (see Figure (2.2).

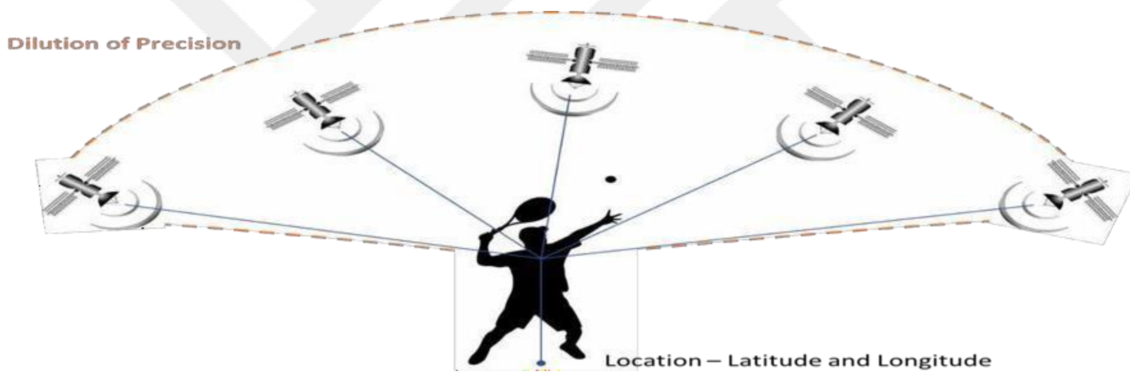


Fig. 2.2 : An example of GPS receiver and satellite distribution.

2.5 GPS: A NEW TOOL TO TRACK ATHLETE MOVEMENTS

With the improvement of new innovations, mentors can have a superior and progressively exact comprehension of the physiological requests of preparing and rivalry. In the most recent decade, time movement examination frameworks, video recording, new PC programming and equipment have effectively used to expand the likelihood of "making" a competitor who can be near be viewed as immaculate from a physical perspective. Lamentably, these kinds of following frameworks are difficult to utilize and they have strategic issues. Along these lines, in the few a years ago, an answer for this issue, has been the presentation of trunk-mounted GPS. These units are commonly little and put in a "holder" verified to the back of the competitor. In this way, position of the competitor alongside separations, speeds and increasing velocities can without much of a stretch be recorded. [10]Describe GPS as a satellite – based navigational innovation that enables specialists to follow developments after some time in various types of situations. These days, the fruitful improvement of this gadget has expanded its application in various fields and game is one of those.

GPS is significantly progressively valuable on the off chance that it is coordinated with a tri-pivotal accelerometer that can gather information about development in three distinct plans of development [13]. Most GPS frameworks currently use accelerometer information to expand or enhance the GPS signal, improving its precision. Subsequently, GPS has turned into the most ideal approach to follow a competitor. [13] Specifies that GPS can be utilized to measure physical effort and the physical requests set on individual competitors, analyze execution during rivalry, survey various outstanding tasks at hand, set up preparing projects, and screen changes in Athlete physiological requests. GPS uses position to follow the two separations and speed. Nonetheless, it has enabled measurements to be built up that identify weakness status, times of high or low force, metabolic interest just as separate physical loads between positions on inside a group activity (Cummins et al, 2013). GPS has the novel capacity to figure and measure the outer preparing load during various practices and matches permitting a synchronous following of a few competitors. Alongside every one of these elements, GPS is viewed as an incredible advancement to screen physiological status of an Athlete, subsequently, with the investigation of the information gathered, it has an extraordinary incentive to anticipate or if nothing else postpone wounds.

2.6 GPS SPORTS TECHNOLOGY

GPS sports is a sport technology company that is used worldwide. They provide wearable technology that is able to measure distance, speed and acceleration (via GPS), body load and impact (via accelerometry) and heart rate. These units allow coaches to monitor, collect and manage data in different sports and during different training sessions or matches. The GPS sports devices are widely used in team sports because they give a better understanding of physiological demands of performance within a large space and can give more information about how to plan specific trainings. Unfortunately, the use of this technology has been limited in court-based sports such as Sports.

The GPS sports system is composed of a custom designed vest which houses the unit (GPS and accelerometer) and contained a heart rate monitoring strap. The latest model (SPI HPU) contains a 15Hz GPS unit, a 100Hz-10G accelerometer and a 50Hz magnetometer. The device also utilizes a Polar HR monitor that is sampled at 100Hz. At the end of each session, data are provided that contain different variables generated by the GPS sports analysis package (TeamAMS):

- Volume Indicators: distance, distance in speed zones, acceleration and deceleration count, body load and heart rate exertion.
- Intensity Indicators: speed, number of sprints, maximum speed, maximum acceleration and maximum heart rate.

For many field based sports, these parameters have been widely reported. Much is known about distances covered, running speeds, heart rates and accelerations during sports such as soccer, rugby and football [13][14].

2.7 VALIDITY AND RELIBILITY

Given the wide use of GPS in the last decade, several studies have been conducted on the accuracy and the reliability of GPS devices. Being aware of the eventual error that a GPS measurement can imply is important for researchers, who have the responsibility of taking it in consideration during a study. Sports-specific GPS are manufactured to collect positional data at several frequencies (the speed at which the unit gathers data, expressed in samples per sec or Hz). Early units operated at a 1Hz sampling frequency while newer units collect data at 15Hz. It is important to note that the higher frequency units actually sample GPS position at lower frequencies, then utilize interpolation from a tri-axial accelerometer to increase sample frequency. For example, the GPS sports SPI HPU unit collects GPS data at 5Hz then uses accelerometer data to interpolate that frequency to 15Hz. Many researchers agree that with higher frequency rate and accelerometer interpolation, the data collected are more precise with less errors [15].

There have been numerous studies examining the validity and reliability of GPS for field-based sport movement distances and speeds (see [16], 2014). Based on previous research, reliability is rated as good (<5%), moderate (5 – 10%) or poor (>10%) [12]. In general, these studies show fairly good reliability and validity of lower speed, longer distance activities [7] with shorter distances and higher speed movements, the GPS accuracy is thought to degrade. [15] and [17]found that as speed increased the typical error of measurement using 10 and 15Hz GPS units increased from <1% to more than 15%. For example, in a recent study, [17] asked subjects to perform change of direction and intermittent intensity tasks while wearing a 15Hz GPS device (GPS sports SPI ProX). They found that accuracy degrades with rapid directional and speed changes. During curvilinear and shuttle running, the measurement biases were 2.2 and 3.0%, respectively while the limits of agreement were 1.7 and 3.4%. It is important to note that [17] as well as others used the track distance as the criterion measurement. Thus, any deviation from the criterion path by the subject would have resulted in excess distance travelled and be interpreted as error.

In 2010, [18] examined the accuracy of 1 and 5 Hz GPS units during simulated court-based (Sports) movements. These units were provided by two difference companies, GPS sports and Catapult. In this study, Athletes were asked to perform several fast and slow change of direction movements while positional data was collected by the GPS units and by video analysis using a VICON system as the criterion measurement. A reflective marker was placed on the GPS units and tracked by video. The advantage of this approach is that the VICON operates at 100Hz and has an error of 0.0008% [18]. They found that as the speed of movement increased, accuracy of the GPS system declined. The reported error for fast and slow movements ranged from 2 to 25%. By using the VICON system and a reflective marker placed over the GPS units, Duffield et al. (2010) eliminated any error that might be produced by errors in the subject following the criterion track and by body lean encountered during changes of direction.

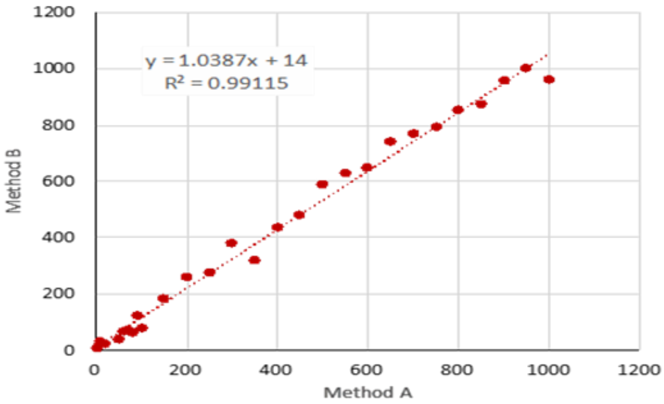
Vickery et al. [19] also used a VICON system to examine accuracy of 5, 10 and 15Hz GPS units in situations where Sports movements are involved as well as field-based movements. A typical soccer field measures 110 x 70m whereas one side of a singles Sports court measures 8.23 x 6.40m. Vickery et al. [19], using VICON as the criterion measurement, showed that 10 and 15Hz GPS units underestimated distances during 2 and 4m side to side shuttle runs by 10-14%.

Underestimation of GPS distance measurements were smaller when performing longer efforts, 20 and 40m shuttle runs.

In Sports, these kinds of movements (changes of direction in a small space) are very common. Thus, researchers must consider the errors of GPS technology in this context. Anotherproblem of GPS is that it tracks movement of the unit that do not necessarily correspond to actual distances travelled by the athlete. In Sports, there are trunk movements that are tracked by the GPS but do not reflect distances covered by the Athlete. For instance, when an Athlete is returning to a serve or reaching for a shot, it is not unusual to for the trunk to move more than the feet. This is not considered a movement or distance covered but as the GPS unit moves, it tracks the movement as distance covered. Thus, determining accuracy based on feet movements may introduce error. Clearly, there is a need to examine the accuracy and reliability of the GPS unit in the absence of Athlete movements.

2.8 DETERMINING ACCURACY AND RELIABILITY

An important criticism of the previous studies is the statistical approach used to compare two methods of distance measurement or to assess the accuracy and reliability of a method versus a standard. The majority of studies examining GPS distance measurements utilized linear regression (Person Product-Moment correlation), intra-class correlation and/or coefficient of variation determination to assess validity [20] (Figure2.3). Altman and Bland argued that these are not appropriate techniques for determining agreement or comparability between two methods. Correlation analyses determine the degree of association between two variables and do not quantify the extent of agreement (Altman & Bland, 1983; Bland & Altman). Further, while correlations can identify random errors, they do not provide information on systematic bias. Bland- Altman [21]suggest that a more appropriate determination of agreement is to examine a plot of the difference between paired measurements versus the mean of the two methods (Figure2.4). This approach, called Bland-Altman analysis yields two important variables that are related to agreement. The first is bias or the mean difference between the two methods. The second is the limits of agreement (LPS) which is the 95% confidence interval of the mean difference. In addition, the Bland-Altman plot shows whether or not the bias is consistent across a range of measurement values or if there are systematic patterns of bias [22]. Further suggests that this approach can



be extended by plotting the percent error between the two measurements versus their mean. This results in a relative expression of both bias and LPS. To date, no validation studies of GPS distances and speeds have used the Bland-Altman approach.

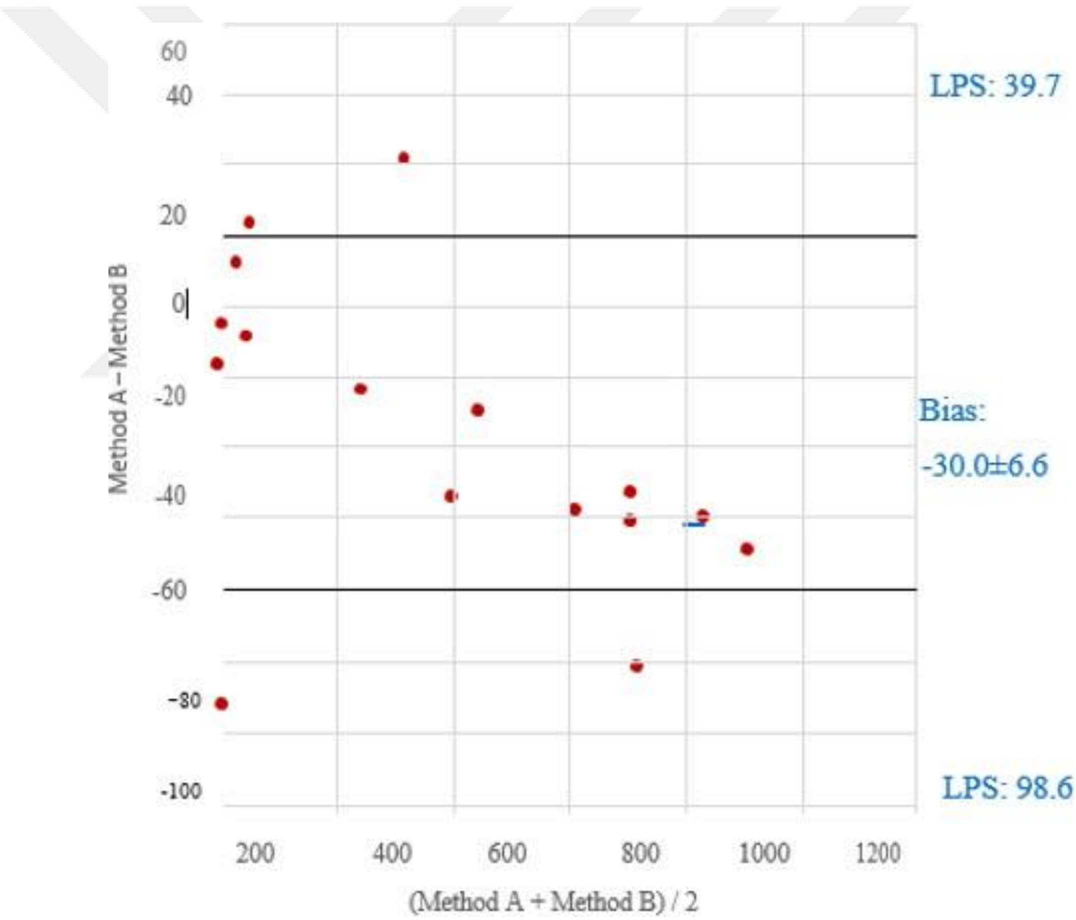


Figure 2.4: Bland – Altman comparison of two methods used to measure the same variable. [22]

In order to understand the agreement between GPS measurements of distance and other measurements or a "gold standard", a Bland-Altman approach is needed. Also, establishment of a gold standard or criterion is needed. Traditionally, the gold standard distance traveled is the distance of a criterion path to be followed by an athlete. However, in many activities, athletes may waver from this path, particularly during high speed and change of direction movements. This is shown in Figure 2.5. During a “zig-zag” course, the criterion distance is measured between the changes of direction point (typically cones placed on a field).

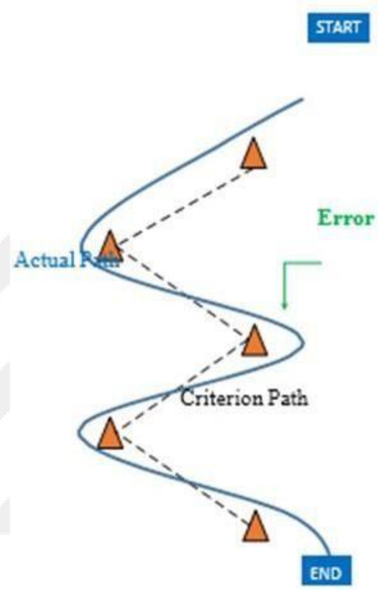


Figure 2.5: An example of an athlete running a “zig- zag” course: the dashed and red lines represent the Athlete’s path whereas the blue line represents to criterion pat

However, Athletes must run past the cone when executing a turn or they may not reach the cone. This is shown in Figure 2.6. The Athlete is changing directions. While his foot reaches the criterion point (or cone), his torso does not. Depending on how the Athlete executes the task, GPS recorded distances could vary considerably from the criterion distance.

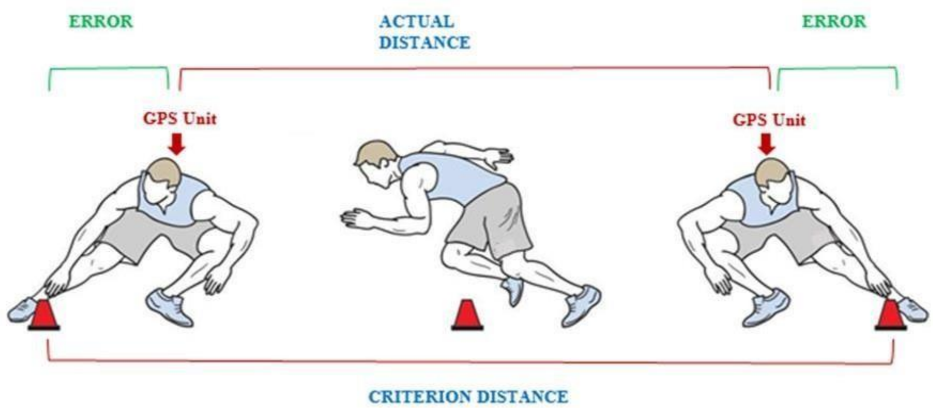


Figure 2.6: Athlete movement which can lead to a measurement error

Activities such as Sports require movements where the athlete's torso may move but the athlete's feet remain stationary. This is shown in Figure 2.7. As can be seen, when the two athletes reach for a ball, the torso moves while the feet do not. This would result in the trunk-mounted GPS unit recording distance traveled while the athlete's entire body did not. Thus, using athlete movements and criterion distances may not be the best approach to evaluating the validity of GPS derived distances.

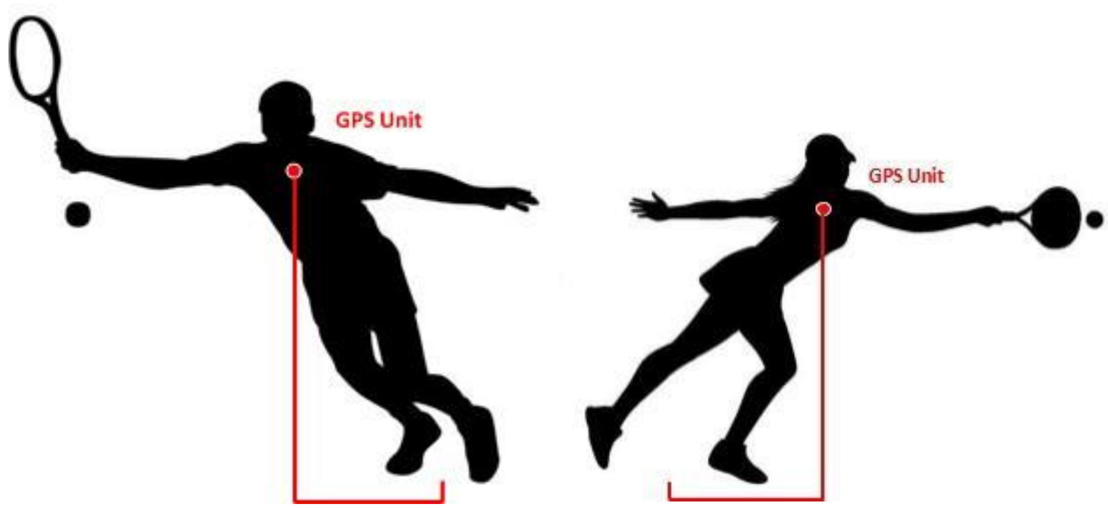


Figure 2.7: Examples of Sports movements where the GPS unit may record distance or Displacement but the athletes' feet remain stationary.

2.9 SUMMARY

Based on this review of literature, several conclusions can be drawn regarding the use of GPS in determining the physical demands of Sports:

- GPS has emerged as a standard for determining the physical demands of sport (distance, velocity and acceleration). Its use is widespread among field sports such as soccer and rugby.
- Court-based sports such as basketball require rapid bursts of activity within a confined space. This results in relatively short movements and numerous changes in direction.
- There is some concern as to the accuracy, validity and reliability of GPS to measure distances traveled during court-based sports such as Sports. Some of this concern stems from the gold standard used to evaluate GPS data and the types of activities evaluated.
- Thus, the usefulness of GPS in monitoring the physical demands of sports such as Sports is questioned.

Given the above, future studies should be directed towards evaluating the validity and reliability of current GPS technology for use in court-based sport

3 PROPOSED SYSTEM HARDWARE DESIGN

PIC microcontroller-based GPS system used for simulation for the proposed study. The proposed GPS transmitter circuit consists of GPS module, PIC161827 microcontroller, GSM module and power source (battery used). In this chapter the schematic diagram of the system introduces which is done using PROTEUS program, PIC microcontroller programmed using mikroC programming language, which is simple and limited instruction language.

3.1 GPS module

The NEO-6M GPS module which used in our system shown in figure (3.2). NEO-6M GPS module has 4 pins: VCC (3.3V or 5V), RX, TX and GND. It uses serial communication (UART protocol) to communicate with the microcontroller where RX/TX pins are for receiving/transmitting data from/to the microcontroller. With the NEO-6M GPS module we can measure position (latitude and longitude), altitude, time (UTC), date, speed and some other data[23].

Fig. 3.1:GPS module

3.2 PIC16F1827 Microcontroller

PIC16F1827 microcontroller made by microchip is suitable for our application due to its low cost, suitable size, in circuit programming. It has 12 analogs to digital conversion ADC channels with10-bit resolution. Also, it has 15 input output pins and four pulse width modulation PWM that is very important in machine control[24]. It contains two type of counter/counter 8-Bit And 16-Bit. It introduced by microchip in three packages: 18-pin PDIP ,20-pin SSOP, and 28-Pin QFN/UQFN as shown in figure (3.2)

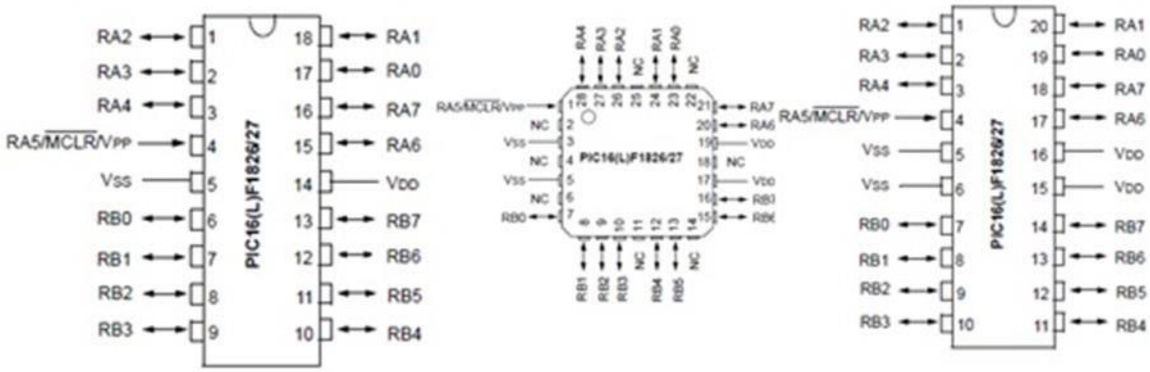


Fig. 3.2: PIC16F1827 microcontroller

This microcontroller supports Extreme Low-Power Management which is very important advantage for limited power sources. Also, it contains Up to two Master Synchronous Serial Port (MSSP) with SPI and I2CTM with 7-bit address masking SMBus/PMBus compatibility. That makes it suitable for our application protype model.

PIC16F1827 has a very good feature such as[25]:

- low operating voltage (1.8V – 5.5V) for our application lithium ion batteries can be used which is suitable for supplying this microcontroller.
- Self-Programmable under Software Control.
- Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST).
- Programmable Brown-out Reset (BOR).
- Programmable Code Protection.
- In-Circuit Serial Programming™ (ICSP™) via two pins.
- In-Circuit Debug (ICD) via two pins.
- Enhance Low-Voltage Programming.
- Power-Saving Sleep mode.
- Operating Current: 75 µA @ 1 MHz, 1.8V, typical.

3.3 GSM Module

SIM900 GSM/GPRS Module is used for wireless communication it is suitable for the application due to simple connection with PIC16F1827 microcontroller and its industrial features such as: the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. Module small size (24×24×3) mm dimensions, makes it suitable to be used for portable and mobile application such as our application. A powerful single chip processor integrated in the module from type of: "AMR926EJ-S core". An embedded Powerful TCP/IP protocol stack (SIMCom) [26]. GSM model shown in figure (3.3)

3.3.1 GSM module features

GSM module introduced very good features such as :

- Quad-Band 850/ 900/ 1800/ 1900 MHz
- GPRS multi-slot class 10/8
- GPRS mobile station class B
- Compliant to GSM phase 2/2 Class 4 (2 W @850/ 900 MHz) \Class 1 (1 W @ 1800/1900MHz)
- Dimensions: 24* 24 * 3 mm
- Weight: 3.4g
- Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
- SIM application toolkit
- Supply voltage range 3.4 V
- Low power consumption
- Operation temperature: -30 °C to +80 °C

Fig. 3.3: GSM module

3.4 PCB Design

The proposed system PCB designed using PROTEUS program which has the ability to design and simulation electronics circuits. This program contains a large library of electronics devices and circuits, also has the ability to add new libraries and design devices. Figure (3.4) shows main schematic display of the PROTEUS program, and figure (3.5) shows PCB page of the program. The program also contains thee dimension view page to show the designed circuits.
PIC16F1827 microcontroller originally found in PROTEUS library, but GPS and GSM added to the library and used for simulation.

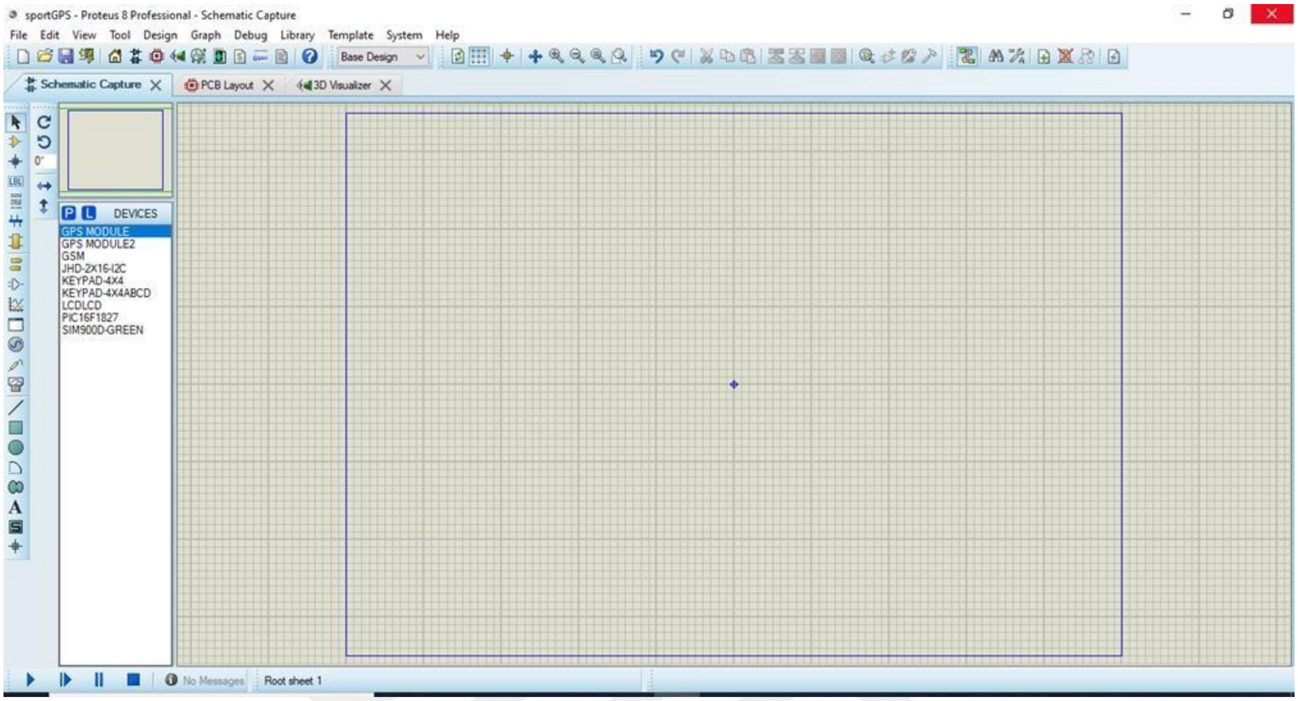


Fig. 3.4PROTEUS schematic page

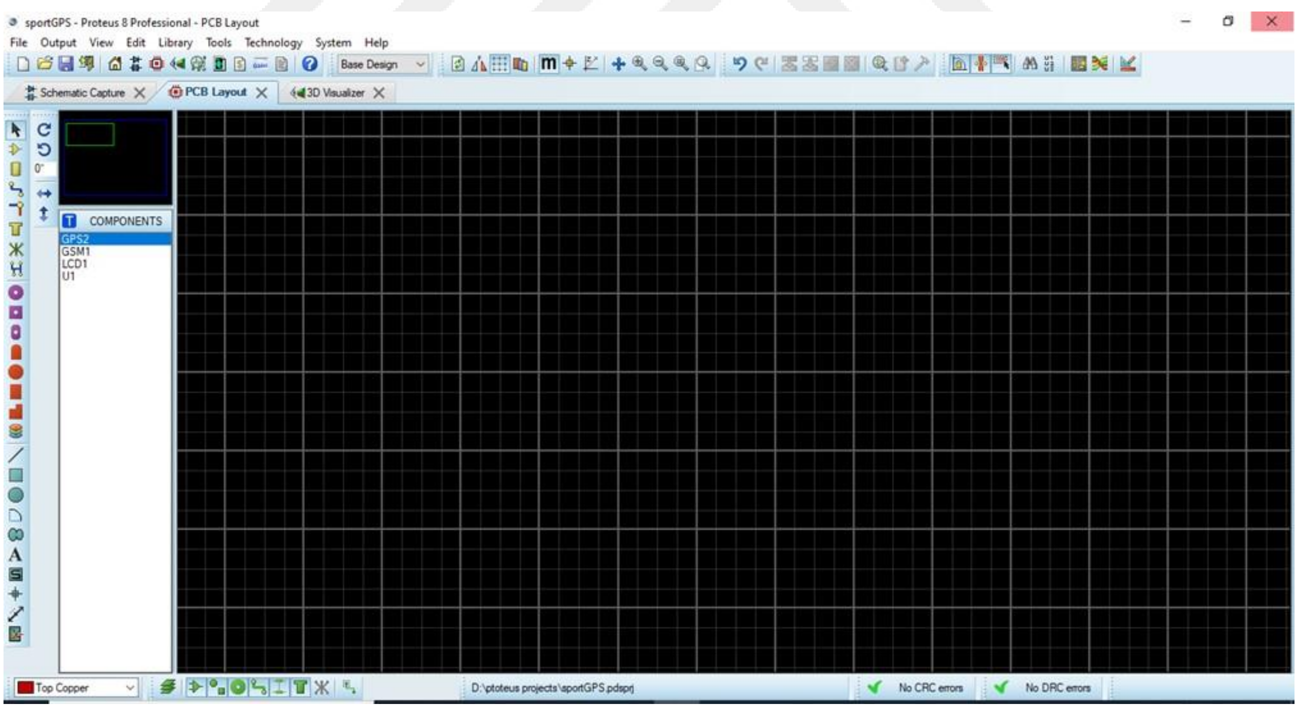


Fig. 3.5: PROTEUS PCB layout

3.4.1 Schematic circuit design for the proposed system

The proposed tracking system schematic circuit shown in figure (3.6).

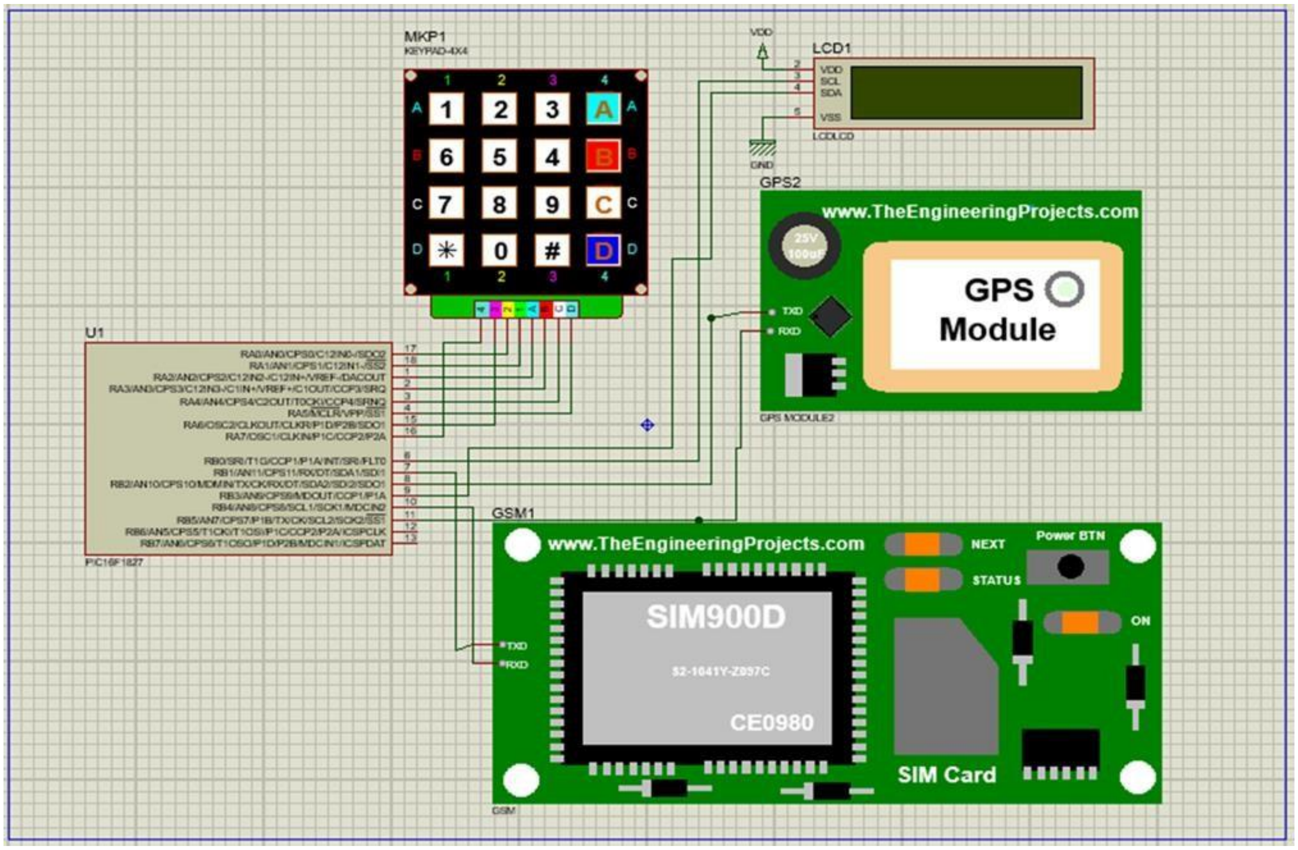


Fig. 3.6: proposed system schematic diagram

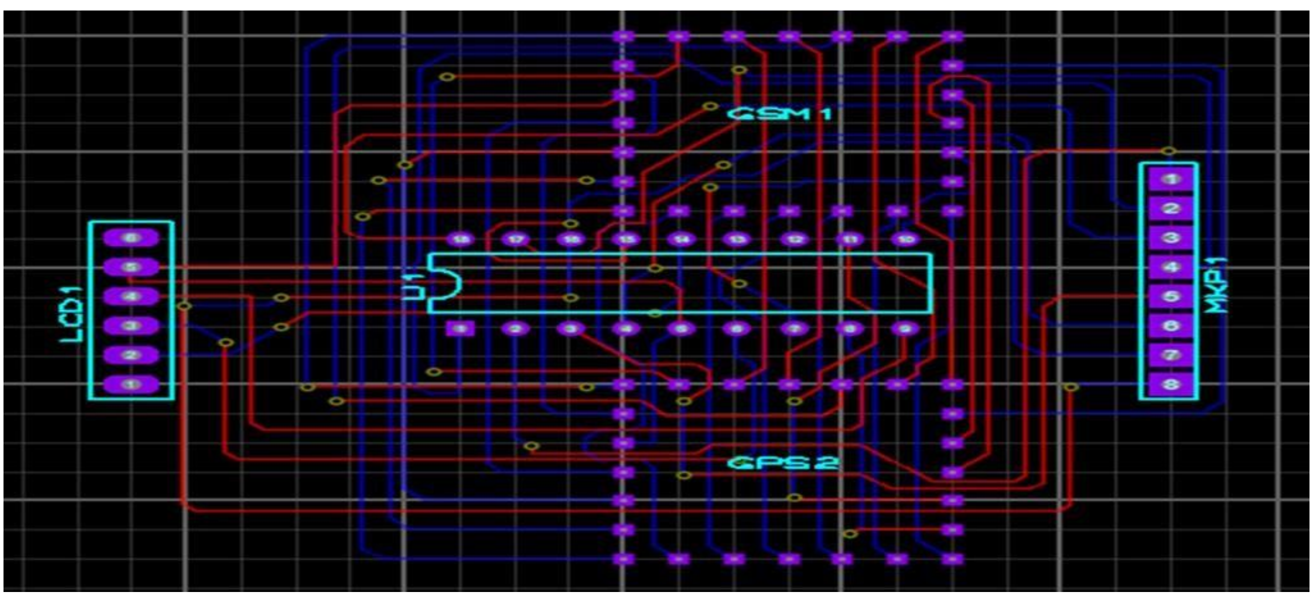


Fig. 3.7proposed system PCB

3.5 Battery charger

Lithium ion battery used for the proposed system an impedance-compensated battery charger used to inhance the effective capacity of the lithium-ion battery. The proposed charger adopts a pulsating current source associated with a pulsating voltage detector to dynamically estimate compensated impedance of battery. With this approach, the discharge-time is extended 12% and the overall battery capacitor is increased 10%. The experimental results based on a lithium-ion battery charger with 11.4V/2.4Ah battery capacity verify these significant improvements[27].

3.6 MikroC program for the system

```
*************************************************************************************

 Interfacing PIC16F1827 microcontroller with NEO-6M GPS module
 C Code for mikroC PRO for PIC compiler
 internal oscillator used @ 8MHz
 Configuration words: CONFIG1 = 0x2CD4
                 CONFIG2 = 0x0700
**************************************************************************************/

// include GPS mikroC library
#include <GPS_mikroc.c>

char txt[15];
unsigned short sats;
float f_res = 0;

// convert byte to string
void byte_to_str(unsigned short nub, char *str)
{
 str[0] = nub / 10 + '0';
 str[1] = nub % 10 + '0';
 str[2] = '\0';
}

// convert float number to string
void float_to_str(float f_number, char *f_str, short size)
{
 uint8_t i = 0;
 int16_t i_part = f_number;

 if(i_part < 0){
  i_part = fabs(i_part);
  f_str[0] = '-';
  i++;
```

```
 }

 if(i_part > 99)
  f_str[i++] = i_part / 100 + '0';

 if(i_part > 9)
  f_str[i++] = (i_part / 10) % 10 + '0';

 f_str[i++] = i_part % 10 + '0';
 f_str[i++] = '.';

 while (size-- > 0){
  f_number -= (int16_t)f_number;
  f_number *= 10;
  f_str[i++] = (uint8_t)(f_number) % 10 + '0';
 }
 f_str[i] = '\0';
}

char* codetxt_to_ramtxt(const char* ctxt)
{
 static char text_[20];
 char i;
 for(i = 0; text_[i] = ctxt[i]; i++);
 return text_;
}

// main function
void main()
{
 OSCCON =  0X70;               // set internal oscillator to 8MHz

 UART1_Init(9600);

 while(1)
 {
 if (UART1_Data_Ready() == 1)
  if(GPSRead())
  {
   // Time
   UART1_Write_Text(codetxt_to_ramtxt("\r\nTime (UTC): "));
   byte_to_str(GPSHour(), txt);
   UART1_Write_Text(txt);
   UART1_Write_Text(":");
   byte_to_str(GPSMinute(), txt);
   UART1_Write_Text(txt);
   UART1_Write_Text(":");
   byte_to_str(GPSSecond(), txt);
   UART1_Write_Text(txt);

   //Date
   UART1_Write_Text(codetxt_to_ramtxt("\r\nDate      : "));
   byte_to_str(GPSDay(), txt);
```

```
    UART1_Write_Text(txt);
    UART1_Write_Text("/");
    byte_to_str(GPSMonth(), txt);
    UART1_Write_Text(txt);
    UART1_Write_Text("/20");
    byte_to_str(GPSYear(), txt);
    UART1_Write_Text(txt);

    // Latitude
    UART1_Write_Text(codetxt_to_ramtxt("\r\nLatitude : "));
    f_res = Latitude();
    float_to_str(f_res, txt, 6);
    UART1_Write_Text(txt);

    // Longitude
    UART1_Write_Text(codetxt_to_ramtxt("\r\nLongitude : "));
    f_res = Longitude();
    float_to_str(f_res, txt, 6);
    UART1_Write_Text(txt);

    // Altitude
    UART1_Write_Text(codetxt_to_ramtxt("\r\nAltitude : "));
    f_res = Altitude();
    float_to_str(f_res, txt, 1);
    UART1_Write_Text(txt);
    UART1_Write_Text(codetxt_to_ramtxt(" meters"));

    // Number of satellites in use
    UART1_Write_Text(codetxt_to_ramtxt("\r\nSatellites: "));
    sats = Satellites();
    byte_to_str(sats, txt);
    UART1_Write_Text(txt);

    // Speed in kmph
    UART1_Write_Text(codetxt_to_ramtxt("\r\nSpeed     : "));
    f_res = Speed();
    float_to_str(f_res, txt, 1);
    UART1_Write_Text(txt);
    UART1_Write_Text(codetxt_to_ramtxt(" kmph"));

    // Course in degrees
    UART1_Write_Text(codetxt_to_ramtxt("\r\nCourse : "));
    f_res = Course();
    float_to_str(f_res, txt, 1);
    UART1_Write_Text(txt);
    UART1_Write_Text(codetxt_to_ramtxt(" degrees\r\n"));

   } }}
// End of code
```

4 METHODOLOGY

4.1 GENERAL METHODS

This study utilized 20 triaxial GPS units (GPS sports). These units contain a 15 Hz GPS receiver and a 100Hz, 16g accelerometer. Record positional data at 5 Hz which is then supplemented or augmented by accelerometer data to record interpolated position at 15 Hz[28][29]. The triaxial accelerometer orientation is determined by a 50 Hz magnetometer (used to orient the axes of the accelerometer). Each unit measures 74mm x 42mm x 16mm and weighs 56g.

The study also used a calibrated trundle wheel (Meter-Man MK45M, Komelon). This wheel has a diameter of 363cm, a circumference of 1.141m and a resolution of 0.1m. At the beginning of each day's testing session, the trundle wheel was calibrated against a 100m distance (measured with a steel tape).

For each trial, two units (paired units) were secured to the handle of the wheel, directly above the axis of the wheel, 8 and 15 cm above the wheel axis and 2.5 cm lateral to the pivot point of the wheel (Figure 3.1). During use, the handle of the wheel rotates from vertical to approximately 20˚ from vertical. This results in a posterior displacement of the center of the upper and lower mounted GPS units of 4 and 7 cm, respectively and no lateral displacement. The paired unit arrangement allowed comparisons between the GPS units and the trundle wheel and between paired units (reliability).

Fig. 4.1: Arrangement of the GPS units attached to the trundle wheel.

4.2 EXPERIMENTAL TRIALS

- Distance (DIST) Trial: The DIST trial was conducted on a 400m running track that conforms to International Association of Athletics Federations specifications. The GPS units and trundle wheel travelled along a 1600m path (four laps of a 400m track). The trial began with the wheel placed directly on the start/finish line and the distance meter reset to zero. The start time ofeach trial was recorded by a satellite-linked digital watch. During the DIST trial, the wheel travelled along a path approximately 0.3m from the inside of the lane. Standard running tracks are designed such that this imaginary line measures 400m. During each lap, the units travelled through 100m at alternating speeds similar to a jog, run and sprint (Figure 3.2). At the end of the final lap, the units were slowed and the wheel brought to a stop directly over the start/finish line.

- Shuttle Run (SHUT) Trial: The SHUT trial was performed on a Sports that meets International Sports Federation specification. For this trial (Figure 3.3), the wheel followed an 8.2m straight line (along the baseline between the singles lines), pivoted 180˚, then returned to the starting point. In order to simulate a Sports match, this path was repeated using 5 “points” of three laps with 20 sec pause between points. The distance and number or points were used to simulate that of a singles Sports game. The pause time represents the maximal allowable time between points in an official Intercollegiate Sports Association match. The SHUT trial had a total distance of 246.9m.

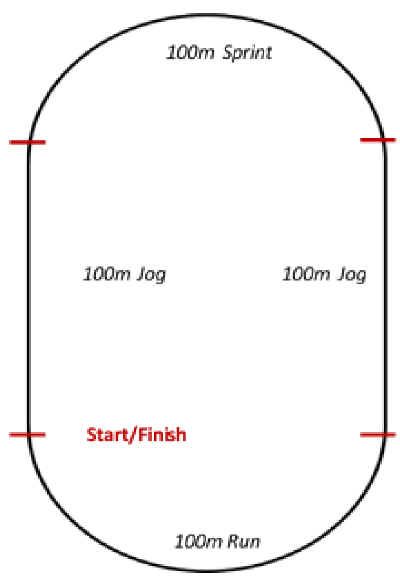


Fig. 4.2: Criterion Path used for the DIST Trial

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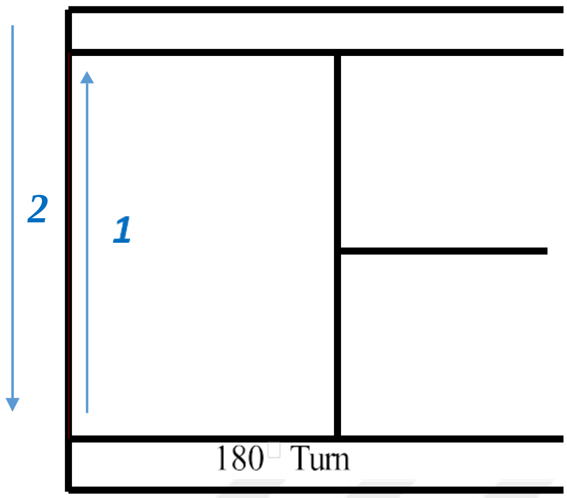

Fig. 4.3: Criterion Path used for SHUT Trial

- Change of Direction (COD) Trial: For the COD trial, the wheel followed a course laid out on a regulation Sports (Figure 3.4). The course consisted of five segments and four turns. For segment 1, the wheel was moved along the baseline between the doubles alley lines (10.8m). An 180˚ turn was executed and the segment 2 consisted of returning the wheel along the baseline. A 90˚ turn was executed and wheel moved along the doubles sideline to the service line (5.5m). The wheel was rotated 90˚ and followed the service line to the other doubles sideline (10.8m). For segment 5, a 153˚ turn was executed and the wheel moved along a straight line towards the intersection of the opposite doubles sideline and the baseline (12.1m). The second lap or point of the course began with a 153˚ turn and moving the wheel along the baseline (segment 1). The distance covered during a single lap of the course was 50.0m. In order to simulate a match, 5 points were executed for each COD trial with a 20s pause between points (250m, 24 turn)

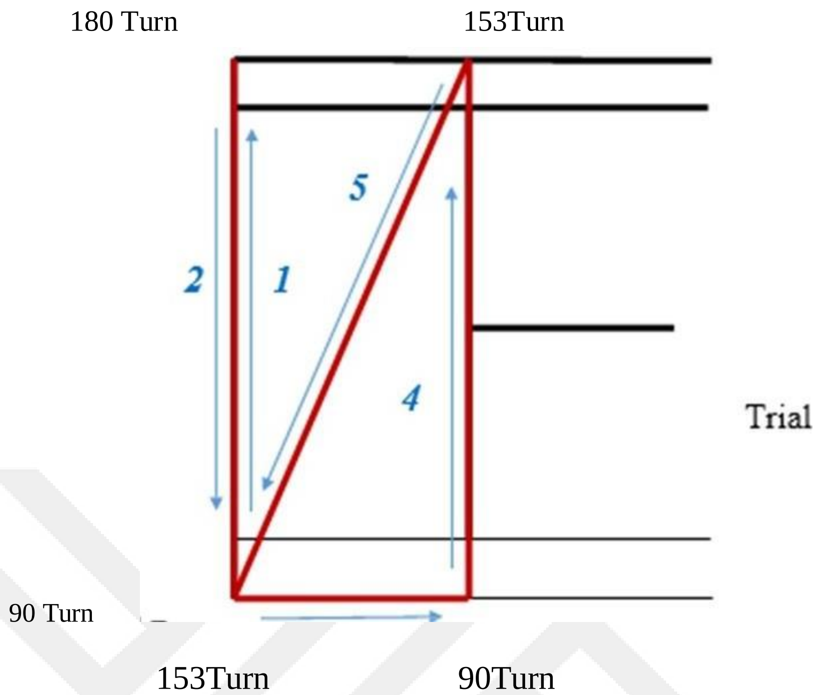

Fig. 4.4: Criterion used for the COD

•

• Random (RAND) Trial: The RAND Trial was performed on a Sports court which meets the International Sports Federation specification. It consisted of 5 points of 10s of random movements within the single court, replicating movements that are common during a Sports match. At the beginning of each point, the wheel was placed directly on the middle of the baseline. In order to simulate a Sports match, this path was repeated 5 times or points with a 10s of pause between points. No criterion distance was established but 5 points covered ~135m. All movements were contained within one side of the singles court (8.23 x 11.89m). A stylized image of the RAND trial is shown in (Figure 3.5)

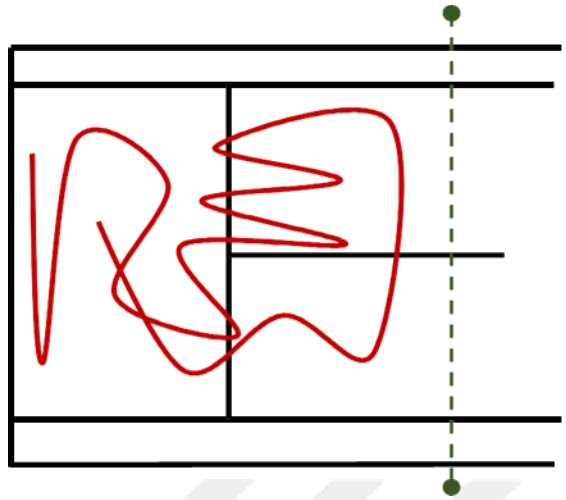

Fig. 4.5: Typical stylized path executed for the RAND Trial

4.3 DATA ANALYSIS AND STATISTCS

After each day's session, data from the SPI HPU units were downloaded and analyzed by the manufacturers software package (Team AMS, GPS sports). The trials were then "split" using the start and end times recorded for each trial. For each trial, total distance was determined. Paired t-tests and repeated measures ANOVA were used to determine difference between the trundle wheel and GPS recorded distances as well as the criterion distances. Significance was established a priori at $p<.05$.

In addition to Bland-Altman analysis, root mean square (RMS) errors were determined using absolute (m) and percent differences. For data reduction and statistical analyses, Excel, Simga-Plot and JMP were used [15].

4.4 HUMAN SUBJECTS

Federal regulations (45 CFR 46) govern the use and consent of individuals involved in human research. This study does not involve obtaining data on or about living individuals. Further, it does not involve collecting individually identifiable information about living individuals. Therefore, it is not considered "research involving human subjects" and 45 CFR 46 does not

Data has been prevailed through an open source sports portal which provides free data for analysis and research purpose. Correlation analyses determine the degree of association between the data for the analysis and do not quantify the extent of agreement. The data was collected from data-hub which is easy to get, use and share. It could be accessed through https://old.datahub.io/organization/sport. Further, while correlations can identify random errors, they do not provide information on systematic bias for the performance of athlete using the reading of GPS provided by the data. In any case, data that is collected in distance between the GPS unit and the criterion distance reflect an inability of the athlete to accurately follow the designated course will result in performance of athlete using the GPS reading provided by the sports portal

4.1.1 RESULTS

Bland-Altman plots were used to determine the bias between the GPS units and LPS units. For this analysis, absolute differences between LPS units and GPS unit derived distances were used as were relative difference as well as movement of athletes shown in Table 4.1. In addition, absolute and relative differences were determined for paired units – the two units attached to the LPS units and following the same criterion path. Using the Bland-Altman approach, bias and limits of agreement weredetermined.

Table 4.1Table 4.1: The movement of the athletes [3].

Movement	Type of movement
1	15 m sprint leading to a 5 m deceleration
2	20 m sprint followed by a 10 m backward movement
3	505 agility test
4	2-90^{o} turns
5	Curve turn towards camera

Table 4.2: The RMSE analysis of the data and comparison of the experimental/theoretical data

Parameter		**GPS**		**Theoretical EPTS**			
				LPS		**VID**	
		Mean	**±SD**	**Mean**	**±SD**	**Mean**	**±SD**
RMSE (distance (m))	Shuttl e run	1.33	0.54	0.22	0.13	0.59	0.28
	Smal l	0.81	0.41	0.23	0.05	0.56	0.12
RMSE (Velocity ms^{-1})	Shuttl e run	0.39	0.08	0.31	0.04	0.52	0.08
	Smal l	0.39	0.06	0.36	0.06	0.47	0.08
	Low spee	0.26	0.13	0.26	0.07	0.33	0.12
	High Spee	0.37	0.25	0.39	0.13	0.50	0.30

RMSE (Acceleration ms^{-2})	Shuttle run	0.56	0.17	0.58	0.10	0.80	0.15
	Small	0.69	0.14	0.69	0.13	0.97	0.19

In addition to Bland-Altman analysis, root mean square error (RMSE) distance, velocity and acceleration were determined using absolute (m) and percent differences. For data reduction and statistical analyses as represented by Table 4.2. There is some concern as to the accuracy, validity and reliability of GPS with RMSE to measure distances traveled during sports or practice for finding RMS errors. Some of this concern stems from the tracking data used to evaluate GPS data and the types of activities evaluated.

4.6 IDENTIFICATION OF INJURIES USING GPS

The injuries of an athlete have been found using the GPS reading available in the dataset. There is some concern as to the accuracy, validity and reliability of GPS to measure distances traveled during court-based sports such as Sports. Following the injuries of competitors utilizing GPS perusing gave gathering independently recognizable data about living people and distinguished the damage on left hip of a competitor is appeared in figure 4.1. Following the injuries of competitors utilizing GPS perusing given by gathering exclusively recognizable data about living -Following the injuries of competitors utilizing GPS perusing gave gathering separately recognizable data about living people and distinguished the damage on left knee of a competitor is appeared in figure 4.3. Following the injuries of competitors utilizing GPS perusing gave gathering separately recognizable data about living people and distinguished the damage on right knee of a competitor is appeared in figure 4.4. Competitors frequently slide to arrive at the game. Because of these attributes, injuries lessens the speed of the entire game, and Athletes have substantially more time to recuperate from every damage. Following the injuries of competitors utilizing GPS perusing gave gathering independently recognizable data about living people and distinguished the damage on left quad of a competitor is appeared in figure 4.5. Further we recommended that this methodology of damage ID can be stretched out by plotting the percent blunder between the various estimations versus their mean of damage utilized in examination. Following the injuries of competitors utilizing GPS perusing gave gathering exclusively recognizable data about living people and distinguished the damage on right quad of a competitor is appeared in figure 4.6. A portion of this worry originates from the best quality level used to assess GPS information and the kinds of injuries assessed given beneath. The usefulness of GPS in monitoring the physical demands as well as injuries of athletes suchas wounds are evaluated and analyzed through this methodological formation of injuries identification in athlete's body.

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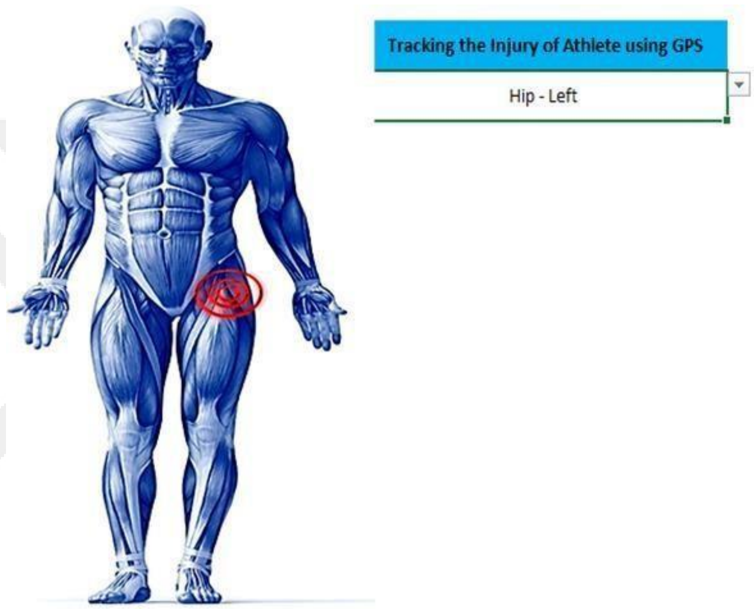


Fig. 4.6: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on left hip of an athlete.

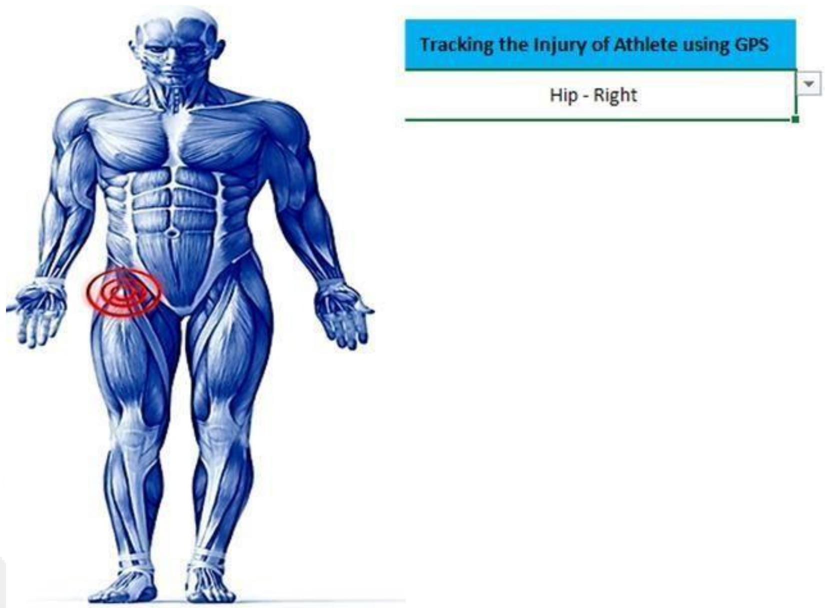


Fig. 4.7: Tracking the injuries of athletes using GPS reading provided by collecting individually identifiable information about living individuals and identified the injury on right hip of an athlete.

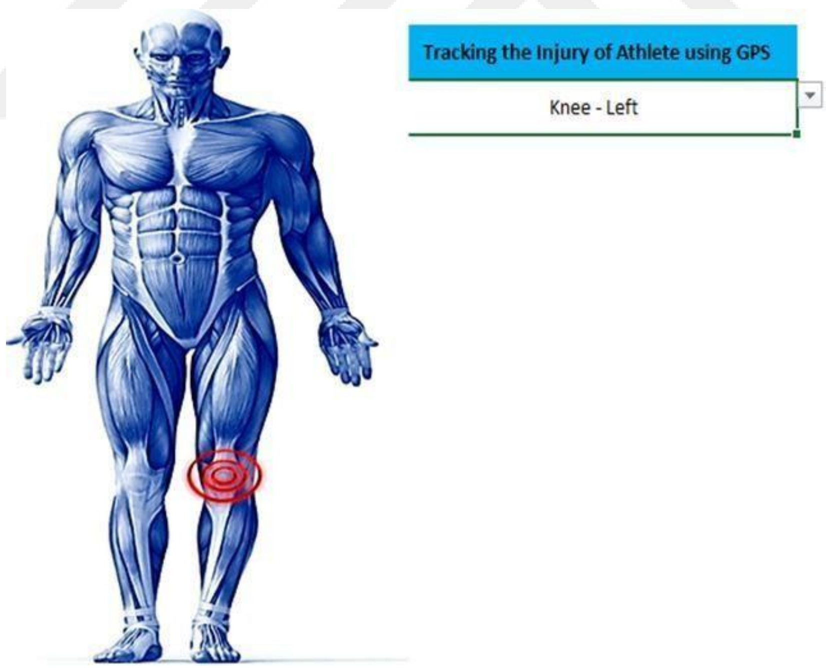


Fig. 4.8: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on left knee of an athlete.

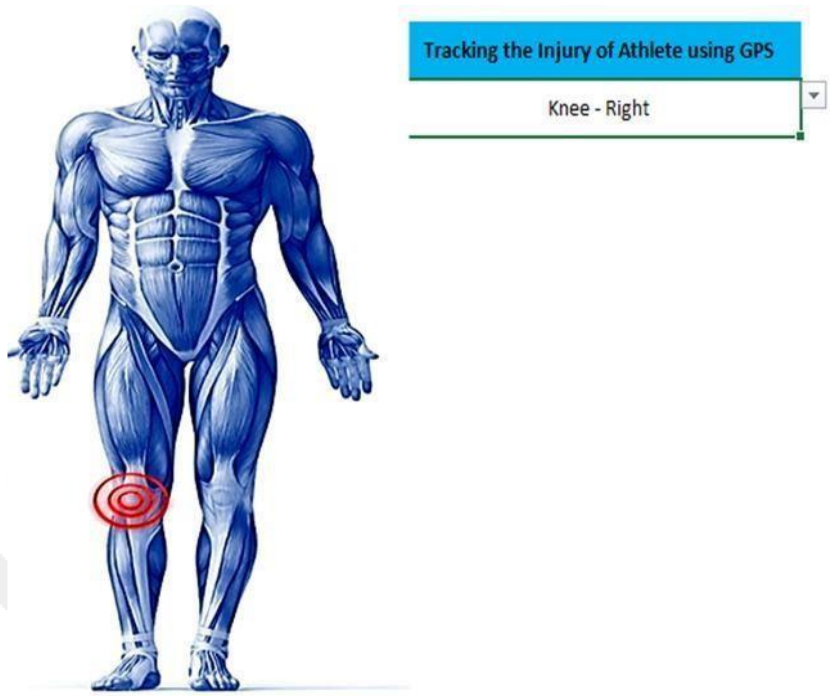


Fig. 4.9: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on right knee of an athlete.

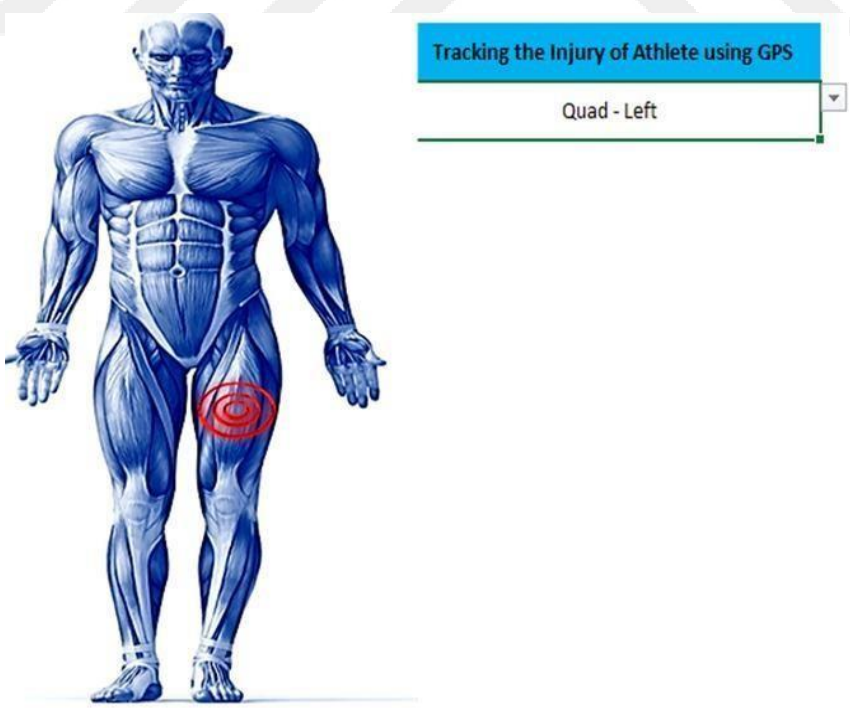


Fig. 4.10: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on left quad of an athlete.

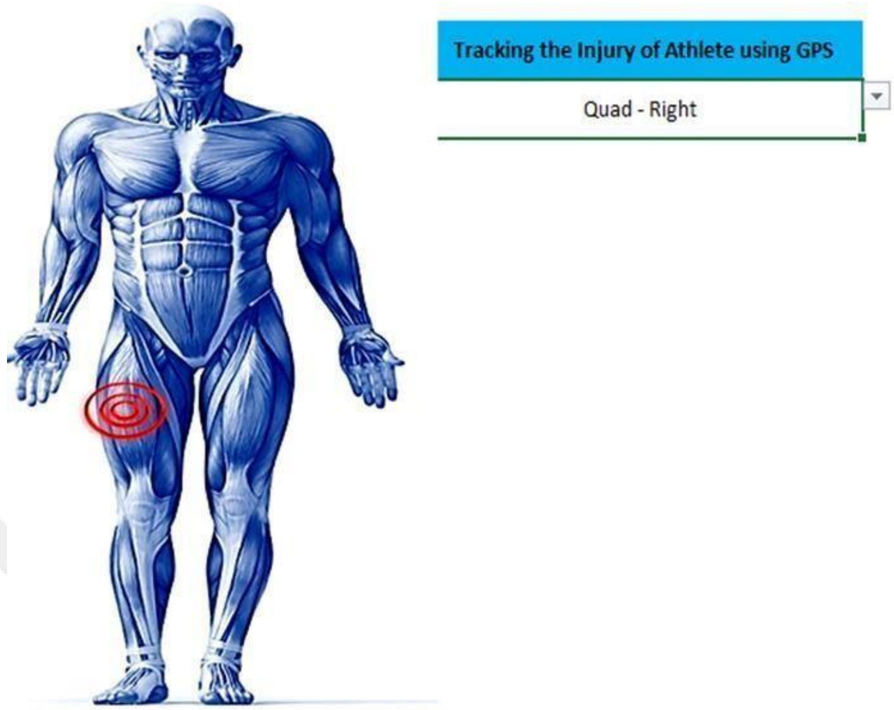


Fig. 4.11: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on right quad of an athlete.

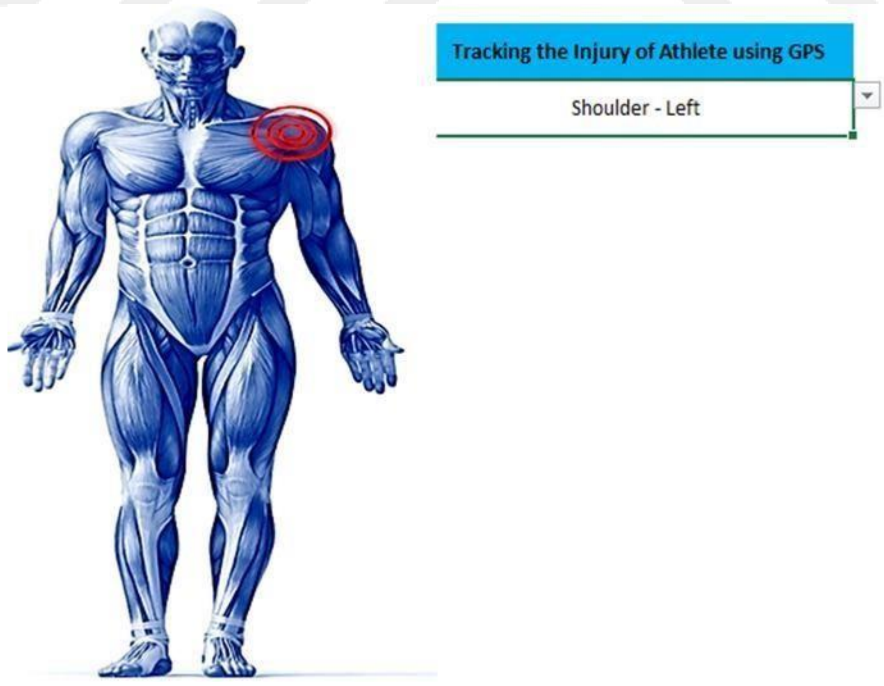


Fig. 4.12: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on left shoulder of an athlete

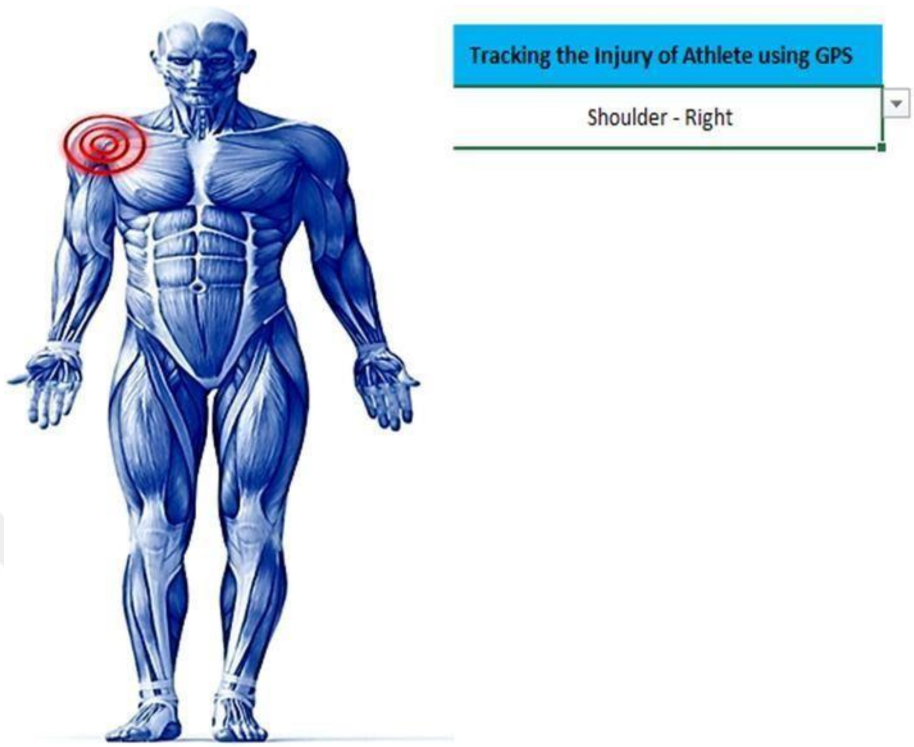


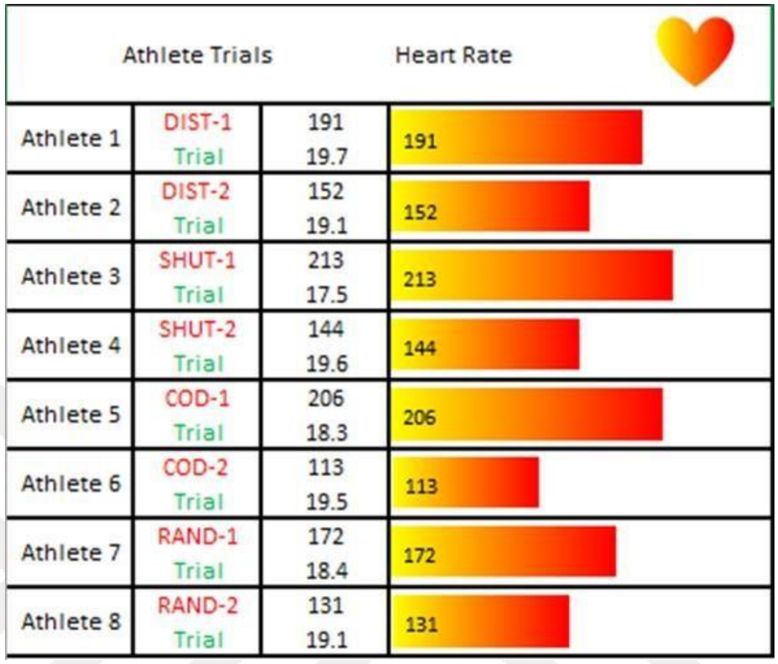
Fig. 4.13: Tracking the injuries of athletes using GPS reading provided collecting individually identifiable information about living individuals and identified the injury on right shoulder of an athlete

4.7 BLAND ALTMAN MEASUREMENTS

The Bland-Altman plot and GPS unit measurements are used for an analysis yielded a bias with the GPS units showing greater distances. Results are seen when percent differences are used for the Bland-Altman analysis. The mean bias was an absolute percent difference.

Bland-Altman analysis of paired GPS unit's analysis showed an absolute bias with percent difference between paired units for each analysis, difference points fall within the upper and lower LPS. RMS error values were 6.61±1.56% and 0.41±0.10%.

Reliability heart rate of athletes between paired units is shown in figure 4.9. For this experiment, distances were compared between the two units simultaneously mounted on the trundle wheel [17]. Bland-Altman plot are shown in Figure 4.10 against each reading in the table. Each point represents the difference between the two units where the distance obtained by the upper unit was subtracted from that obtained by the lower mounted unit. For the court-based trials (DIST, SHUT, COD and RAND), accumulated distances covered during each of the five intervals or simulate points” were compared between the GPS and LPS units and between paired units for measuring the athletes heart rate.



Athlete Trials			Heart Rate
Athlete 1	DIST-1 Trial	191 19.7	191
Athlete 2	DIST-2 Trial	152 19.1	152
Athlete 3	SHUT-1 Trial	213 17.5	213
Athlete 4	SHUT-2 Trial	144 19.6	144
Athlete 5	COD-1 Trial	206 18.3	206
Athlete 6	COD-2 Trial	113 19.5	113
Athlete 7	RAND-1 Trial	172 18.4	172
Athlete 8	RAND-2 Trial	131 19.1	131

Fig. 4.14: The results of athletes and their Bland Altman trial show very good validity and reliability for their heart rates. Limits of agreement between the GPS and LPS were less than ±9.8% and between paired units less than ±200% for all DIST, SHUT, COD and RAND

In Sports, tracking the performance of athletes are very important and should be done remotely. Thus, researchers must also consider the errors of GPS technology in this context for better performance measurements. Another problem of GPS is that it tracks performance of the unit that do not necessarily correspond to actual distances travelled by the athlete. In Sports, there are trunk performance that are tracked by the GPS but do not reflect distances covered by the Athlete. For instance, when an Athlete is returning to a serve or reaching for a shot, it is not unusual to for the performance of athlete to measure more than the analyzed. This is not considered a performance or distance covered but as the GPS unit moves, it tracks the performance based on data collected as displayed in Figure 4.11. Thus, determining accuracy based on performance may introduce error. Clearly, there is a need to examine the accuracy and reliability of the GPS unit in the absence of Athlete performance measurement. The presentation of an Athlete named as "Alan" in light of 7 days and 28 days moving normal for Week-1 given by the manual check to GPS perusing for 7 days and 28 days moving normal for Week-2 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.13. The exhibition of an Athlete named as "Alan" in light of 7 days and 28 days moving normal for Week-3 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.14. The presentation of an Athlete named as "Alan" in view of 7 days and 28 days moving normal for Week-4 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.15. The exhibition of an Athlete named as "Alan" in light of 7 days and 28 days moving normal for Week-5 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.16. The presentation of an Athlete named as "Alan" in light of 7 days and 28 days moving normal for every one of the five weeks given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.17. Most GPS systems now utilize accelerometer data to augment or supplement the GPS signal, improving its accuracy. It is important to note that analysis as well as evaluation of performance of athlete used the tracking data as the criterion measurement. Thus, any deviation from the criterion tracking data by the subject would have resulted in excess distance travelled and be interpreted as error. Similarly the results have also being tracked for another athlete and results have been showed respective of the performance of athlete based on tracking data. The exhibition of an Athlete named as "John" in light of 7 days and 28 days moving normal for Week-1 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.18. The exhibition of an Athlete named as "John" in light of 7 days and 28 days moving normal for Week-2 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.19. The presentation of an Athlete named as "John" in light of 7 days and 28 days moving normal for Week-3 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.20. The presentation of an Athlete named as "John" in light of 7 days and 28 days moving normal for Week-4 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.21. The presentation of an Athlete named as "John" in view of 7 days and 28 days moving normal for Week-5 given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.22. The presentation of an Athlete named as "John" in light of 7 days and 28 days moving normal for every one of the five weeks given by the manual check to GPS perusing for 7 days and 28 days is shown in Figure 4.23. The presentation of an all Athletes dependent on 7 days and 28 days moving normal for every one of the five given by the manual check to GPS perusing for 7 days and 28 days. The last chart speak to the presentation of all competitors dependent on their GPS readings showed in Figure 4.24. These reading allow athletes to monitor, collect and manage data in different sports and during different training sessions or matches. The GPS sports devices are widely used in team sports because they give a better understanding of physiological demands of performance within a large space and can give more information about how to plan specific trainings. Unfortunately, the use of this technology has been limited in sports so these results are quite satisfying with respect to the tracking data that was available for tracking the performance of athletes during their playing sessions.

Tracking Athlete Body Power		
Athlete 1	GPS	52
	LPS	49
Athlete 2	GPS	35
	LPS	40
Athlete 3	GPS	47
	LPS	54
Athlete 4	GPS	54
	LPS	40
Athlete 5	GPS	51
	LPS	44
Athlete 6	GPS	37
	LPS	46
Athlete 7	GPS	49
	LPS	40
Athlete 8	GPS	36
	LPS	42

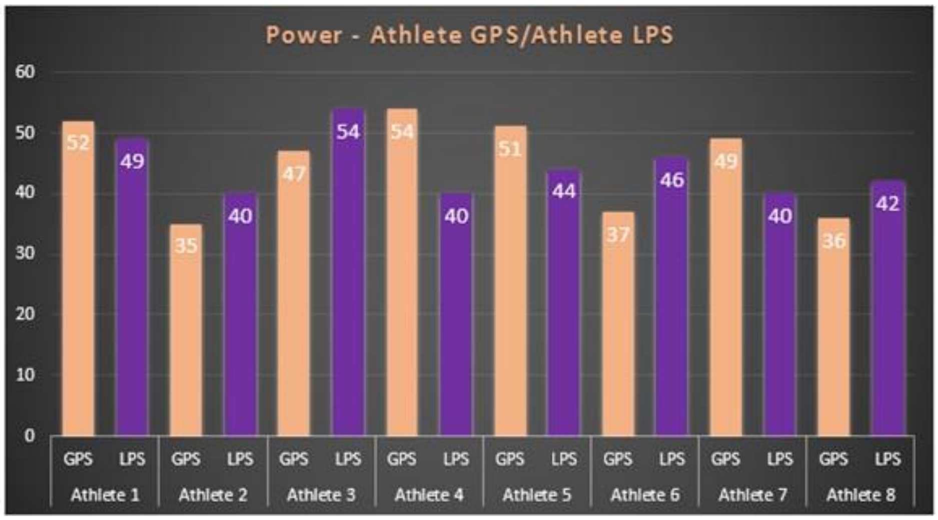


Fig. 4.15 Bland-Altman plots of the GPS reading and trial using absolute differences (upper panel) and percent differences (lower panel). The solid green and blue lines indicates the GPS and the LPS reading of different athletes in the table.

4.2 TRACKING THE PERFORMANCE OF ATHLETES

Activities such as Sports require movements where the athlete's body may move but the athlete's feet remain stationary. The reading of GPS helps tracking the athletes and their performance load during the workout and their practicing sessions. The tracking data represents the recorded movements of athletes as given in figure 4.11. Thus, using athlete movements and criterion distances is the best approach for evaluating the validity of GPS derived distances and measuring the performance load of athletes

Week	Date	Athlete	Load	28 Day Rolling Averag	7 Day Rolling Averag	Tracking Data	28 Day Manual Check	GPS Readin for 28day	GPS Readin for 7day	GPS Findings
Week 1	1/4/2016	Alan	180	180	180	1.0	180	180	180	1.0
Week 1	1/4/2016	Ben	61	61	61	1.0	61	61	61	1.0
Week 1	1/4/2016	David	186	186	186	1.0	186	186	186	1.0
Week 1	1/4/2016	Joe	99	99	99	1.0	99	99	99	1.0
Week 1	1/4/2016	John	131	131	131	1.0	131	131	131	1.0
Week 1	1/4/2016	Michael	168	168	168	1.0	168	168	168	1.0
Week 1	1/4/2016	Niall	183	183	183	1.0	183	183	183	1.0
Week 1	1/4/2016	Paul	100	100	100	1.0	100	100	100	1.0
Week 1	1/4/2016	Steven	121	121	121	1.0	121	121	121	1.0
Week 1	1/4/2016	Tom	250	250	250	1.0	250	250	250	1.0
Week 1	1/5/2016	Alan	0	90	90	1.0	168	168	135	0.8
Week 1	1/5/2016	Ben	165	113	113	1.0	68	68	87	1.3
Week 1	1/5/2016	David	124	155	155	1.0	182	182	171	0.9
Week 1	1/5/2016	Joe	0	50	50	1.0	92	92	74	0.8
Week 1	1/5/2016	John	133	132	132	1.0	131	131	132	1.0
Week 1	1/5/2016	Michael	92	130	130	1.0	163	163	149	0.9
Week 1	1/5/2016	Niall	123	153	153	1.0	179	179	168	0.9
Week 1	1/5/2016	Paul	0	50	50	1.0	93	93	75	0.8
Week 1	1/5/2016	Steven	147	134	134	1.0	123	123	128	1.0
Week 1	1/5/2016	Tom	118	184	184	1.0	241	241	217	0.9
Week 1	1/6/2016	Alan	123	101	101	1.0	165	165	132	0.8
Week 1	1/6/2016	Ben	123	116	116	1.0	72	72	96	1.3
Week 1	1/6/2016	David	195	168	168	1.0	183	183	177	1.0
Week 1	1/6/2016	Joe	0	33	33	1.0	86	86	56	0.6
Week 1	1/6/2016	John	0	88	88	1.0	122	122	99	0.8
Week 1	1/6/2016	Michael	188	149	149	1.0	164	164	159	1.0
Week 1	1/6/2016	Niall	169	158	158	1.0	178	178	168	0.9
Week 1	1/6/2016	Paul	197	99	99	1.0	100	100	106	1.1
Week 1	1/6/2016	Steven	64	111	111	1.0	119	119	112	0.9
Week 1	1/6/2016	Tom	0	123	123	1.0	224	224	163	0.7
Week 1	1/7/2016	Alan	71	94	94	1.0	158	158	117	0.7
Week 1	1/7/2016	Ben	133	121	121	1.0	76	76	105	1.4
Week 1	1/7/2016	David	71	144	144	1.0	175	175	150	0.9
Week 1	1/7/2016	Joe	121	55	55	1.0	88	88	72	0.8
Week 1	1/7/2016	John	103	92	92	1.0	121	121	100	0.8
Week 1	1/7/2016	Michael	0	112	112	1.0	153	153	119	0.8
Week 1	1/7/2016	Niall	151	157	157	1.0	176	176	164	0.9
Week 1	1/7/2016	Paul	97	99	99	1.0	100	100	103	1.0

Fig. 4.16 : Data collected based on five weeks for different athletes by their respective names depending on how the Athlete executes the task, GPS recorded distances could vary considerably from the criterion distance for 7 and 28 rolling averages. The dates have also been mentioned in the dataset for analysis

Fig. 4.17 :The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for Week-1 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

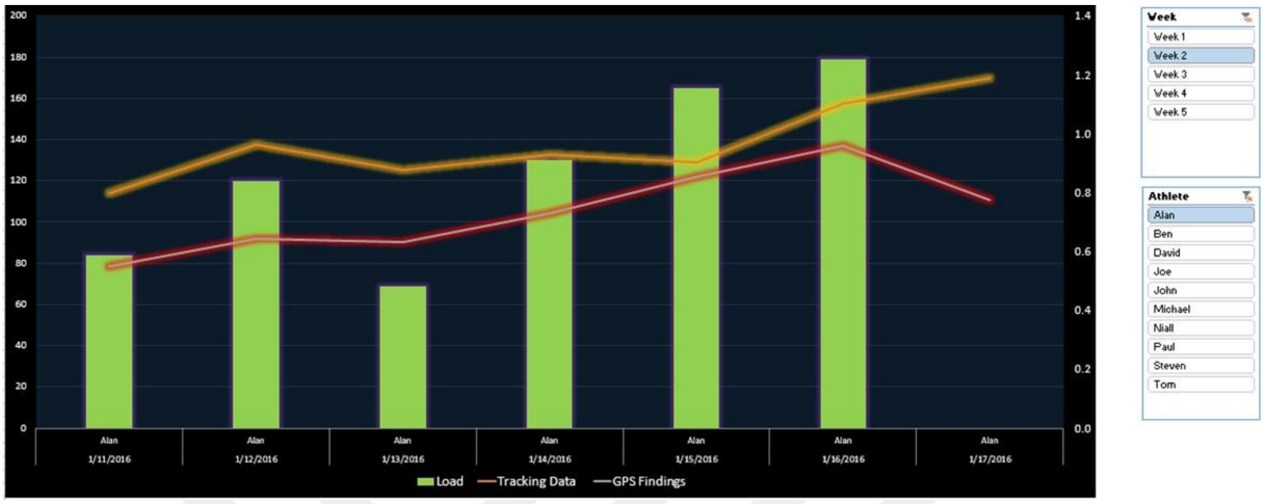


Fig. 4.18 :The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for Week-2 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS read

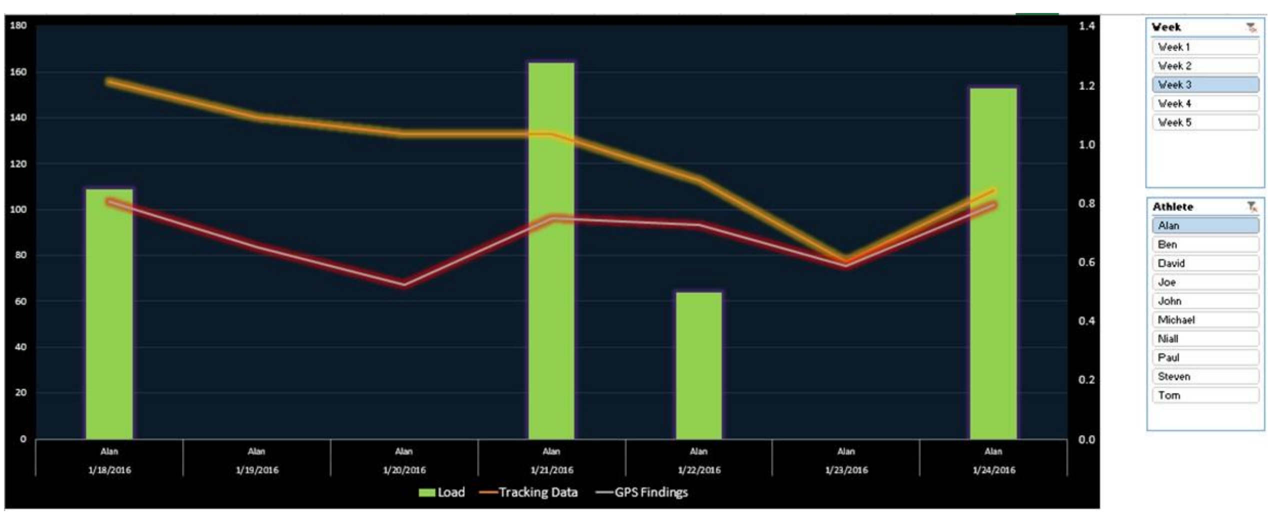


Fig. 4.19 : The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for Week-3 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings

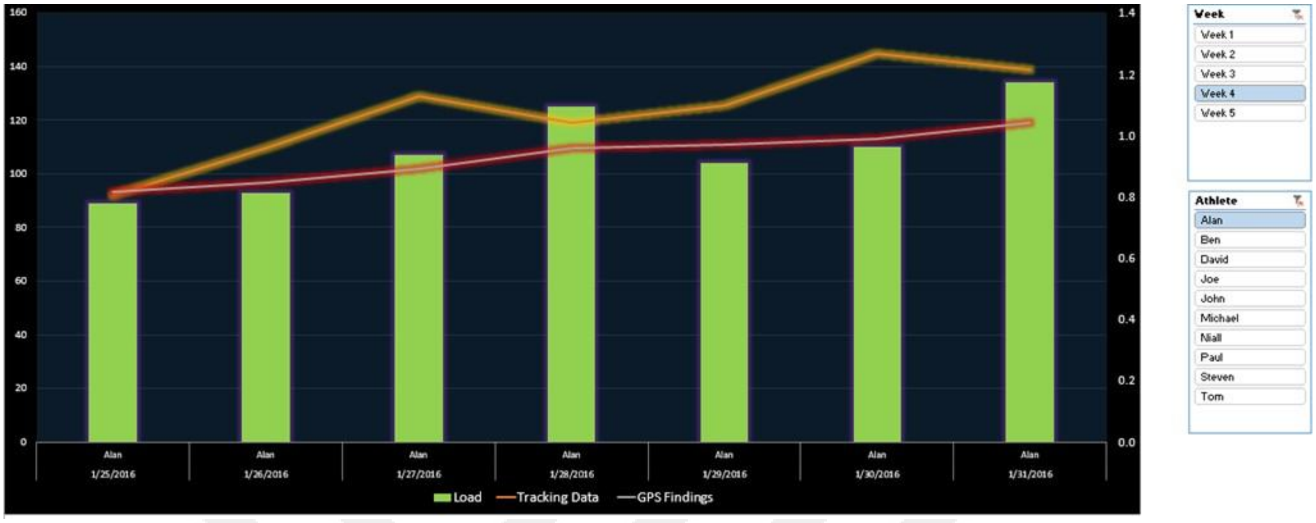


Fig. 4.20: The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for Week- 4 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

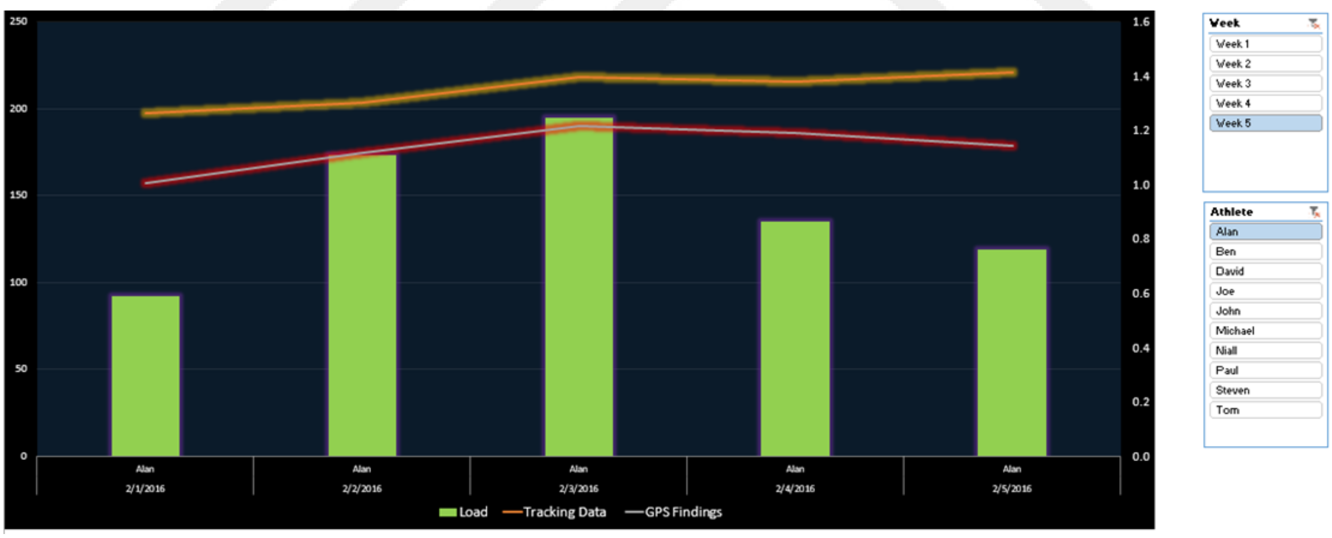


Fig. 4.21: The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for Week-5 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

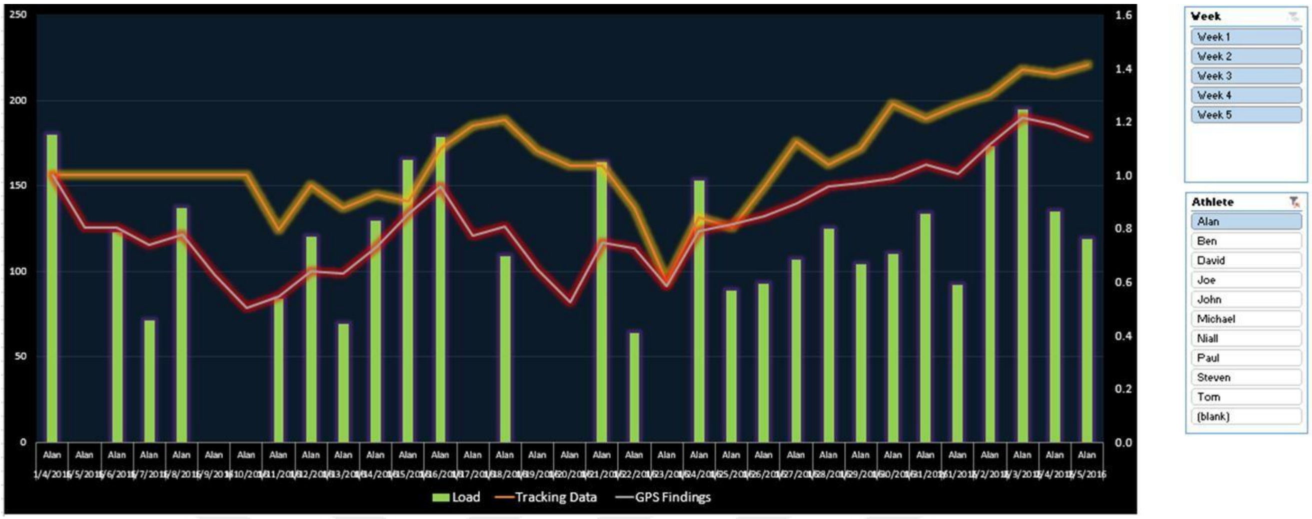


Fig. 4.22: The performance of an Athlete named as "Alan" based on 7 days and 28 days rolling average for all five weeks provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

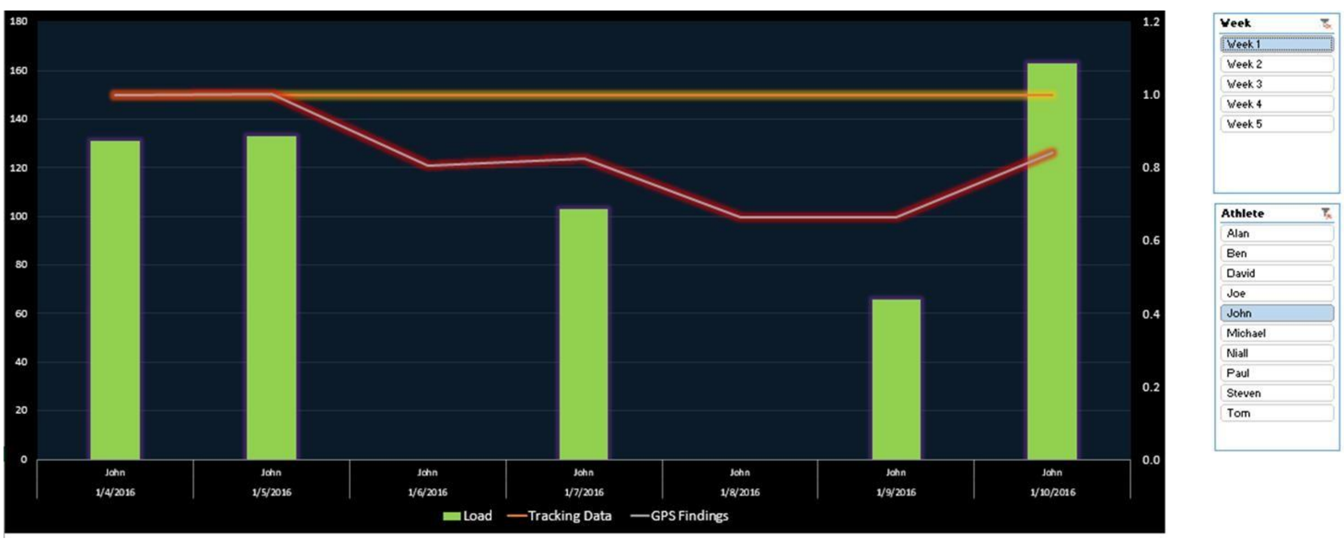


Fig. 4.23**:** The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for Week-1 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

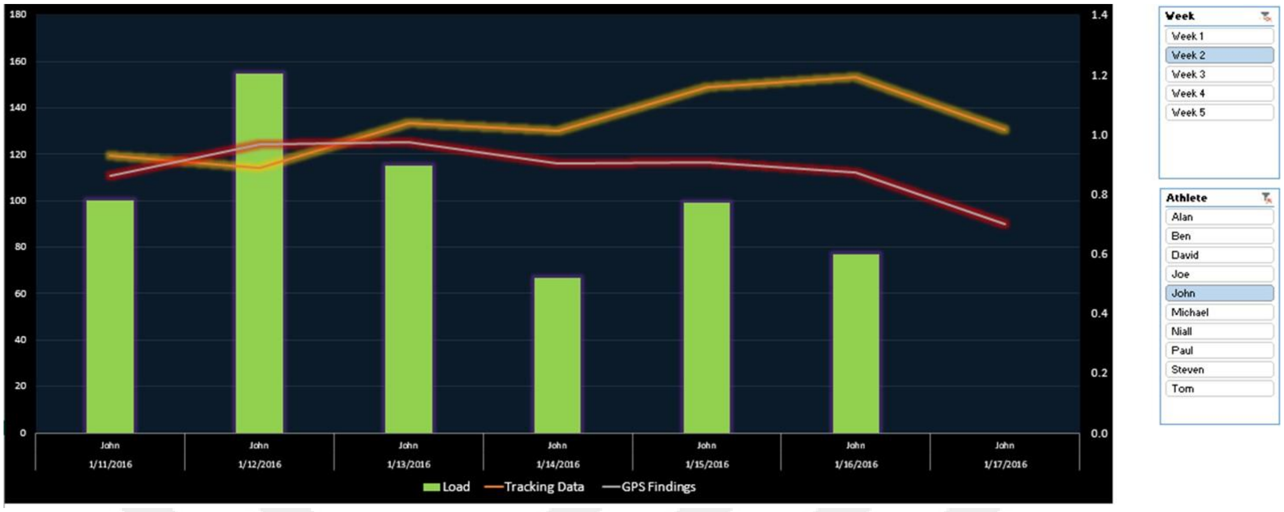


Fig. 4.24: The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for Week-2 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS read

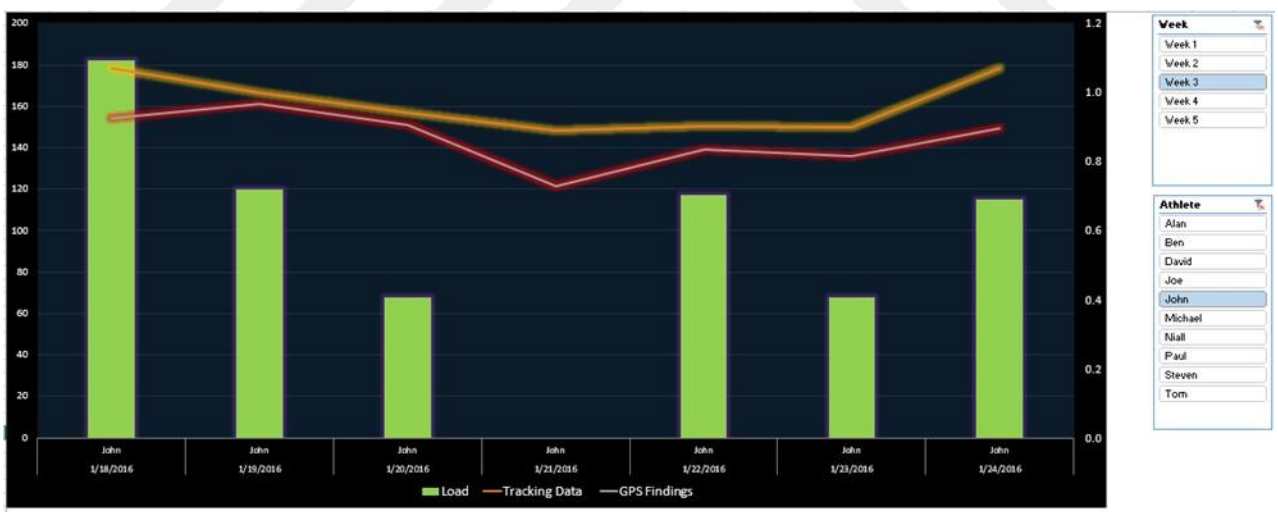


Fig. 4.25: The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for Week-3 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

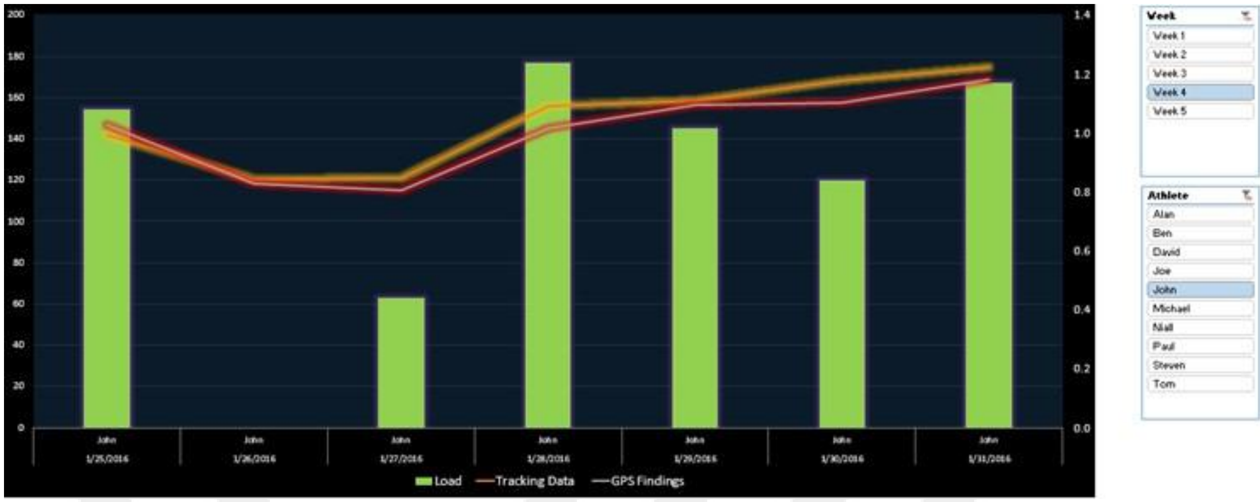


Fig. 4.26: The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for Week-4 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings.

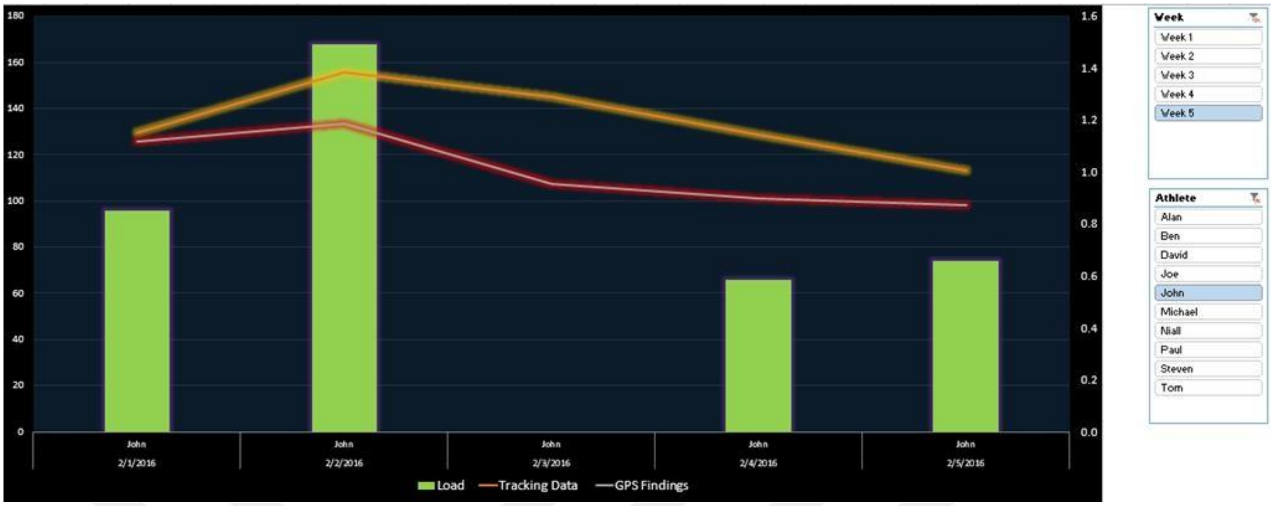
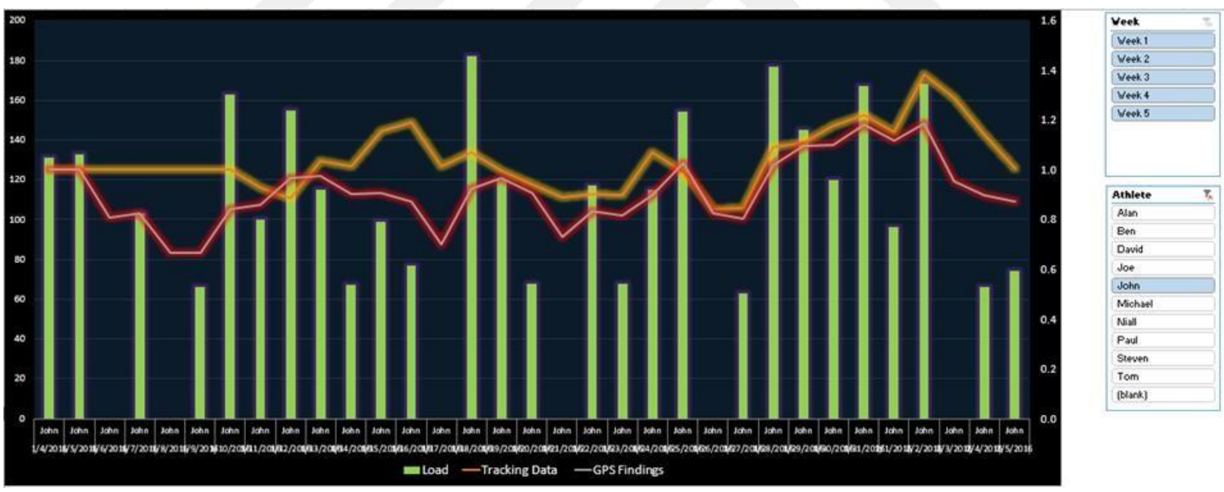


Fig. 4.27: The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for Week-5 provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the



performance graph using GPS reading.

Fig. 4.28: The performance of an Athlete named as "John" based on 7 days and 28 days rolling average for all five weeks provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS reading .

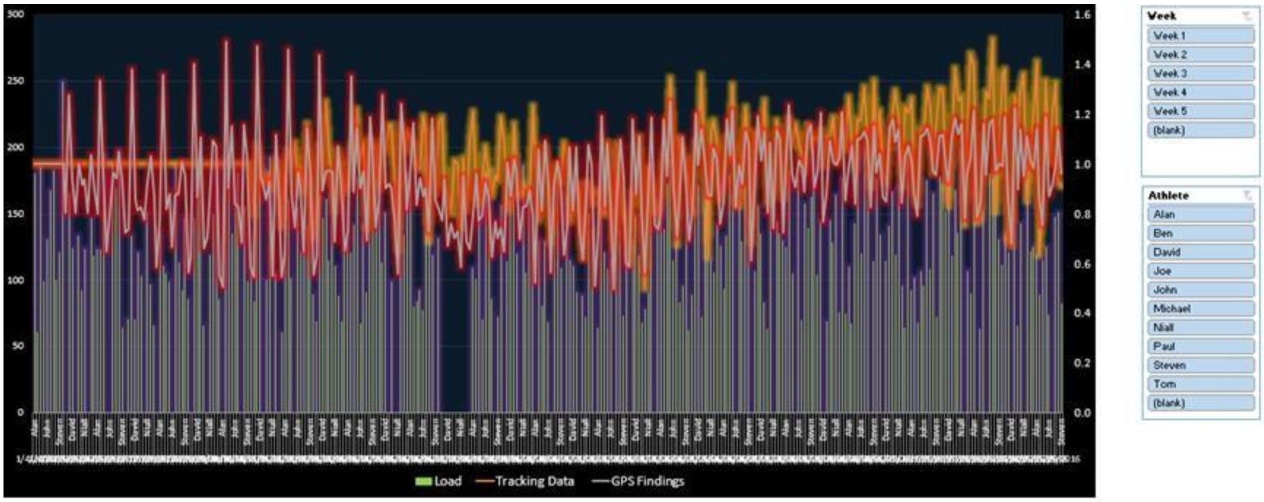


Fig. 4.29: The performance of an all Athletes based on 7 days and 28 days rolling average for all five provided by the manual check for GPS reading for 7 days and 28 days. The blue bar represents the Load, Orange line represent the Tracking data and finally the GPS finding for an athlete is represented by the Grey colored line in the performance graph using GPS readings. The final graph represents the performance of all athletes based on their GPS readings.

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Table 4.3: Comparison of Mean bias for each trial along with previous studies.

Measuring Factors		**DIST**	**COD**	**SHUT**	**RAND**
Drew MK et al., 2016 [41					
Very Low Distance	< 70 km	25	68.0	1.2 (0.4-3.8)	0.73
Low Distance	70 - 94	21	52.4	1.3 (0.5-3.5)	0.64
Moderate (reference)	95 - 143	68	44.1	1.0	-
High Distance	144 - 170	34	29.4	0.6 (0.2-1.6)	0.28
Very High Distance	> 170 km	26	61.5	3.2 (1.3-8.5)	0.02*

Bradley PS et al., 2007 [39]

Very Low Distance	< 108 km	17	82.4	5.6 (1.4-22.8)	0.02*
Low Distance	108 - 124	14	57.1	1.3 (0.4-5.2)	0.55
Moderate (reference)	125 - 164	88	45.5	1.0	-
High Distance	165 - 184	37	45.9	1.0 (0.4-2.2)	0.93
Very High Distance	> 184 km	18	27.8	0.3 (0.1-1.0)	0.06

Henderson G et al., 2010 [40]

Very Low Distance	< 76 km	13	38.5	0.6 (0.2-2.1)	0.40
Low Distance	76 - 88	19	78.9	6.0 (1.6-23.3)	0.01*
Moderate (reference)	89 - 112	94	44.7	1.0	-
High Distance	113 - 125	21	42.9	0.8 (0.3-2.1)	0.64
Very High Distance	> 125 km	27	48.1	1.0 (0.4-3.0)	0.94

Cross MJ and Williams's S et al., 2016 [43]

Very Low Distance	< 76 km	13	0.0	0.0	0.00
Low Distance	76 - 88	19	31.6	4.6 (1.2-17.4)	0.03*
Moderate (reference)	89 - 112	94	9.6	1.0	-
High Distance	113 - 125	21	9.5	1.0 (0.2-4.7)	0.96
Very High Distance	> 125 km	27	22.2	2.6 (0.8-8.1)	0.09

Table 4.4: Mean bias for each trial along studies will concluded.

		DIST	COD	SHUT	RAND
Measuring Factors Our Approach (Age)	< 20 y	35	31.4	0.9 (0.4-2.3)	0.80
	20-21 y	30	16.7	0.4 (0.1-1.0)	0.05*
	22-24 y (reference)	60	35.0	1.0	-
	25-26 y	28	39.3	1.3 (0.6-2.9)	0.57
	27+ y	26	42.3	1.5 (0.6-4.2)	0.42

In comparison schedule above in table 4.3 and 4.4 it's about our studys and previous studie , comparison on different points it's its terms of gps instrument , function , standared evaluation , varible analyzed and sustainability , a churned with using best root in our study to reach it's show our study it's better then five research above by using speical characteristic

5 DISCUSSION

5.1 SUMMARY OF RESULTS

The utilization of GPS to gauge outstanding task at hand during court-based games, for example, Sports has stimulated a ton of enthusiasm for mentors and coaches. Be that as it may, a key concern is the exactness and unwavering quality of this innovation for fast alter of course developments inside a bound space. In this examination, the GPS sports SPI HPU units were observed to be extremely exact and solid for these kinds of movement. The GPS units overestimated standard separations during the DIST, SHUT and COD preliminaries by 1.1, 0.52 and 2.39%, separately. Be that as it may, the GPS units overestimated the trundle wheel separations during each of the four preliminaries by under 2.5%. Tasteless Altman examination indicated inclination estimations of under 2% and LPS estimations of ±5%. Unwavering quality, controlled by looking at combined units utilized at the same time, was likewise awesome. Matched units contrasted by under 2% over all preliminaries. Dull Altman predisposition esteems were less that 0.7% and the LPS were likewise ±5%. For both legitimacy and unwavering quality estimations, over 95% of the focuses fell inside the LPSs. Given this, it is presumed that the SPI HPU GPS units can be unquestionably used to decide separations kept running during court-based games, for example, Sports.

By and large, the GPS sports innovation demonstrated an incredible precision in every one of the four preliminaries. These trails included both moderate speed developments with little alter in course (DIST) just as rapid developments with various alters in course (SHUT, COD, RAND). The percent mistake would in general be most noteworthy for the RAND and littlest for the DIST preliminaries. Nonetheless, the distinctions were not factually unique. By the by, this raises the likelihood that as number of alters in course increment and the territory of development diminishes, the GPS mistake increments.

While this examination recommends awesome legitimacy and unwavering quality of the SPI HPU units, it is imperative to see these two parameters with regards to how they are being used. Reference [30] accentuates that Bland-Altman investigation just evaluates or characterizes the degree of understanding between two techniques for estimation. This investigation just as the present information don't suggest that those points of confinement are satisfactory inside a specific setting. Reference [30] proposes that adequate cutoff points ought to be characterized from the earlier, in light of research or commonsense contemplations and objectives. For instance, if the planned utilization of the SPI HPU units is to furnish a mentor or therapeutic staff with a sound gauge to separation went during an instructional course or rivalry for use in periodizing exercises, a 2% blunder might be more than satisfactory. Notwithstanding, if the units are to be utilized in an examination setting where a test mediation may bring out little (1-3%) changes in separation, at that point the utilization of the SPI HPU unit may be faulty. Accordingly, while this investigation demonstrates generally excellent legitimacy and unwavering quality of these units for separation estimation during games, for example, Sports, the client is a definitive evaluator of these gadgets.

5.2 COMPARISON WITH OTHER STUDIES

In different examinations, for example, [28] and [20], specialists thought about separations recorded by the GPS units with video assurance utilizing VICON. The exactness in these investigations was observed to be in the middle of 4 to 10%. It's isn't promptly clear why the aftereffects of the present examination show more prominent exactness. It is notable that the VICON and comparative video framework have high exactness, a lot more prominent than the trundle wheel utilized in the present investigation. Subsequently, an increasingly exact "highest quality level" may clarify the contrasts among GPS and video determined separations in these examinations contrasted with the present investigation. Contrasts between studies could likewise reflect distinction in the GPS unit utilized (GPS sports SPI Elite and Catapult MinnimaX). The two units report GPS positions at 15Hz. And all use 100Hz accelerometry information to enhance 5Hz GPS information to acquire the 15Hz detailed qualities. Further, the GPS sports gadgets use a magnetometer to situate the triaxial accelerometer while the Catapult gadgets utilize a whirligig. Makers of these gadgets use restrictive calculations to incorporate GPS and accelerometer information. Chan et al (2006) show that the decision of calculation can affect the determined separations. While it isn't clear if the units studies use various strategies for processing separation, it is conceivable that such a distinction could influence legitimacy scores. Given this, future examination into the legitimacy of the SPI HPU units ought to incorporate a video-based estimation framework.

Different investigations used a basis separation as their best quality level with evaluating legitimacy of GPS units for separation estimations. Notwithstanding, this expect the individual wearing the GPS unit is fit for following the model way. Any deviation along this way brings mistake into legitimacy assurance. [31]Performed a few estimations on the running track. Subjects needed to pursue developments design on a van and curvilinear running track while wearing a 15Hz GPS gadget (SPI Pro X, GPS sports Systems, Australia). During the curvilinear developments, they found a measurably noteworthy overestimation of the way (2.6%). This mistake could reflect contrasts out yonder of the way (13,200m) and genuine separation goes by the subjects wearing GPS units. For instance, the trundle wheel frequently digressed a few inches from benchmark during the SHUT preliminary and the turns were not constantly executed on the singles line. Additionally, during the DIST preliminary, the objective was to pursue a fanciful line situated 0.3m from within path one. All things considered, there was extensive blunder in following this way. Be that as it may, in the present investigation, the GPS units were verified to the trundle wheel. Subsequently, any blunders or deviations in following the measure way would be distinguished by the wheel. Truth be told, both the haggle recorded more separation than the basis in every preliminary. Along these lines, the utilization of an aligned trundle wheel as the best quality level is desirable over a standard separation.

5.3 LIMITATIONS

In this exploration, there are a few confinements that must be contemplated when translating the outcomes. Regarding the nature of the GPS flag, the SPI HPU units give a check of the quantity of satellites utilized in the figuring of position. Nonetheless, they don't give weakening of exactness data (HDOP, VDOP, and so on). Low DOP qualities show restricted satellite sign impedance, appropriate satellite area and high caliber of area assurance. High DOP qualities could influence a portion of the outcomes by bringing blunder into the GPS position assurance. As noted, SPI HPU DOP qualities couldn't be recorded. All information were gathered on days with insignificant overcast spread and in regions where there is restricted structures and trees. In this manner, negligible obstruction would be normal. Likewise, a different GPS beacon utilizing during information gathering announced DOP flag under 1.0 much of the time and under 2.0 in all cases. This proposes an outstanding or astounding GPS signal quality. Nonetheless, it is imperative to take note of that DOP esteems can contrast between accepting gadgets, notwithstanding when situated at or close to a similar position. Along these lines, while there is no proof to recommend that the present outcomes were affected by poor sign quality, no information are accessible to confirm this.

Another inadequacy, is that the trundle wheel can't gauge both forward and in reverse developments. At the point when the wheel moves in reverse, separation is subtracted by the mechanical counter. Subsequently, so as to mirror in reverse developments during the SHUT and RAND preliminaries, the wheel needed to turn or rotate on its ground contact point before being pushed straight ahead. In the event that the wheel was incidentally moved in reverse during any of the preliminaries, the separation meter would think little of the genuine separation voyaged. Further, if the wheel lost contact with the ground or "slipped" sideways, the separation recorded by the wheel could be influenced. For this examination, extensive consideration was taken to guarantee consistent contact with the ground during the preliminary. Likewise, filled in as the best quality level, "overwhelming" the standard halting point at that point significant consideration was taken to abstain from switching the wheel. As the wheel separation sponsorship up was not expected to approve the GPS units.

For this investigation, the units were situated over the trundle haggle from the wheel's placeof contact with the ground. As the handle of the wheel pivots advances and in reverse, without wheel development, the units would record these as separation voyaged (4 and 7cm degrees of revolution). What's more, any sideway lean of the wheel would likewise present blunder. Care was taken to keep up the handle similarly situated through every one of the preliminaries. In any case, it is conceivable that the handle and units were not generally situated over the wheel ground contact point, particularly during the RAND preliminary where developments and alters in course fluctuated extensively.

5.4 APPLICATIONS

Given that the SPI HPU unit can be utilized effectively to quantify separations went during court-based games, these gadgets ought to demonstrate valuable in checking the physiological requests of preparing and rivalry. Gabbett and partners [12] have delivered a progression of rich examinations and survey articles intended to measure "Competitor load" and to utilize that data to limit damage hazard. For these examinations, this gathering has used evaluations of seen effort just as separations went as burden measurements. They contend that intense changes in burden (increment or abatement) raise the danger of damage. Despite the fact that, these examinations were led in field based games, for example, rugby, soccer and cricket, they have suggestions for Sports. Utilizing GPS units, mentors and coaches could undoubtedly screen separations spreads, paces and increasing speeds during preparing and matches. These information could then be observed or followed through the span of a season with an end goal to confine intense changes in burden and lessen damage hazard.

6 CONCLUSION

6.1 CONCLUSION AND FUTURE WORK

This dissertation concludes up and demonstrated an impressive exactness and dependability in every one of the preliminaries performed. Its usage on a Sports court could be valuable during the assessment of Athlete's physical requests. Mentors searching for an apparatus that could help them in arranging explicit trainings and breaking down matches can unquestionably utilize these gadgets. Furthermore, the high legitimacy and unwavering quality of these gadgets make them valuable to the scientist hoping to decide separations went during court-based games. What's more, the dependability and following of the competitors was generally excellent. Matched competitors demonstrated impressive understanding in determined separation as they were moved along a similar way. Also, this held for every one of the four preliminaries. Additionally, there was no precise inclination between the upper-and lower-mounted units. In this way, one

load can be positive about utilizing the GPS sports SPI HPU units to deciding separations secured by Athletes during court-based games like football. The present information give proof to help this thought. As can be found in Figure(4.1), there are observable deviations in the GPS flag between laps or focuses executed. During the preliminaries, the objective was to pursue the foundation way as intently as could be expected under the circumstances. It was obvious during the examination this was done to contrasting degrees.

Future research ought to likewise concentrate on examining the connections between Athlete duringSports and damage chance. Further, these gadgets can create different measurements of burden, for example, pulse, increasing speed, and effect. These factors give records of both volume and force of action. While no investigation has tended to the mix of these or other variable to measure preparing load, future examinations should endeavor to do as such. Extra information on both outside burden and the competitor's physiological reactions could demonstrate amazing in checking preparing with an eye towards augmenting execution and limiting damage hazard.

A significant issue that isn't tended to in this investigation is the thing that comprises "separation voyaged" during a movement, for example, Sports and henceforth, vitality use. GPS units record separations gone by the unit, not really by the Athlete. For instance, when an

Athlete is getting a serve, he/she regularly influences from side to side. With a trunk mounted GPS unit, this would be recorded as separation went in spite of the feet staying stationary on the ground. A comparative circumstance emerges as Athletes broaden and go after shots. As needs be, vitality might be consumed moving the storage compartment even while the feet are planted. Along these lines, there is a need to characterize what is implied by separation went during explicit exercises. At any rate a legitimate utilization of phrasing is required. For instance, the idea of separation secured during a Sports match may be communicated as GPS unit separation secured as opposed to Athlete separation. Regardless of these confinements, the present outcomes recommend that GPS sports SPI HPU units are both exact and dependable. Contrasting trundle wheel separation estimations and the separations dictated by the GPS units next to no outright and relative predisposition, no steady inclination and little RMS mistake.

New advances are additionally rising that could be combined with GPS units to screen both Athlete burden and specialized execution. Play-Sight is another apparatus that uses a video framework to follow both Athlete and ball developments during Sports (www.playsight.com). This framework gives information on separations gone by the Athlete just as shot sort, area, speed and turn. Until this point, the legitimacy and unwavering quality of the separation computations has not been finished by free specialists. Further, the mix of physical requests (for example separation, pulse, and so forth) and specialized information (shot and administration area and speed) could be amazing in dissecting match execution. Furthermore, how Athlete wellness and the advancement of weariness sway execution could be resolved.

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APPENDIX A

SAMPLE GPS DATA RECORDED DURING A DIST TRIAL [33].

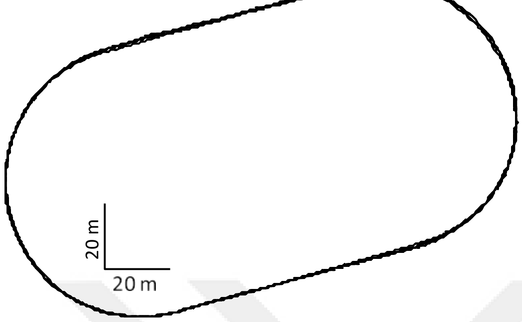
APPENDIX B

SAMPLE OF RAW GPS DATA RECORDED DURING THE SHUT, COD AND RAND TRIALS [36].

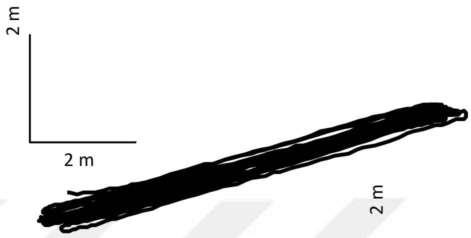
APPENDIX C

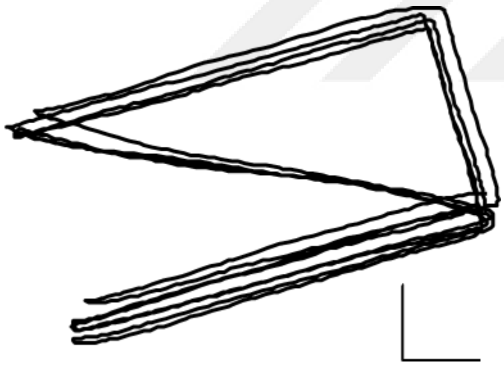
SAMPLE OF RAW GPS DATA RECORDED DURING THE DIST, SHUT, COD AND RAND TRIALS.

DIST Trial

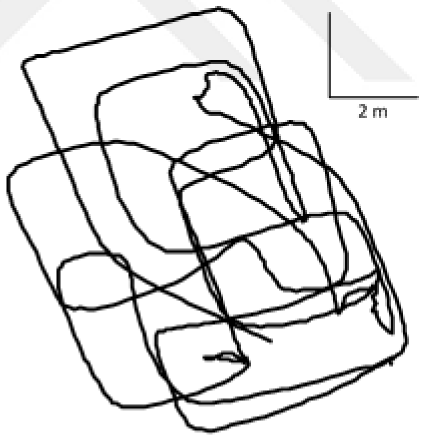


SHUT Trial





COD Trial



RAND TRIAL