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Procedia Engineering 34 (2012) 443 – 448

Procedia Engineering

www.elsevier.com/locate/procedia

9th Conference of the International Sports Engineering Association (ISEA)

Application of GPS devices to longitudinal analysis on game and training data

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Accepted 02 March 2012

Abstract

In elite level team sport, the application of longitudinal data analysis is often overlooked due to the tools and techniques required for processing large quantities of data. The research presented in this paper explores the information available to coaches and players when looking at data taken from an entire first grade Australian Rules Football team for a full non-premiership season. Specifically this paper explores the relationship between training and game demand on an individual level as well as exploring the relative demand on different player field positions.
The hardware used in this research was the GPSports SPI Inertial tracking unit. This device contained a GPS unit tracking at 5Hz providing the latitudinal and longitudinal position of the players. This GPS information was then extracted in order to reconstruct the speeds of the athlete throughout a game.
This research found strong correlations between the overall intensities of the training sessions and the physical demand of first grade games. It also identified small differences in the demand of different on field positions.

Keywords: Australian rules football; running; fitness/training; team sports; GPS

1. Introduction

Sport, especially at the elite level, is a highly competitive environment where athletes strive to become the best in their field. It is therefore highly important for coaches to monitor their athletes both in competition and training in an effort to seek ways to better improve performance [1].

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1877-7058 © 2012 Published by Elsevier Ltd.
doi:10.1016/j.proeng.2012.04.076

In elite level team sport, the application of longitudinal data analysis is often overlooked due to the tools and techniques required for processing large quantities of data. One of the more common methods of determining the workload on elite level athletes is through the use of video based analysis tools [2-4]. These systems rely on the post processing of video recordings of athletes to derive the physical demands of game and training sessions. However, the limitations of these systems have been studied [5] and can often vary due to user defined physical movement categories [6]. With continuing developments in individual monitoring systems and increases in technology, it is quickly becoming commonplace for athletes to wear portable GPS based monitoring equipment during training and game situations.

GPS have previously been used as a method to analyze workload through over-ground running speed in individuals for specific game or training sessions [7]. Other studies have gone a step further and explored workload across multiple games [6] and seasons [8]. This study extends from these previous works by comparing the speed distributions of several different elements that relate to physical demand in Australian Rules Football (AFL). AFL is a team based ball sport in which requires athletes to kick, hand-pass, or run an oval shaped ball up the field.

2. Methodology

This paper explores the demand on elite first grade AFL athletes by examining the time spent running in different speed zones. Although not the only factor contributing to energy expenditure during game and training sessions, running provides coaches and athletes with an insight into game or training load [8]. Previous studies have explored the physical demand on elite level athletes during competition, however, these studies require time consuming, manual, video analysis methods [4]. This study aims to apply fast post processing techniques in an effort to provide athletes and coaches with new monitoring tools.

This study made use of the data collected across an entire season from a first grade AFL team. This data includes 2700 training or competition GPS recordings from 44 athletes. The GPS data was recorded using a GPSports Wi SPI GPS tracking unit. This device contains a 5 Hz GPS logger capable of logging the latitudinal and longitudinal position of the player for around 6 hours on a single charge. The unit was placed in a specially designed vest that when worn by the player positions the sensor on the upper back around the middle to upper thoracic vertebrae. Data was recorded for all athletes during all training sessions and for most athletes during first grade and reserve games and is summarized in the table below. Athlete data was restricted due competition rules and in some cases injury.

Data collection summary (mean and standard deviation across all players n=44):

Table 1. A summary of the average and total GPS data from a first grade Australian Rules Football team

	Mean	Standard Deviation	Total
Game	11h 49m 56s	4h 4m 9s	21d 16h 37m 3s
Training	12h 6m 18s	2h 47m 50s	22d 4h 37m 28s

All gathered data was obtained and handled in accordance with the Griffith University Ethical Standards (Ethical approval code: ENG/04/10/HREC).

3. Comparisons

Traditionally when looking at game and training sessions the physical performance of an athlete is examined for each individual session. This research led to the development of MATLAB tools to allow for multiple game and training sessions to be grouped together and compared to other game or training

sessions. This analysis methodology opens up a vast range of potential to explore many different aspects of elite level athletes and game performance.

In the following comparisons the speed of the athlete is calculated from the GPS latitudinal and longitudinal positions as calculated by the GPS. The time spent at each speed (rounded to km/h) is accumulated and the results are displayed in the form of a bar graph. This provides a computationally fast analysis method with an easy to understand, visual output of the frequency distribution of an athletes speed. As Figure 1 shows, with the recording of longitudinal data opportunities to explore aspects such as game and training comparisons, player position comparisons, individual athlete comparisons and multiple athlete comparison emerge. In each case, the frequency distributions have been normalized to provide a representation of the distribution of running demands as opposed to using un-normalized data, which provides the total time spent at each speed. Each label in Figure 1 refers to where each topic is discussed in this paper.

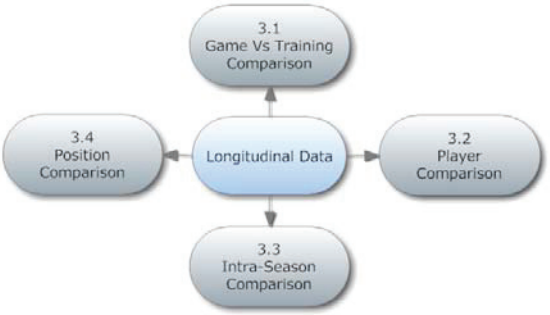

Fig. 1. A graphical representation of the possible comparison techniques made available with the recording and analysis of longitudinal data

3.1. Game and Training Comparisons

One aspect of athlete performance monitoring is the comparison of the physical demand of games with the intensity of training sessions. This type of comparison is generally made across individual training or game sessions, however, further insight can be obtained by comparing the trends across multiple games and training sessions or even an entire season. Figure 2 shows two examples of this method of data comparison. The graphs show the distribution of running speeds in both games and training sessions across an entire season for two different athletes. Graph (a) has been constructed from an individual athlete with no significant injuries or setbacks (19 games, 43 training sessions). It can be seen that the distribution of speeds between the game and training data is quite similar, with the athlete spending slightly more time running at low velocities (<10km/h) and higher velocities (>18km/h) during training. This indicates that, the athlete's training regime closely represents the demand of his role during competition. In Graph (b) the same comparison technique was performed for an athlete who suffered a season ending injury after only 4 games (4 games, 17 training sessions). It can be seen that the distribution of training speeds has been shifted due to the athlete undertaking a rehabilitation training program. From the example provided in Figure 2, a comparison between game and training data can provide coaches with an insight into the physical demand of competition, and how current training sessions reflect these demands.

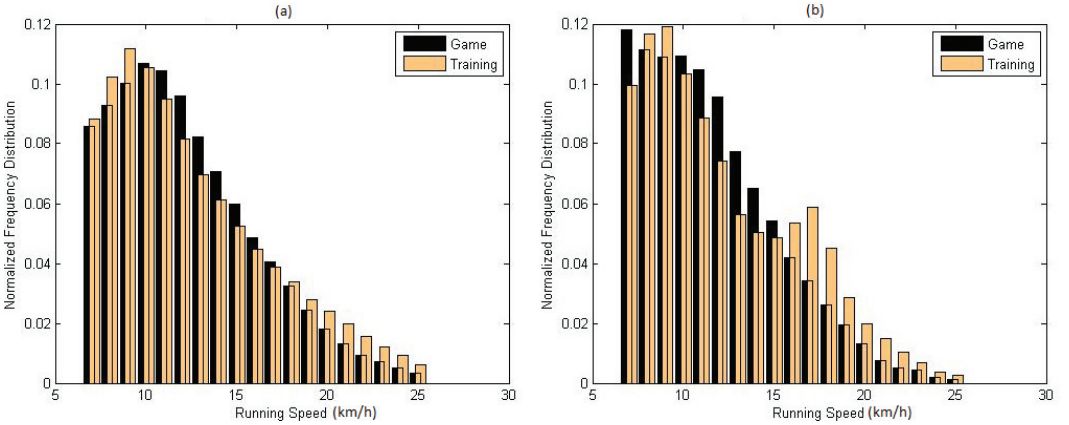

Fig. 2. Comparison of athlete competition and training data. (a) data taken from an uninjured athlete (19 games, 43 training sessions) and (b) data taken from an injured athlete (4 games, 17 training sessions)

3.2. Player Comparison

A comparison between multiple players can provide coaches with a method to grade performance and/or monitor physical workload. With longitudinal data, coaches can now compare multiple athlete performance over anything from a single game or training session to an entire season. The two graphs in Figure 3 show comparisons between the same two athletes over different time periods.

In Figure 3 the graph on the left shows a comparison between two midfielders for a single first grade game. Since each game is unique, and the demand on each athlete is different, the distribution of speed varies quite extensively between them. Applying the same technique to the entire season provides an overview of the physical demand on each of the athletes as seen in graph (b). It can be seen that the two athletes experience a very similar demand across multiple games with Athlete 1 averaging only a slightly higher mean speed. This data comparison demonstrates how this analysis can provide useful coarse and fine grained information on athlete workload.

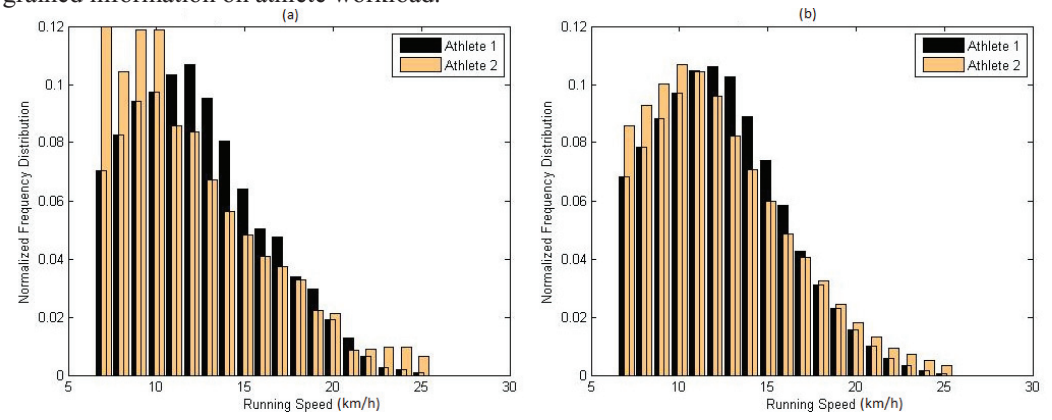

Fig. 2. Comparison of two athletes taken from first grade competition data. (a) Data taken from a single first grade game, and (b) data taken across an entire season

3.3. Intra-Season Comparison

A comparison of an athlete's performance is often critiqued from game to game. It is however much harder to identify performance trends across multiple games or even training sessions. This research has developed a technique that allows for a rapid comparison between the times spent at different running speeds of an athlete across any number of games or training sessions.

In figure 3 a comparison between the first quarter of a season and the second quarter of the season for two different athletes can be seen. In this figure each graph is a combination of both training and competition data for each athlete. Graph (a) on the left shows an athlete who played the same position for the entire season without significant injury or setback. As expected the demands of the games remained relatively consistent. Graph (b) on the right shows the distribution of speeds during training for an athlete that experienced a minor injury just prior to the start of the season. As expected, the data from the first quarter of the season (whilst in rehabilitation training) fits a very different pattern from the training undertaken during the second quarter. This is particularly obvious in the data when looking at the first quarter of the season where the athlete focused heavily on running speeds around the 15-20km/h range as part of a rehabilitation training regime.

By grouping and comparing the data within a season, coaches can look for any significant differences in training or competition performance. This approach can be applied on a shifting scale, looking at several games or training sessions, up to half a season's data.

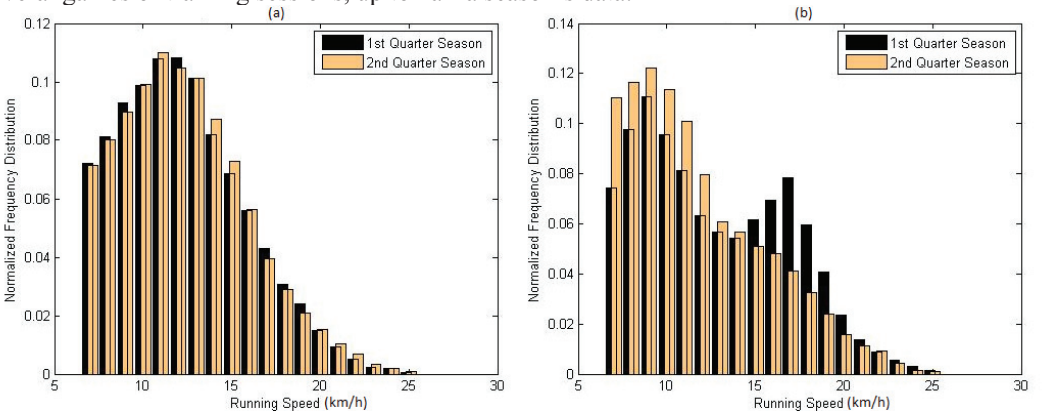

Fig 3. First quarter and second quarter season comparisons. Graph (a) shows data taken from an uninjured midfielder, and Graph (b) data taken from an athlete that undertook rehab training during the first quarter of the season

3.4. Position Comparison

Previous studies have identified key differences between the physical demands of Australian Rules Football athletes that play in different positions [8]. It can therefore be helpful to coaches to be able to track the physical demands on specific positions and design training sessions appropriately. This study randomly selected five athletes from each of the major positions (forward, midfield and defence).

Figure 4 shows the difference in speed distributions for different positions when averaged across five players who completed the season without major injury or setback. Graph (a) shows quite clearly a large difference between forward and midfield positions. It can be seen that a forward spends a considerably larger time below 10km/h with respect to other speed. This is contrasted by the midfield positions which can be seen to spend the majority of their running time between 9km/h – 13km/h. It can also be observed that forwards tend to spend more time than the midfielders at speeds greater than 20km/h. These results

support previous studies [8] concluding that midfielders cover more ground at higher speeds than forwards or defenders. This comparison technique provides coaches with the ability to track the physical demands of the different positions providing assistance in the creation of specific training sessions that tailor to each position.

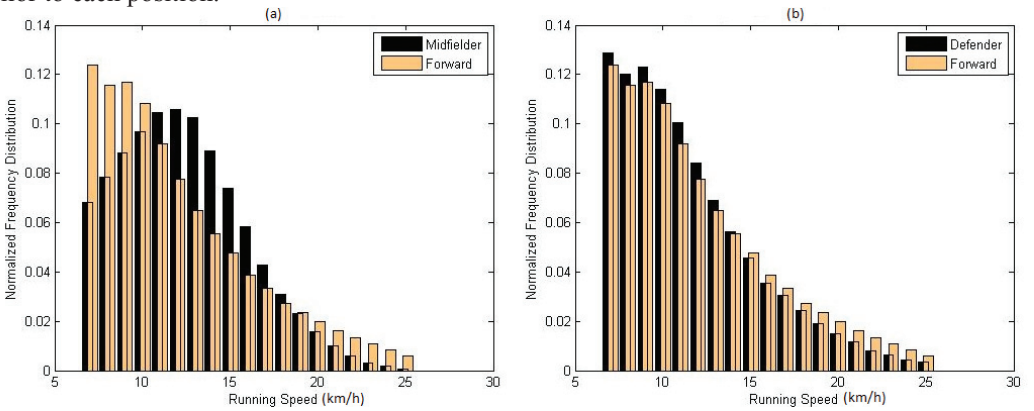

Fig 4. Player position comparison. Graph (a) shows a comparison between competition data from five midfielders and five forwards, and Graph (b) shows a comparison between competition data from five defenders and five forwards

4. Conclusion

This research has shown that longitudinal data analysis can be applied to Australian Rules Football, to provide coaches with new information on athlete training and performance. Overall, this research has shown how information on the difference in training and completion intensities can be explored both between different athletes and within an individual athlete's season. It has explored how performance averages can differ when comparing training and competition over varying scopes in time and it has briefly explored the difference in running demands of player positions.

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