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Research Article

A Comparison of a Smartphone App with Other GPS Tracking Type Devices Employed in Football

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ABSTRACT

Objectives: The purpose of this study was to evaluate the use of a smartphone application in comparison against current GPS tracking type devices that are used to track players during football training and match play. Football involves repeated multi directional movements of the whole body at varying speeds and varying distances from walking to high speed running. Therefore, to evaluate validity and reliability of smartphones and elite tracker devices both were assessed and compared against each other for common metrics employed in football player activity tracking.

Methods: These being, walking ≤ 6 km/hr, jogging 6.1-12km/hr, running 12.1-18km/hr, high speed running ≥ 18 km/hr, total distance (m), max speed (km/hr) and positional heat map. Post analysis values obtained showed that there were no significant differences between smartphones employed in the study $p < 0.001$ 95%. Furthermore, values with both the smartphone app and the GPS tracking device showed a high degree of correlation ($r = 0.94-0.99$, $p < 0.001$).

Results: The results of this study show that a smartphone application can be used for capturing data in football environments. However, caution should be taken over what data to collect and use.

Conclusions: That said, having the ability to easily capture such data with a smartphone can provide a practical and inexpensive tool to measure and easily visualise physical activity in football participation.

INTRODUCTION

Recent advances in wearable technology, in particular global positioning systems (GPS), enable measurement of athlete movement patterns and physical demands involved in sport [1]. Sports scientists and coaches, use this quantitative data to help establish the external loads of training and competition, in sports such as football [2]. Information obtained provide a detailed analysis of what each player has experienced during training and match play. This then allows Practitioners to tailor periodised training programs [3], which help to reduce the likelihood of injury [4,5] and attempt to optimise future performances [6,7]. Moreover, coaches are able to identify specific positional demands and individual performances and thus gain an advantage over

their opponents as they are able to make tactical adjustments to compliment the physical characteristics identified [8]. Key metrics such as total distance covered, running at different speeds and distance covered are among the various types of activity measured [9]. There are many more including maximum speed achieved, distance covered walking, Jogging, Running, Sprinting and even positional mapping [10] and have now become the norm during training sessions and in match play [11,12].

Advances in technology has allowed these to become more accessible and has resulted in these becoming more common place in most professional and some non-professional teams. The wearing of devices to track player activity in football has recently been allowed under the rules of The Football Association [13], termed Elite Performance Tracking Systems (EPTS). These are worn by players in a suitably constructed top normally underneath their playing jersey in a purpose designed tight fitting vest ensuring stability of device in situ between the shoulder blades whilst enabling unrestricted movement of upper limbs and torso, that allows

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approved devices to be securely fitted [14]. As with other team sports, football has adopted a standardised method whereby these devices are placed in a pocket of a purpose built garment that players wear, the device then sits on the upper back between the shoulder blades (Figure 1). For the use of any type of device in competitive match play they have to be approved by sport governing bodies and referees having the final say [14].

Football continues to increase in popularity, from 265 million participants in 2007 to more recent estimates of over 500 million worldwide [15]. The UK alone has over 11 million registered participants [16] at various levels from recreational to Elite level, this study also reported that the largest number of participants take part at a recreational level. There has been a vast number of studies that have identified the physical demands imposed at the Elite 11 level [17-20] yet there is still very little known in comparison to other formats and levels across the participation landscape. Small sided football is one of the most popular formats of the game as it is employed across the football landscape [21]. Elite level teams use it as a tactical and physical conditioning training tool and there is evidence that it is utilised at all levels [22]. In a recent survey it was reported that there are over 1.5 million adults participating in England each week [23] and over 30,000 registered teams [16]. It is estimated that number has increased due in part to the growth of numerous facilities housing commercial leisure leagues. One example of the many commercial enterprises promoting this type of football in the UK has over 400 venues with in excess of 5,000 registered league teams and over 70,000 regular users [24]. There has been some studies that have looked at physical activity in non-elite football [15] these have been more observational or involving laboratory type testing [25] they do conclude that participation does improve health but that more quantitative data is needed to better understand the activities involved and the exact health benefits [26]. In populations outside the elite environment, the use of wearable technology such as GPS has become popular with a vast array of devices available. Many of these have been shown to have little to no relevance, as they do not report accurately on activity being recorded [27]. It has also been reported that devices can over or underestimate on activity being tracked [28]. This is mainly due to the quality of wearable technology being used and what movements are being tracked [29]. Studies evaluating the use of wearable technology across all

users found that there are large discrepancies in the quality of data questioning the validity and reliability and this is even found in elite athletic populations [30,31].

Similar technology to that within GPS tracking type devices can be found in smartphones, a device which is now widespread with a reported 41 million of the UK population now using a smartphone [32]. With the development of easily accessible applications, the use of smartphones for these has grown. There is evidence emerging of elite professional team sports such as football adopting the use of smartphone applications, which are able to quantify power, force and velocity in running and proven to be as reliable as equipment used in a laboratory [33,34]. However, it should be noted that this application evaluated in their study had only been proven with one type of smartphone that being the Apple IOS. Thus, it warrants further investigation to evaluate other types of smartphones and applications to include Android as well as IOS. It has been reported [35] that smartphone technology could be used to collect data effectively in football such as distances and speeds. Although the authors reported limitations in their study as they had no comparison with other devices currently used. To the current authors knowledge these have still not been assessed across a range of smartphones with it being reported that many only being tested on one device [36]. Added to this many studies have questioned the validity and reliability of various GPS tracking devices specifically in team sports [28,37-39]. The purpose of this study is therefore to evaluate a smartphone application installed on IOS and Android and across a range of smartphones from Low to high end specification, for reliability and effectiveness in measuring physical activity. Added to this to also compare against a range of GPS tracking type devices currently being used in football.

The aims of this study were; To validate the use of a range of mobile device as a reliable method to gather physical data and to compare against other tracking devices used in football. Furthermore to evaluate use and comparison with other tracking devices in a football environment.

METHODS

Experimental approach to the problem

The study was designed in two parts, firstly to validate a range of popular smartphones (Table 1) both Android and Apple IOS type devices with an suitable application installed (PIN Services Ltd India) that tracks movement and a range of GPS tracker type devices; Viper (Stat sports Newry, Northern Ireland), Playertek (Catapult group Australia) Polar (Polar Electro Warwick, UK), Axsys (AxSys performance Canberra, Australia). These all to be transported over a 20 meter shuttle course to a total distance 100 meter to quantify total distance covered in meters, various speeds in km/hr classified as walking ≤ 6.5 km/hr, jogging ≥ 6.6 km/hr and an activity positional heat map (Figure 2). Secondly a Smartphone and GPS tracker were tested in a small sided



Figure 1. Garment pocket for housing of devices

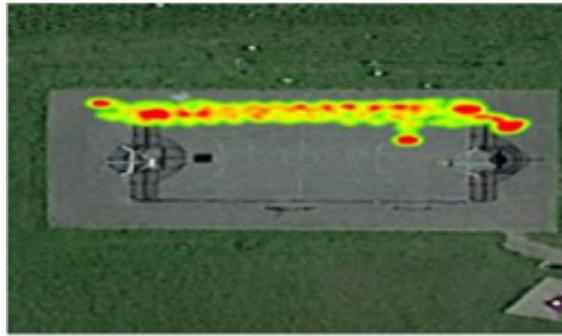


Figure 2. Positional heat map performing shuttle test activity

football environment on all-weather 4th Generation astro turf playing surface small sided football Pitch measuring 36 × 27meters boarded all round with a goal at each end. Results evaluated for comparison of common metrics used in football of total distance covered, various speeds, maximum speed reached and an activity positional heat map.

Subjects

Full time professional football players at a professional football club (n = 10, with a mean age 19 ± 1.8 years, height of 177 ± 6 cm, body mass of 77.6 ± 4.3 kg and estimated body fat percentage of 7.2 ± 1.2%) respectively participated in this study. Informed consent was provided by each player. Academic ethics approval was obtained even though the data was obtained from activities that players routinely undertook as part of the monitoring process during the course of the football season. This was to conform with parental consent which was also given for any player under the age of 18 years (n = 3). Participants completed a health screen questionnaire prior to the study, in addition each participant’s capabilities to participate in physical activity was assessed by a Doctor and qualified Physiotherapist.

Experimental procedure

Part 1: Six mobile smartphones with the same application installed and 4 GPS tracking devices. On a clear sunny day on a hard standing area 2 cones were placed 20 meters apart A subject carrying all in a purpose built aid that housed all devices, first walked between each cone 5 times turning at



Figure 3. Pocket displaying a GPS tracker device and smartphone in situ

each cone 180°, travelling in total 100 meters. This was then repeated at a faster pace to replicate jogging, the test was then repeated on 2 more occasions and an average for each device over the 3 sessions was calculated. On completion of the test each smartphone and device had data collected which was then cropped in order to only collect data from when performing the test for later analysis (Table 2).

Part 2: 10 professional football players were grouped into 2 teams of 5 with each team defined by the wearing of a colour top for each team. A player was then selected from one of the teams to wear the GPS tracker unit with a smartphone in purpose built garment as used in previous tests (Figure 3). Each individual device was checked that switched on prior to start and remained on for the duration of testing. All participants were experienced in the wearing of the vests and units as they wear for all football training as well as Match play, player wearing the two devices did not complain of any issues nor did it impede in any way their normal range of movement or performance from the result of wearing of vests and fitted units. Play commenced in a 5v5 small-sided game format, 4 × 5 minute periods with 2 minutes rest between each period. As soon as the whole session was ended play stopped and data uploaded for analysis and presented. To ensure that just the in game data was collected for analysis, data was cropped so as to only use the actual in game data for each game of 5 minute periods (Figure 4). Data collected for analysis from both devices included: total distance covered measured in meters, Total distance covered at various speeds measured in metres, classified as walking ≤6km/hr, jogging 6.1-12km/hr, running 12.1-18km/hr, high speed running ≥18km/hr, maximum speed as km/hr (Table 3) and an activity positional heat map.

Table 1. Smartphone brand, manufacturer and date of manufacture

Brand of smartphone	Manufacture details	Year of manufacture
HTC ONE	HTC corporation Taiwan	2014
Iphone 5se	Apple inc USA	2017
Iphone 5	Apple inc USA	2016
Samsung Fame	Samsung Electronics South Korea	2013
Samsung Fame	Samsung Electronics South Korea	2015
Samsung Young 2	Samsung Electronics South Korea	2015

Table 2. Smartphone & GPS tracking device shuttle test Mean ± SD of total distance

Device	Total distance (m)	Total distance walking (m)	Total distance jogging (m)	Max speed (km/hr)	Total distance (m)	Total distance walking (m)	Total distance jogging (m)	Total distance running (m)	Max speed (km/hr)
HTC one	98.0±3.4	72.2±5.5	24.8±5.3	6.7±0.5	99.8±2.2	7.8±2.6	45.7±10.6	46.2±8.8	14.2±0.8
Iphone 5 se	95.0±7.8	61.7±6.5	33.3±4.0	7.0±0.6	91.7±18.8	12.3±8.4	34.0±6.6	45.3±33.4	14.3±0.6
Iphone 5	96.7±2.3	54.3±13.2	41.7±10.6	6.9±1.0	100.7±3.8	9.7±5.5	53.0±22.1	38.3±30.1	13.6±0.6
Fame a	88.3±9.5	68.3±12.7	20.0±16.4	7.4±0.4	94.3±9.1	8.7±2.1	41.3±5.1	43.7±16.2	13.7±0.5
Fame b	88.0±7.6	60.3±15.9	28.0±16.1	6.7±0.8	94.7±8.9	8.3±1.5	39.7±22.7	47.0±28.6	14.3±1.3
Young 2	94.7±4.9	58.3±24.7	36.0±28.8	6.6±0.6	86.3±5.5	7.3±3.2	42.0±36.7	37.0±34.7	13.1±1.0
Polar	104.6±2.4	74.5±28.5	30.1±30.5	6.5±0.4	100.7±4.9	8.8±3.4	58.1±11.2	33.8±8.3	14.4±0.3
Viper	99.2±2.2	73.7±15.7	25.4±14.4	6.5±0.48	100.9±3.0	8.1±2.4	64.6±30.1	28.2±30.4	14.3±0.9
Playertek	97.0± 3.5	N/A	N/A	6.4±0.7	97.0±3.5	N/A	N/A	N/A	13.8±0.8
axsys	98.1±1.3	67.8±17.7	30.3±18.9	6.9±0.5	102.2±3.8	8.5±2.2	52.8±11.5	40.8±7.1	14.7±0.6

Table 3. GPS tracker device and smartphone tracking in 5 aside football match mean and SD over 4 games

Device	Total distance (m)	Total distance walking (m)	Total distance jogging (m)	Total distance running (m)	Total distance High speed running (m)	Max velocity (km/hr)
GPS Device	484.83±68.99	83.29±82.88	131.29±46.82	229.82±173.43	39.78±15.85	22.27±190
HTC one	476.88±54.12	100.33±90.61	159.25±65.99	202.25±170.95	15.05±13.17	23.34±1.91

Statistical analysis

Data are presented as mean ± SD, along with 95% confidence intervals (Table 4). First, to analyse the reliability of the smartphone app used for measuring the total distances and various speed zones employed, and to analyse with other types of smartphone coefficient of variation (%CV) were used. Secondly a repeated measures ANOVA was used to compare the smartphone app with GPS tracking device. Third to calculate the concurrent validity, the bivariate Pearson product moment correlation coefficient (r) was used. The Statistical Package for Social Science (SPSS, version 25) was used for all analysis.

RESULTS

There were no significant differences between types of smartphones in running (P<0.001; partial eta squared:

0) and high-speed running (P<0.001; partial eta squared: 0) distance, only small differences in walking (P=0.673; partial eta squared: 0.22) and jogging (P=0.578; partial eta squared: 0.26) distance and a small difference in total distance (P=0.328; partial eta squared: 0.35). Furthermore, only trivial differences in maximum speed were observed (P=0.934; partial eta squared: 0.11). Smartphone app and GPS tracking device showed a high degree of correlation (r = 0.94-0.99, P<0.001)

DISCUSSION

With ever-evolving smartphone applications and the increase in GPS tracking technology being used in sport, an analysis of a smartphone application and comparison with a range of GPS tracker devices currently used in sport was warranted.

The use of smartphone technology to measure physical activity is nothing new as there has been objective studies that support the use of in this way and reported that these were reliable and valid [40,41]. The major findings of this study support studies that reported that a smartphone application can reliably monitor physical activity [42,35]. This present study has gone further than previously published work in the area by assessing the validity and reliability across a range of smartphones, on what differences there are and comparison with a range of current GPS tracking devices used in sport and in a sport specific environment. However the current study does have limitations, only a small sample size of smartphones (n=6) were used in comparison, to the well over 100 different brands and types commercially available. Therefore a much larger study evaluating a greater number of smartphones would further the validity of wider use. A further potential limitation is that of the technology advancing at such a fast rate and the ability to objectively

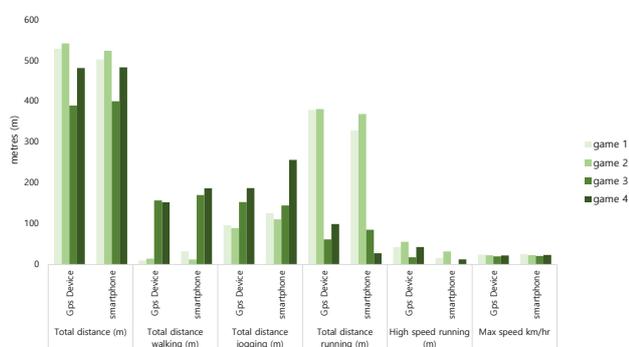


Figure 4. Comparison of GPS device and Smartphone in 5 aside football match play over 4x5 minute games

Table 4. Differences for each variable including 95% confidence intervals

	Mean Difference	Standard Deviation	Standard Error of the difference	95% Confidence Intervals
Total Distance (m)	8.0	17.1	9.8	-23.4, 39.3
Walking Distance (m)	-17.0	15.3	8.8	-45.1, 11.0
Jogging Distance (m)	-28.0	31.9	18.4	-89.5, 30.6
Running Distance (m)	27.6	42.0	24.3	-49.7, 104.8
HSR Distance (m)	24.7	5.3	3.1	14.9, 34.6
Max Speed (km×h ⁻¹)	-1.1	0.4	0.3	-1.9, -0.3

evaluate the commercial claims made by manufacturers. Whilst the benefits allow for more advanced hardware and sensors [43,44,45], that are able to better report more types of physical activity in addition to those detailed within this present study. In keeping with results in previous studies [46], this present study found that GPS tracking type devices are a reliable and valid method in quantifying physical activity, but with varying levels of accuracy [47].

A current restriction is that of the rules for allowing their use in competitive match play, with a referee being the ultimate person responsible allowing these to be used or not. As with the GPS tracking devices currently being used in match play these had many barriers to overcome and are now widely accepted and allowed according to the rules of the game of football [13]. With the increase in affordability, GPS tracker devices and systems have become widely available and now used in the majority of training and match play within many football clubs [48]. As this is still a relatively new addition to the sport science toolbox within many football clubs, there warrants demand for further assessment on validity and reliability and is in line with studies that recommend further research [39]. Additionally, in any study comparing different types of technology across the football landscape, then measures of physical activity being reported need to accurately reflect those currently being performed [49]. By using the same software application for both GPS tracker device and smartphone allowed for consistency in the present study in the presentation of data resulting in better reliability [50] in reporting on the different speed zones when comparing GPS tracker device to smartphone.

Previous studies have highlighted significant differences across different methods and systems provided to track movement specifically in football [51]. With many of the metrics being reported differently by companies supplying these devices, specifically the variance in speed zones and this could explain why in the present study that there were such large differences when comparing Walking, jogging, running and High speed running across GPS tracker devices [1,28]. There was not so large a differences in the smartphones as they all had the same application installed and therefore all metrics were the same. There are challenges when conducting in depth analysis of commercial products in any area and GPS tracker devices are no different and whilst it is understandable that each varies their product to individualise in attempts to gain increase sales, for any researcher it is difficult especially as is in the present study where some metrics were not accessible (Table 2) and this

has been reported in reviews of the literature [4,52,53]. This has caused much controversy in establishing reliability and validity in the use of GPS tracking devices in sport with both early studies [30] and more recent studies [54] continuing to highlight the need to set industry wide standards for the use in sport. Having the ability to easily monitor physical activity enables more people, some who maybe Fans of football to better connect to what their idols are doing and increase motivation to engage in physical activity related to football [55,56]. This increased motivation from engagement of fans in smartphone applications has been shown to have health benefits [57]. A further benefit is that with the capability to more accurately measure along with the capacity to report on more physical activity in diverse populations can help Health organisations and governing bodies to better understand participation [58] across the football landscape and thus inform solutions to benefits in health. By not having the need for additional technology, other than the installation of a suitable application, makes a compelling argument for the smartphone to be used as a reliable alternative to GPS tracker devices, that negates further costs to users.

CONCLUSIONS

The ability to readily monitor and evaluate physical activity is important in the areas of sport performance and health. This study shows that across a range of smartphones with a suitably installed application, that physical activity can be reliably measured and applied to sport such as football. Also that it can be used to compare with other GPS tracking devices as used in sport. Having knowledge of the differences as described in this study enhances understanding and better equips participants and practitioners when evaluating performance and future needs. This in turn enables for better planning and the periodisation of training according to the individuals needs and requirements to be able to perform to maximise the benefits of the physical activity undertaking.

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Conflicts of Interest

The authors declare no conflict of interest.

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