To Infinity and Beyond: The Use of GPS Devices within the Football Codes

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Authors:

James J. Malone[1], Stephen Barrett[2], Chris Barnes[3], Craig Twist[4], Barry Drust[5]

[1] School of Health Sciences, Liverpool Hope University, Liverpool, UK
[2] Sport Medicine and Science Department, Hull City FC, Hull, UK
[3] CB Sports Performance Ltd, Rugeley, UK
[4] Department of Sports and Exercise Sciences, University of Chester, Chester, UK
[5] Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

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Corresponding Author:
Dr. James Malone
School of Health Sciences, Liverpool Hope University, United Kingdom, L16 9JD
malonej2@hope.ac.uk
+44 (0)151 291 3264

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Abstract

The quantification of external load through global positioning systems (GPS) is now commonplace across the different football codes. Despite this acceptance amongst sports science practitioners, confusion still remains around which are the most appropriate metrics to use when monitoring their athletes. In addition, the translation of the message between the data gathered and the athletes and coaches can often be lost. The aim of this commentary is to provide discussion and recommendations when using GPS for athlete monitoring.

Keywords: Monitoring; Training Load; Microtechnology

Introduction

The introduction of global positioning systems (GPS) incorporating inertial sensors (accelerometers, magnetometers and gyroscopes) in the early 2000's increased dramatically the amount of data available to applied practitioners regarding athlete training and match activity. This increase in available information has been mirrored by an exponential growth in research outputs (from 3 to 136 articles per year between 2001 and 2018 in PubMed databases). Practitioners use these technologies to quantify athlete locomotion (including accelerations, decelerations and power) during exercise. However, despite the widespread use of such devices, confusion still remains around the most appropriate metrics to use, and how information generated can be most effectively reported back to key stakeholders (i.e. coaches and athletes). The purpose of this commentary is to provide discussion and recommendations when using GPS for athlete monitoring.

GPS Data Collection and Metrics

When monitoring athletes over a longitudinal period, it is important that practitioners are able to separate the 'signal' from the 'noise' to make evidence-based decisions. Thus, the first step practitioners must conduct when using GPS devices is to quantify the amount of noise (i.e. error) within the particular GPS system and metrics that they are using. Akenhead and Nassis (2016) recently identified the main GPS-based metrics that practitioners currently use, which included acceleration efforts and distance covered above 5.5 m/s (i.e. high speed running). A recent review by Scott et al. (2016) found that older models of 1-Hz and 5-Hz GPS devices demonstrate poor reliability and validity for such measures. In addition, 15-Hz devices were found to be similar to 10-Hz devices for velocity-based metrics (Scott et al. 2016), suggesting that there may be no additional benefit to the increased sample rate that 15-Hz GPS devices offer. Whilst 10-Hz devices offer the most common solution to these issues, some issues still remain around higher intensity movements (e.g. distance > 7 m/s) for particular devices (Scott et al. 2016). Practitioners are therefore encouraged to conduct their own in-house reliability/validity assessments on the specific device and metrics they use. The use of inertial sensors with their higher sampling rates (e.g. 100-Hz) may offer an alternative solution, with previous studies demonstrating acceptable levels of reliability and validity (Barrett, Midgley, & Lovell, 2014). It is also important when quantifying the noise in the data that this is conducted over the same time period that practitioners subsequently wish to use when looking at changes in data (e.g. day-to-day, week-to-week). In the case of high measurement error, practitioners should consider removing these metrics altogether from their daily monitoring strategies to avoid basing key decisions on potentially erroneous data (Figure 1). For example, a practitioner may observe a change in a metric from one training day to the next (e.g. match day (MD) -4 to -3) of 10% and deem this to be a ‘significant’ change to warrant adjustment in a player’s programme. However, the noise of the metric might outweigh the signal (i.e. > 10% error) and thus a training data interpretation error may occur.

When collecting GPS data for both practice and research, it is important that practitioners adhere to recommended guidelines for data collection, processing and reporting (Malone et al. 2017). All devices must be calibrated and worn using tight-fitting garments provided by the manufacturer to prevent unwanted movement of the device. This is of particular importance if practitioners are reporting inertial sensor derived metrics (e.g. PlayerLoad™) (McLean, Cummins, Conlan, Duthie, & Coutts, 2018). Athletes are encouraged to use the same GPS device across all sessions due to issues with inter-unit reliability when using devices interchangeably (Scott et al. 2016). Collected data should be checked individually using indictors of data quality, such as number of satellites connected (<6 generally poor quality) and the horizontal dilution of precision (HDOP) (<1 considered poor quality). Practitioners should be mindful that whilst manufacturer recommended upgrades in device firmware will improve certain operational aspects (e.g. bug fixes), they may also affect data outputs, and thus interpretations of longitudinal data (Varley et al. 2017). Likewise, the thresholds used within manufacturer’s software across both velocity and inertial sensor-based metrics should be kept consistent for all athletes.

GPS Data Interpretation

One area that is sometimes neglected by practitioners is the use of appropriate statistical analysis when determining the meaningful change in key GPS metrics. Practitioners who are early adopters of the technology typically use descriptive statistics (e.g. average and maximum values) which might offer limited insight into the athlete monitoring process. Rather than using group analysis on which to base decisions, practitioners are encouraged to use individual athlete analysis methods. Ward et al. (2018) recently highlighted the most common statistical approaches for individualising athlete monitoring within team sports. Magnitude-based decisions (MBD) (formerly magnitude-based inferences) allows practitioners to interpret the magnitude of the observed effect, in terms of being either substantial or trivial (Hopkins, 2019). Central to the MBD approach is the determination of the smallest worthwhile change (SWC), i.e. a change that is of practical importance. Ward and colleagues (2018) recently argued that the SWC should be determined from the within-individual coefficient of variation (CV) for metrics that are repeatedly collected on a daily basis (e.g. GPS data). The individual players' change in their data can then be visually presented with 95% confidence intervals and the corresponding MBD interpretation in relation to the change % bias

The most appropriate GPS metrics should relate to the training outcome that is of interest and ultimately linked to the sporting demands (Impellizzeri et al. 2019). Practitioners can sometimes report GPS numbers rather than considering the primary goals for a particular session linked to athlete adaptation and load (e.g. "today should be a 6 km day"). There is also a misconception that external load can be quantified using a single metric from GPS devices. However, athlete monitoring is complex and thus multiple appropriate metrics must be used in conjunction rather than isolation (Vanrenterghem et al. 2017). For example, in a football microcycle, there may be 6 days between matches in a typical Saturday to Saturday one-match week. Within this period, players will be programmed for recovery after the previous match (i.e. MD +1 and MD+2). Players will then undertake a training stimulus (MD-4 and MD-3) followed by specific match preparation (MD-2 and MD-1). Within the recovery phase of this microcycle, practitioners will want to focus on metrics such as maximal velocity and high speed distance covered in order to limit the amount of high intensity actions players perform according to recovery principles. During the loading phase, this might be broken down into an 'intensive' day (e.g. drills with smaller spaces, thus looking at acceleration/deceleration and inertial sensor-based metrics) and an 'extensive' day (e.g. drills with larger spaces, thus looking at high speed and sprint distance covered as key metrics). Finally, during the match preparation phase of the microcycle, coaches might limit the amount of training volume to taper the overall load (i.e. using total distance covered to monitor the amount of training volume performed).

Practitioners will often use physical data provided by GPS devices in isolation without the integration of technical information. Without the use of such information, it can be difficult for practitioners to fully understand the contextual factors involved with fluctuations in physical data (Paul et al. 2015). One approach used by practitioners to prescribe training practices is the quantification of peak match demands and development of the 'worst-case scenario' during intensified periods for athletes. However, both the methods used to determine the peak demands and subsequent application into training drills have recently been questioned (Carling et al. 2019). Practitioners are encouraged to understand the tactical stimulus and associated technical skills necessary alongside physical requirements when developing peak match demand-based drills for conditioning (Bradley & Ade, 2018). Numerous GPS manufacturers have now included the option to import video-based tracking data into their software to allow practitioners to monitor their athletes longitudinally across both training and matches. Taberner et al. (2019) recently reported strong agreement (r = 0.96 – 0.99) for total, high speed (> 5.5 m/s) and sprint (> 7 m/s) distance between an augmented 10-Hz GPS device and the TRACAB semi-automated camera system (mean bias of 1-4%). However, an earlier model from the GPS manufacturer demonstrated a mean bias of 10% for both high speed and sprint distance despite reported agreement (r = 0.92 – 0.99), suggesting that caution must still be applied when importing video data into GPS software as the associated error is device-dependent.

Translating the Message to Key Stakeholders

Despite the increased integration of sports science support within the applied setting, the translation of science to the key stakeholders is a crucial hurdle that must be overcome to help influence practice positively. Due to the high number of metrics available, the way in which we provide feedback can become confusing and thus adding more complexity to the problem. Information generated should be presented such that it positively adds to conversations with athletes and coaches, rather than merely creating confusion. Effective feedback frameworks involve several key stages, which include: timing of feedback, dialogue with the recipient, making the information understandable and agreement on action points, all of which will need to be individualised to the end recipient (Hattie et al. 2007). Unfortunately, however, all too often, practitioners will invest significant amounts of time putting together reports that are printed off and left for coaches and players to interpret, creating little buy-in from these key stakeholders. The sport scientist should understand and complement the philosophies of the coaches, with GPS monitoring just one 'tool' in the toolbox of support provided. The development of a practitioner's soft skills, such as being personable and an effective communicator, are arguably more important than the generation of vast databases of GPS metrics. As described by Buchheit (2017), practitioners must go 'into the trenches' with coaches and players, building a solid rapport during training sessions and social situations, gaining buy in and trust to positively influence the decision making process. For a detailed review of how such relationships might be fostered, readers are directed to the recent two part article by Lacome et al. (2018) on the use of GPS metrics and building coach buy in.

Take Home Messages

Since the introduction of GPS into the football codes over the past >15 years, both the hardware and quality of associated data outputs have improved considerably. In the present commentary, we have highlighted the need for careful consideration when selecting the most appropriate metrics. Practitioners should determine the amount of 'noise' within their own group of athletes and monitoring practices, using the specific device and time sampling points they intend to use longitudinally. It is also recommended that practitioners adhere to the guidelines provided regarding data collection, processing and reporting. In particular, consistency in terms of both the hardware and software settings is crucial to provide a solid platform for data interpretation. The use of individual athlete statistical analysis methods is strongly encouraged to base decisions upon rather than the use of group analysis. Of these methods, MBD allows practitioners to interpret the magnitude of the observed effect and determine the 'signal' compared to the metric 'noise'. Finally, we emphasised the importance of effectively translating the message to key stakeholders by building a solid rapport and using appropriate feedback strategies. With the ongoing development of newer devices/technologies and associated sport-specific algorithms, practitioners should be strongly encouraged to keep things simple and effective, rather than over complicate an already difficult area to comprehend.

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Figure Captions

Figure 1. Decision making framework when selecting the most appropriate GPS metrics to monitor athletes.

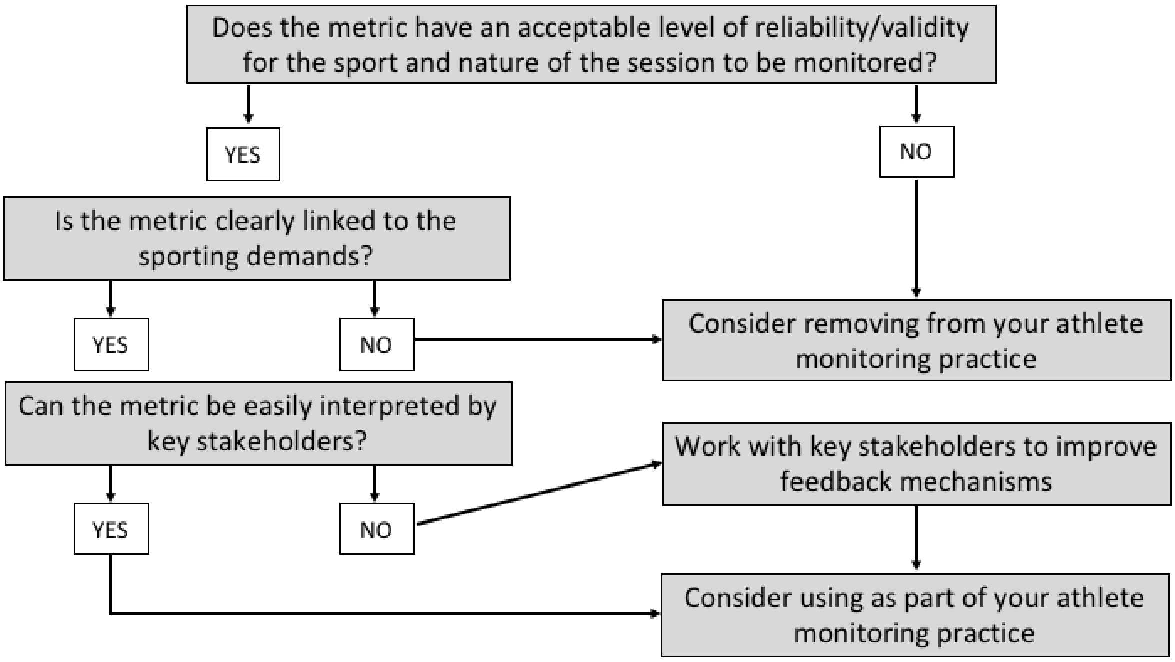
Does the metric have an acceptable level of reliability/validity for the sport and nature of the session to be monitored?
YES
NO
Is the metric clearly linked to the sporting demands?
YES
NO
Consider removing from your athlete monitoring practice
Can the metric be easily interpreted by key stakeholders?
Work with key stakeholders to improve feedback mechanisms
YES
NO
Consider using as part of your athlete monitoring practice

Figure 1.