Standardisation of Acceleration Zones in Professional Field Sport Athletes

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ABSTRACT
Running acceleration data provides important information about the physical demands placed on field sport athletes. However, the absence of clearly defined acceleration zones has contributed to the minimal examination of this variable. This study aimed to develop a standardised set of acceleration zones and determine any differences in accelerations between elite and sub-elite Australian footballers. Thirty-nine professional male Australian footballers performed a 30 m sprint from a standing start. Timing lights were placed at 0, 10, 20 and 30 m to calculate accelerations over 0-10, 10-20 and 20-30 m splits. The accelerations over these splits were 3.27 $m \cdot s^{-2}$, 1.81 $m \cdot s^{-2}$ and 0.33 $m \cdot s^{-2}$. The differences between the elite and sub-elite groups for time, velocity and acceleration over the splits were examined using independent t-tests and effect sizes. Acceleration zones were determined by using maximal acceleration to establish the subsequent acceleration zones. In this case 20%, 45% and 85% of maximum acceleration were used to develop low (0.65-1.46 $m \cdot s^{-2}$), moderate (1.47-2.77 $m \cdot s^{-2}$) and high (>2.78 $m \cdot s^{-2}$) zones. No differences between the elite and sub-elite athletes for each acceleration category were found. The development of standardised acceleration zones will assist with the assessment and understanding of accelerations in field sport athletes. This has the potential to improve the implementation of training programs and recovery sessions. Further, these accelerations zones are seemingly applicable for both elite and sub-elite field sport athletes.

Key words: Acceleration, Australian Football, Sprinting

Reviewers: Lee Brown (California State Univesity, Fullerton, USA)
Tim Gabbett (Australian Catholic University, Australia)

INTRODUCTION

To date, time-motion analysis in field sports has predominantly been used to examine movement demands such as the total distance covered, average speed and the distance covered, time spent and number of efforts performed at different speed zones [1-3]. Specifically, it has been reported that field sport athletes will, on average, perform 72 to 117 very high-intensity efforts during a match depending on the criteria used for this speed zone [3, 4]. There has been a particular focus on high intensity movement demands, due to their relationship with fatigue and the apparent performance of players and teams [5-7]. This information has assisted conditioning staff and coaches to better understand the physical demands placed on field sport athletes and the design and implementation of training programs [8, 9].

In contrast, there has been scarce examination into the accelerations of field sports athletes during training sessions and matches. Acceleration is defined as the rate of change in velocity [10] and as with high intensity movement demands, fast accelerations are highly fatiguing and integrally associated with important moments of field sport matches such as the ability to beat an opponent to the ball [10-13]. Consequently, to adequately determine the amount of high-intensity movements performed it is necessary to monitor accelerations during training sessions and matches [14]. Field sport athletes are often required to perform maximal efforts over short distances such as <10 m [15], hence the ability to accelerate maybe more important than maximal running velocity in field sports [16-19]. Therefore, the valuable information that could be acquired from understanding and measuring the accelerations of field sport athletes during training sessions and matches for coaches and conditioning staff, means that a set of clearly defined acceleration zones are required. However, as has been reported previously, [20] it is important to analyse both acceleration and velocity data as not all efforts produced in field sports matches or training sessions involve the independent performance of high accelerations or high velocities.

There has been some preliminary reporting in Australian football, soccer and rugby league on the number of accelerations performed during a match using global position system (GPS) units [2, 10, 14, 16, 21]. These studies have revealed that, on average, field sport athletes will perform between 56 and 96 high acceleration efforts ($>2.78\ m{\cdot}s^{-2}$) in a match, depending on a players position [10, 14]. This information has contributed towards improved understanding of the physical demands placed on field sport athletes [10, 16, 21], but there is no clear agreement on the most suitable acceleration zones to use. Specifically, a study developed four acceleration zones ($1.5\ m{\cdot}s^{-1}$, $2.0\ m{\cdot}s^{-1}$, $2.50\ m{\cdot}s^{-1}$ and $2.75\ m{\cdot}s^{-1}$), that were categorised as the number of times the participants changed velocity over 1 s time intervals [16]. Further, multiple studies have defined a maximal acceleration as $>2.78\ m{\cdot}s^{-2}$, which was based on the nature of field sport accelerations and the viewing of GPS training and match files [2, 10, 14]. However, the lack of information provided regarding the ideal method to develop acceleration zones suggests that adopting the technique implemented when developing speed zones for non-motorised treadmills could be used [22, 23]. This involves using maximal sprinting speeds (MSS) to develop the subsequent speed zones [22, 23]. Additionally, a set of standardised speed zones using data from Global Positioning System units has been developed to determine the velocity distribution of elite field sport athletes [20]. Further, this study demonstrated the importance of measuring both high acceleration efforts and high-velocity sprint efforts [20]. By developing a standardised set of acceleration zones a more comprehensive analysis and understanding of accelerations may be made between studies.

In addition to the methodological shortcomings when considering accelerations, it has been identified that differences exist in movement demand outputs between elite and semi-elite field sport athletes [24, 25]. Therefore, similar differences may be evident for accelerations. This information would be important to ensure the correct analysis of accelerations during training and matches and improve the understanding of variations between elite and semi-elite athletes. Accordingly, obtaining this knowledge would enable the design of training programs for elite and semi-elite athletes to assist with the development of acceleration qualities. Therefore, it appears necessary to investigate whether separate acceleration zones are required when analysing elite and semi-elite field sport athletes.

The aim of this descriptive study was to calculate acceleration zones that would be suitable for examining accelerations during field sport training sessions and matches. A further aim of this study was to determine whether different acceleration zones were required for elite and semi-elite athletes. Based on previous research, it was hypothesised that suitable acceleration zones could be calculated from peak accelerations over a 30 m sprint and that a difference would exist between elite and semi-elite athletes [22, 25, 26]. The findings of this study will provide a standardised set of acceleration zones that could be used by future studies where acceleration is the dependent variable, enable improved analysis of accelerations in field sports and an understanding of the demands placed on field sport athletes.

METHOD

PARTICIPANTS

Thirty nine elite and semi-elite male Australian football athletes (22.8 ± 3.5 yrs, 86.6 ± 8.6 kg, 186.9 ± 7.8 cm) volunteered to complete the testing. For the comparison between elite and semi-elite Australian footballers, data was separated based on the number of Australian Football League matches played that year. An athlete was classed as elite if they >10 senior Australian Football League matches during a 22 match season. A semi-elite player was classified as an athlete who played <5 senior Australian Football League matches during a 22 match season. Using this convention, 22 participants were classified as elite (24.2 ± 3.8 yrs, 88.5 ± 9.0 kg, 187.7 ± 7.2 cm) and 17 were classified as semi-elite (21.1 ± 2.3 yrs, 84.0 ± 7.5 kg, 185.8 ± 8.7 cm). As with all professional sporting teams, participants were required to be well nourished and properly hydrated before any testing was performed. Prior to the commencement of testing, approval was granted by the Human Research Ethics Committee at the University of Technology, Sydney. Further, all participants were required to complete a written informed consent form following full explanation of all procedures.

EXPERIMENTAL PROCEDURES

Testing was completed in warm conditions with minimal wind present. The test was completed on a grassed football oval that was dry underfoot. During the warm-up and testing, all participants wore plastic moulded stud football boots. Before the testing commenced, participants were involved in a dynamic warm-up, which consisted of jogging, specific drills and stretching of particular lower body muscles to be used during the testing.

Participants performed two maximal 30 m sprints and were instructed to commence with their preferred foot forward and their front toe positioned 30 cm behind the start line (which was marked using a tape measure). Further, all participants performed a self-initiated standing start. Of the two efforts completed the one involving the greatest acceleration was used for analysis. Prior to the testing participants were instructed to accelerate as fast as possible over the entire distance and to ensure they continued to accelerate through the last set of timing lights. Participants had up to five minutes recovery time between each effort, which ensured that participants would be capable of performing a true maximal effort on both occasions. Testing was conducted towards the end of an Australian Football League pre-season (January).

A tape measure was used to place timing lights (Smart Speed®, Fusion Sports, Queensland, Australia), at the 0 m, 10 m, 20 m and 30 m marks with time recorded to the nearest 100th of a second to assess the peak acceleration of each participant (accurate to 0.01 s, [27]). The timing lights were set at a height of 0.7 m and placed to ensure there was a 2 m wide lane for the participants to sprint maximally through. By determining accelerations over these distances, the athlete's peak acceleration could be used to calculate a standardised set of acceleration zones. In order to determine test-retest reliability of the testing protocol, 13 players performed a 30 m maximal sprint on two separate days. Coefficient of variation (CV) were calculated for each of the split times (0-10 m, 10-20 m and 20-30 m) collected over the two testing days, with the findings revealing that the CV scores were all <3.4%. This demonstrates the good test-retest reliability of the testing method used.

STATISTICAL ANALYSIS

Data is reported as means ± standard deviation. For the descriptive reporting of the set of standardised accelerations zones for Australian footballers, no statistical tests were conducted. For the comparison of accelerations between elite and semi-elite Australian footballers, a two-way ANOVA with a Bonferoni post hoc test was performed to identify any differences between the two groups. Statistical Packages for Social Sciences® (version 20) was used to perform this analysis. In order to determine the magnitude of difference between the two groups, effect size estimates were calculated and categorised based on the divisions devised by Cohen [28]. An alpha level of $p<0.05$ was set as the level of significance for all statistical tests.

RESULTS

The mean times to cover 10 m, 20 m and 30 m were 1.75 ± 0.05 s, 3.01 ± 0.08 s and 4.20 ± 0.12 s, respectively. Raw mean velocity and acceleration data are presented in Table 1. No significant differences were found between elite and semi-elite Australian footballers for time ($p>0.05$, $F=2887.8$), speed ($p>0.05$, $F=538.5$) and acceleration ($p>0.05$, $F=1176.3$) over the three splits (Table 1).

Table 1. Results (mean ± SD) from 30 m sprint test for time, speed and acceleration in Elite (n=22) and Sub-elite players (n=17)

	Elite (n=22)	**Sub-Elite (n=17)**	**P Value**	**Cohen's d**
Time (s)				
0-10 m	1.75 ± 0.05	1.75 ± 0.05	1.00	0.1
10-20 m	3.00 ± 0.08	3.01 ± 0.08	1.00	0.0
20-30 m	4.20 ± 0.12	4.20 ± 0.12	1.00	0.1
Speed ($m \cdot s^{-1}$)				
0-10 m	5.72 ± 0.17	5.71 ± 0.15	1.00	0.1
10-20 m	7.98 ± 0.25	7.99 ± 0.25	1.00	0.0
20-30 m	8.37 ± 0.28	8.39 ± 0.32	1.00	0.1
Acceleration ($m \cdot s^{-2}$)				
0-10 m	3.27 ± 0.19	3.26 ± 0.17	1.00	0.1
10-20 m	1.81 ± 0.19	1.82 ± 0.18	1.00	0.1

20-30 m	0.33 ± 0.09	0.35 ± 0.18	1.00	0.1

DISCUSSION

Only limited research has reported on the accelerations of field sport athletes during matches and training sessions [10, 14, 16, 21]. Currently, there are differences in the acceleration zones presented in the literature, which limits the ability to make comparisons between studies and impacts on the understanding of the accelerations of field sport athletes. Therefore, the intent of this work was to establish a standardised set of acceleration zones for field sport athletes. This is especially warranted as the prevalence of examinations of accelerations in field sports is increasing [10, 14, 21, 29]. The methodology of this study has identified the acceleration profile of professional Australian footballers [11, 30]. Specifically, the 30 m sprint length and the location of the timing lights (0, 10, 20 and 30 m) were selected as previous research has revealed that the greatest period of acceleration occurs over the first 10 m of an effort [30, 31] and that this distance provides a good reflection of acceleration capabilities [32]. Consequently, this has enabled the calculation of a set of acceleration zones that could be used to categorise different accelerations. Further, there were no significant differences in the accelerations of elite and semi-elite Australian footballers.

In order to develop a set of standardised acceleration zones, it was necessary to select zones that adequately reflected the abilities of field sport athletes and the typical movements of field sport matches. Specifically, during field sport matches athletes often perform maximal efforts from walking or running starts [31] and are often required to perform these efforts whilst having to change direction [33]. Furthermore, as the distance of typical sprints in field sports are no more than 20 m in length [34, 35], it was deemed that the development of acceleration zones should be calculated using percentages of peak acceleration. This was similar to the procedure used on non-motorised treadmills during intermittent exercise protocols, whereby the participant's MSS is used to determine subsequent sub-maximal speed zones [22, 23, 36]. Further, recent examinations using Global Positioning Systems in field sports have developed a standardised set of velocity zones based on the distribution of different velocities over a match [20]. Consequently, it is plausible to use similar conventions when determining acceleration zones. However, in contrast to these studies, in the current study the sample's mean peak acceleration rate was used to calculate three acceleration zones.

The percentages selected for the current study to develop three distinct zones were 20%, 45% and 85% of the sample's mean peak acceleration reported from the 0-10 m split (3.27 $m \cdot s^{-2}$) [26, 30]. Therefore, the three acceleration bands were calculated as low (0.65-1.46 $m \cdot s^{-2}$ [20-45% peak acceleration]), moderate (1.47-2.77 $m \cdot s^{-2}$ [45-85% peak acceleration]) and high acceleration (>2.78 $m \cdot s^{-2}$ [>85% peak acceleration]). There is currently no precedent with regard to the calculation of a range of acceleration zones, therefore it is necessary to use research that has reported on the development of speed zones. Current research has revealed that the walking and running speed zones used in the analysis of field sport matches are capable of measuring low and medium intensity efforts [1, 35], which the MSS research reported earlier equate to 20% (walking) and 45% (running) of MSS [22, 23]. The resultant low and moderate acceleration zones corresponded with these zones and accordingly would be capable of measuring these important efforts. The high acceleration zone determined in the current study is identical to the high acceleration zone used in recent studies examining accelerations in Australian football, rugby league and soccer [2, 10, 14]. The analysis from these studies confirmed the ecological validity of this zone. Consequently, the three acceleration zones selected are capable of analysing low, moderate and high intensity acceleration efforts of field sport athletes. The application of these zones when analysing movement demands in field sport athletes will enable comparison between studies, which has not been possible due to the methodological differences used by researchers in this area [10, 16, 21]. Furthermore, the establishment of these zones will assist with the analysis and understanding of accelerations in field sport athletes.

The results from the comparison between the acceleration of elite and semi-elite Australian footballers demonstrated that there were no differences between the two groups (Table 1). These findings were further supported by the trivial effect size results (<0.2), confirming the minimal difference between the two groups (Table 1). Therefore, the same set of standardised acceleration zones may be utilised for both elite and semi-elite Australian footballers. The findings from the current study, although in contrast to previous research examining field sports such as rugby league [37], may be a consequence of the homogeneity of a high-performance playing group. This supports the use of relative acceleration zones to enable comparisons between athletes. However, the findings highlight that accelerations over a 30 m sprint test should not be used to differentiate between elite and semi-elite Australian footballers and may also have implications for other field sports. Nevertheless, future research should examine whether there are indeed differences between elite and semi-elite athletes for the distance covered, time spent or number of accelerations performed in applied settings such as training sessions and matches.

The use of the professional field sport athletes was a notable strength of this study, but only Australian football athletes were used. While this limits the applicability of the results to other field sports due to differing physical demands, it enabled a thorough examination of the accelerations of this type of field sport athlete. The examination of peak accelerations based on 10 m split times as opposed to 5 m splits, although comparable with the methods used in previous studies [38], would have impacted on the reported mean peak acceleration rate. Similarly, the current study did not examine the impact of participants commencing an acceleration effort from a walking or running start. Therefore, a descriptive analysis of accelerations in field sport matches and training sessions using these specific acceleration zones appears warranted to further support the selection of these zones and assist with the understanding of accelerations in field sports. Furthermore, an improved knowledge of the occurrences of acceleration efforts will potentially reveal the nature of these important outputs in field sports. Accordingly, the capacity of coaches and conditioning staff to monitor and understand accelerations in field sports will be enhanced, assisting with the design and implementation of training programs and recovery sessions.

CONCLUSION

Acceleration efforts are an important component of field sport performance. However, there has been minimal research investigating acceleration outputs in team sport athletes during match-play. The current study developed a set of acceleration zones suitable for analysing the accelerations of field sport athletes during match-play and training. The use of these acceleration zones can improve the understanding of the nature and occurrence of accelerations in field sport matches. Consequently, this information will assist coaching and conditioning staff to monitor athlete workloads and improve the implementation of training programs that are specific to the demands of matches. Interestingly, since no differences were evident in the maximal accelerations between elite and semi-elite Australian footballers, the same set of acceleration zones may be utilised for both groups.

ACKNOWLEDGEMENTS

The authors thank the staff and players from Sydney Swans Football club for their assistance with this project. There has been no external financial assistance with this project.

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