Knowledge of bout duration influences pacing strategies during small-sided games

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Abstract

This investigation examines pacing during intermittent team sports. Sixteen junior Rugby League players participated in eight different small-sided offside touch games. All games were 24 min, but bout durations differed in continuous (1 × 24 min) or repeated (2 × 12, 3 × 8, 4 × 6, 6 × 4, 8 × 3, 12 × 2 or 24 × 1 min) formats. Repeat bouts were interspersed by 2 min of passive rest, and participants were informed of the bout duration immediately prior to the game. Heart rates, ratings of perceived exertion and data gathered from global positioning system devices were used to investigate the pacing strategies employed within each game. No significant ($P > 0.05$) between-game differences were observed in total distance; however, during the 1-min bouts, high-speed movement was significantly ($P < 0.05$) increased, during the first and second quarters of the 24 × 1-min game compared to all other formats (effect size range: 0.75 ± 0.61-1.38 ± 0.47). Furthermore, the rate of decline in high-speed movement over-time was greatest during the 24 × 1-min game with large differences observed between the first and third quarters (effect size: 0.90 ± 0.58). Greater moderate-speed (effect size range: 0.62 ± 0.63-1.56 ± 0.40) and less low-speed (effect size range: 0.69 ± 0.62-1.54 ± 0.40) distances were also observed during the 1-min bouts, yet heart rates were higher during the continuous 1 × 24-min game. Pacing strategies during intermittent activities are influenced by the number and duration of exercise bouts. Practitioners should consider within-game bout durations when prescribing game-based activities to improve aerobic capacity.

Keywords

Rugby, GPS, physiological, velocity, acceleration

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Abstract

This investigation examines pacing during intermittent team sports. Sixteen junior Rugby League players participated in eight different small-sided offside touch games. All games were 24-minutes, but bout durations differed in continuous (1 × 24 minutes) or repeated (2 × 12 minute, 3 × 8 minute, 4 × 6 minute, 6 × 4 minute, 8 × 3 minute, 12 × 2 minute or 24 × 1 minute) formats. Repeat bouts were interspersed by 2-minutes of passive rest and participants were informed of the bout duration immediately prior to the game. Heart rates, ratings of perceived exertion and data gathered from global positioning system devices were used to investigate the pacing strategies employed within each game. No significant (P>0.05) between-game differences were observed in total distance, however during the one-minute bouts high-speed movement was significantly (P<0.05) increased, during the first and second quarters of the 24 × 1 minute game compared to all other formats (Effect size range: 0.75 ± 0.61-1.38 ± 0.47). Furthermore, the rate of decline in high-speed movement over-time was greatest during the 24 × 1 minute game with large differences observed between the first and third quarters (Effect size: 0.90 ± 0.58). Greater moderate-speed (Effect size range: 0.62 ± 0.63-1.56 ± 0.40) and less low-speed (Effect size range: 0.69 ± 0.62-1.54 ± 0.40) distances were also observed during the one-minute bouts, yet heart rates were higher during the continuous 1 x 24 minute game. Pacing strategies during intermittent activities are influenced by the

number and duration of exercise bouts. Practitioners should consider within-game bout durations when prescribing game-based activities to improve aerobic capacity.

1.0 Introduction

Pacing considers the regulation of effort during exercise to ensure homeostasis is maintained, and is affected by the duration of the event and by the motivation, knowledge and experience of the athlete (St Clair Gibson, 2006; St Clair Gibson, Schabort, and Noakes, 2001; van Ingen Schenau, De Koning, and De Groot, 1992). Our current knowledge of pacing has been primarily derived from continuous effort exercise, and it is known that the pacing strategy can be moderated given feedback, and without feedback from afferent signals of a changing physiological status (Foster, Schrager, Snyder, and Thompson, 1994; Mauger, Jones, and Williams, 2009; St Clair Gibson, 2006). However, it has recently been shown that pacing during intermittent sprints is also influenced when athletes are given knowledge of an end-point for the exercise period (Billaut, Bishop, Schaerz, and Noakes, 2011). Notably, Billaut and colleagues observed greater power output and increased electromyographic activity when participants believed that trials involved a lower number of repeated sprint activities. In contrast, power output and muscle activation was lower when participants were given no information regarding the number of sprints to be performed. Such results indicate that pacing strategies are employed in repeated sprint activities and are influenced by a pre-conceived knowledge of the exercise demand. Considering the demand for repeated sprint activity, pacing strategies may therefore be important during team sports.

It is known that high-speed distances progressively decrease in team sports as match-play extends (Coutts, Quinn, Hocking, Castagna, and Rampinini, 2010; Mohr, Krustrup, and Bangsbo, 2003; Waldron, Highton, Daniels, and Twist, 2013). The progressive decline in physical effort may be representative of accumulated fatigue, or alternatively a subconscious pacing strategy that reflects an individual's fitness to ensure systems failure does not occur prior to the end of a game (Edwards and Noakes, 2009). In respect to known pacing strategies, the decline in running speed may also be comparable to that observed during longer distance endurance events where it is favourable to employ an initial all-out strategy at the start of a race, followed by more constant pacing (van Ingen Schenau, De Koning, and De Groot, 1992). However, the intermittent and unpredictable nature of team sports leads to variability in match running performance such that comparisons to continuous exercise modalities are difficult to ascertain.

Evidence of pacing in team sport may be present from time-motion analysis indicating a significant reduction in high intensity movement following intense periods of high intensity effort (Bradley and Noakes, 2013). Indeed indications of varied pacing strategies may be observed in team sport suggesting winning teams may regulate their efforts allowing for an end-spurt of high intensity activity (Black and Gabbett, 2013). However, it is difficult to attribute variations in high intensity activity during team sports to winning and losing considering the impact that technical actions and situational variables have on the movement profiles observed, and outcomes of competitive team sport (Dellal, Lago-Penas, Wong, and Chamari, 2011; Lago, Casais, Dominguez, and Sampaio, 2010). Pacing may yet be apparent when comparing interchange and full game players. Interchange players cover greater distances at high intensity in the first half, and an 'end-spurt' in the final stages of the second half (Black and Gabbett, 2013; Mohr, Krustrup, and Bangsbo, 2003; Waldron, Highton, Daniels, and Twist, 2013). Thus, the distribution of effort may differ during intermittent teams sports representative of an all-out, variable, parabolic, or fast start pacing strategy (Foster, Schrager, Snyder, and Thompson, 1994; Garland, 2005). The differences observed between interchange and whole game players suggest that knowledge of a defined endpoint assists intermittent team sport athletes set the most appropriate pacing strategy (St Clair Gibson, 2006). Indeed, when given knowledge of substantially reduced game-time demands in Rugby sevens, increased high-speed distances are observed (Higham, Pyne, Anson, and Eddy, 2012). However, Rugby sevens may be considered similar to a small-sided game, where it is known that player numbers relative to pitch size can influence the activity patterns and physiological responses observed (Kennett, Kempton, and Coutts, 2012).

If one considers the variables that can influence the responses observed during small-sided games, (Kennett, Kempton, and Coutts, 2012; Rampinini et al., 2007) this forum may be suitable to examine pacing in team sport by manipulating the exercise duration, and providing athletes with knowledge of game-time. It is known that high-speed distances are reduced during 24 minutes of continuous game time, when compared to 4 × 6 min bouts interspersed with passive rest (Hill-Haas, Rowsell, Dawson, and Coutts, 2009). The increase in high-speed activity during small-sided games interspersed with rest may reflect a time-dependent anticipatory pacing strategy, and an associated increase in mechanical power output similar to that observed during repeat sprint bouts (Billaut, Bishop, Schaerz, and Noakes, 2011). However, Hill-Hass *et al.*, examined games differing in player number and pitch size, and did not describe the activity patterns within-games (Hill-Haas, Rowsell, Dawson, and Coutts, 2009). Therefore, it is not known if the increased high-speed distances were reflected by differential pacing strategies. Furthermore, simulated models of power production and dissipation indicate that a constant pacing strategy benefits performance during exercise greater than 2-minutes (de Koning, Bobbert, and Foster, 1999). It may therefore be important to examine bout durations greater than, and less than 2-minutes to confirm if different pacing strategies are employed during intermittent team sport activities. This study will uniquely investigate the impact of bout duration on pacing in team sport by examining within-game variations of speed and distance during small-sided games.

2.0 Methods

Sixteen amateur junior male Rugby League players who were members of the same team enrolled at a sport high school (mean ± SD and 90% confidence intervals, [CI]; age 14.9 ± 0.5 [14.6 to 15.1] years; height 171.7 ± 4.4 [169.3 to 174.0] cm; mass 65.3 ± 7.5 [61.2 to 69.4] kg) participated in this study. Written information was provided to each participant's parent/guardian and written informed consent was given prior to commencing the study. Each participant completed a health screening questionnaire. All procedures were approved by the University Human research ethics committee and by the state education research approval process (SERAP) for research in New South Wales government schools.

Prior to any small-sided game-play, three maximal effort sprints were performed to gain peak acceleration ($m.s^{-2}$, 0-10 m) and peak speed ($m.s^{-1}$, 10-20 m) (Swift Speedlight, Swift Performance Equipment, QLD, Australia). The 20 m multistage shuttle run test was chosen to estimate maximal aerobic power and maximal heart rate considering its known validity and familiarity to the group examined in this investigation (Ramsbottom, Brewer, and Williams, 1988). The multistage shuttle run was repeated at the end of the study, so that any training effects could be considered.

Eight four-a-side off-side touch games played within 20 m (width) x 40 m (length) field dimensions were examined within a 9-day period. Teams were comprised of the same players matched for position, and all games were played against the same opposition. Each of the eight games involved a total 24 minutes of activity, however the format of game-play differed such that the activity period was applied in continuous or repeated bout formats; a) 1 × 24 minute bout; b) 2 × 12 minute bouts; c) 3 × 8 minute bouts; d) 4 × 6 minute bouts; e) 6 × 4 minute bouts; f) 8 × 3 minute bouts; g) 12 × 2 minute bouts; and h) 24 × 1 minute bouts. Repeated bouts were interspersed with 2-minutes of passive rest. Participants were informed of the game format providing pre-conceived knowledge of the time demand for exercise within bouts immediately prior to starting the game. A maximum of 3 sessions took place each week separated by a minimum of 24 hours rest. The order of game-play was randomised, in most sessions and with the exception of the 24 × 1 minute game, two games took place with 20-minutes passive rest between games. However, time constraints prevented more than one game being played when the 24 x 1 minute game was played, thus two sessions involved only one game. A standardised warm up and cool down involving low intensity running and dynamic stretching of the upper and lower limbs was performed at the start and end of each session. During game-play, the attacking team were given three plays with the ball, a turnover in play occurred in the event of a try being scored, dropped ball, or completion of three plays. All participants were familiarised during a 3 x 5 minute game. No data was recorded in this session.

A global positioning system (GPS) device, sampling at 10 Hz was positioned on the upper back of each participant according to manufacturer guidelines (SP4 MinimaxX, Catapult Sports, Melbourne, Australia). Heart rates were monitored continuously from ventricular depolarisation (Polar T31c, Kempele, Finland) and integrated with the GPS software (Sprint 5.0 Catapult Sports, Melbourne, Australia). The reliability of data collected via GPS is significantly improved when using a 10 Hz system, which is of particular importance when analysing shorter sprint distances commonly observed in team sports (Castellano, Casamichana, Calleja-Gonzalez, San Roman, and Ostojic, 2011; Varley, Fairweather, and Aughey, 2011). Speed zones were categorised as low (0-25%), moderate (25-50%), high (50-70%) and very high (>70%) relative to each individuals' peak speed ($m.s^{-1}$, 10-20 m), acceleration zones as low (20-45%), moderate (45-85%) and high (>85%), relative to peak acceleration ($m.s^{-2}$, 0-10 m) and heart rates as low (<75%), moderate (75-85%), high (85-90%) and very high (>90%) relative to maximum heart rate. Ratings of perceived exertion (RPE), using a 15 point Borg Scale were recorded at the end of each bout when participants were asked, "how hard did you feel the exercise was?". Thus a single

RPE (after 24 minutes) was provided for the 1 × 24 minute game. During each of the repeated bout games, participants were asked “how hard did you feel the exercise was?” and RPE’s were recorded whenever a break between bouts occurred. Two (2 × 12 mins) to twenty-four (24 × 1 mins) RPE’s were therefore reported during repeat bout games. RPE’s were averaged across bouts to compare between games.

GPS data were analysed in one minute blocks and summed (velocity and acceleration distance zones and efforts), or averaged (relative % time in heart rate zones) to reflect four equal six minute quarters. Data from all participants were collapsed and statistical analysis were performed using a one-way repeated measures analysis of variance (ANOVA) to determine differences between bouts within the same game, except where a paired t-test was required (2 x 12 minutes). A two-way (game format x quarter) repeated measures analysis of variance (ANOVA) was used to determine differences across the eight games. Where significant interactions were observed, a Tukey's honestly significant difference post hoc test was applied to determine the source of those differences. Data are reported as means and 90% confidence intervals [CI], descriptive statistics include ± standard deviation. In the event of significant differences, Cohen’s effect size (*d*) statistics were used to determine the magnitude of the effect. Effect sizes of <0.2, 0.2-0.6, 0.61-1.2, 1.21-2.0 and >2.0 were considered trivial, small, moderate, large, and very large, respectively (Hopkins, Marshall, Batterham, and Hanin, 2009). An alpha level of $P<0.05$ was set for all statistical analyses.

3.0 Results

The results are reported for fourteen participants from whom complete data sets were obtained. Prior to any small-sided game-play, maximal heart rate (198 ± 8 [194-202] beats.min^{-1}), peak speed (7.66 ± 0.60 [7.38-7.94] m.s^{-1}) and peak acceleration (3.19 ± 0.49 [2.96-3.42] m.s^{-2}) were obtained. No significant difference in estimates of aerobic power were observed before (42.8 ± 6.4 [39.5-46.1] ml·kg·min^{-1}), or after (44.9 ± 5.0 [42.3-47.5] ml·kg·min^{-1}) the experimental testing period.

The average distance in each quarter relative to peak speed is displayed in Figure 1. Table 1 highlights the within-game between-bout effect size (±90% confidence intervals) where significant differences were observed. Within game differences between-bouts were observed during the 1 × 24, 2 × 12, 4 ×6 and 24 ×1 minute games (Table 1). The total distance covered during the 24 minute period of game-play was similar between formats; however a number of differences were observed between-bouts across the eight game formats (Table 2). Analysis of the distance covered in the defined velocity bands identified between-bout variability in the increased ($P \leq 0.05$) distance covered at low-speed after the first quarter during the 24 × 1 minute game and in the final quarter of the 12 × 2 minute game. The greatest between-bout differences were observed in the 24 × 1 minute game, where the associated effect size for the observed changes was moderate. Conversely, significantly decreased low-speed distances were observed across quarters of the 8 × 3 minute game, however the associated effect sizes observed were small. Small to moderate decreases in the distance covered at moderate speed were observed during the 1 × 24, 2 × 12, 12 × 2 and 24 × 1 minute games, and at high-speed during the 2 ×

12, 4 × 6 and 24 × 1 minute games. No significant between-bout differences were observed in any game at very high-speed.

Insert Figure 1 about here

Insert Table 1 about here

Insert Table 2 about here

Low-, moderate- and high-acceleration distances across the four quarters are displayed in Figure 2 and the effect size (±90% confidence intervals) for within-game between-bout differences in table 3. Generally, small to moderate decreases in low-acceleration distances ($P \leq 0.05$) were observed during the 1 × 24, 2 × 12, 4 × 6, 12 × 2 and 24 × 1 minute games, however a small increase from the third to fourth quarters of the 4 × 6 minute game was also observed. Small to moderate decreases in moderate-acceleration distances ($P \leq 0.05$) were observed during the 2 × 12, 12 × 2 and 24 × 1 minute games. Sporadic changes in high-acceleration distances were observed during the 4 × 6 and 6 × 4 minute games, such that significant differences between quarters were observed ($P \leq 0.05$), however effect sizes were small.

Insert Figure 2 about here

Insert Table 3 about here

Between games low-speed movement was reduced during the 24 × 1 minute game ($P \leq 0.05$). Moderate to large effect sizes were observed in the first and second quarters of the 24 × 1 minute game when compared to all other game formats (table 4a). However, moderate-, high and very high-speed movement was increased during the 24 × 1 minute game. The largest effect size differences were observed in the first and second quarters (table 4a). In addition, low- moderate- and high-acceleration distances were greatest during the 24 × 1. The associated effect size between quarters of the 24 × 1 minute game compared to all other game formats were in most cases moderate to large during the first, second and third quarters at high acceleration distances (table 4b). Low-speed distances were greatest, and high- to very high-speed and acceleration distances and lowest, during the 8 x 3 minute game.

Insert Table 4a/b about here

The number of high-speed efforts performed also differed across the four quarters of the 2 × 12, 3 × 8, and 6 × 4 minute games and moderate-acceleration efforts differed across the four quarters of the 3 × 8, 6 × 4 and 2 × 12 minute games. High-speed and acceleration efforts were greatest during the 24 × 1 minute game, and lowest during the 8 × 3 minute game. However, no difference in the number of very high-speed, or high-acceleration efforts were observed between games.

The average heart rate within each quarter of the eight games is presented in Table 5. Heart rates were lower during shorter and higher during longer bouts across all four quarters. During the 3 × 8 minute game, participants spent less time ($P \leq 0.05$) at <75% of maximal heart rate in the final quarters. An increase ($P \leq 0.05$) in time spent at 75-85% of maximal heart rate was observed during the 24 × 1 and 2 × 12 minute game. No significant within-game differences were observed at 85-90% and >90% of maximal heart rate. The average rating of perceived exertion recorded was highest during the 1 × 24 minute game, and increased over time in all games.

Insert Table 5 about here

4.0 Discussion

This investigation provides novel evidence to suggest that knowledge of a time-dependent end-point can effect pacing during intermittent team sports. Pacing was influenced by the demand for continuous exercise, with relatively increased moderate, high and very high-speed and acceleration activities during games of shorter bout duration. It has been suggested that athletes adopt a pacing strategy to optimise performance, whilst avoiding premature fatigue and systems failure (St Clair Gibson, 2006). During the 24 minute bouts of exercise assessed in this investigation, the pacing strategy employed may reflect attempts to avoid the excessive physical distress associated with intense intermittent exercise.

In this study, a 2-minute recovery period was applied between repeated bouts, a rest period previously shown as sufficient to maintain performance during intense repeated sprint exercise (Balsom, Seger, Sjödin, and Ekblom, 1992). However, the intermittent base upon which team sports are built is also known to deplete muscle glycogen and creatine phosphate which also correlate with decreased sprinting performance (Krustrup, Mohr, Steensberg, Bencke, and Kjaer, 2006; Krustrup et al., 2004). In this investigation, the decreased work-to-rest ratio associated with the increased frequency of rest during games with shorter bout durations lead to increased moderate to very high-speed movement, suggesting reduced muscle fatigue and an increased capacity to maximise high energy phosphates as the primary energy source (Billaut and Bishop, 2009; Bogdanis, Nevill, Boobis, and Lakomy, 1996). The associated reduction in metabolic stress may also result in augmented neural drive and is seen when participants anticipate shorter periods of repeated sprint activity (Billaut, Bishop, Schaerz, and Noakes, 2011; Kent-Braun, 1999).

Interestingly, moderate to large reductions in low-speed activity were observed alongside similarly increased moderate to high-speed activity during the 24 × 1 minute game. The present results, and the analysis of full-game team sports (Black and Gabbett, 2013), suggests these increased low-speed activities may be necessary to facilitate metabolic recovery and, or modulate effort and maintain the capacity to perform at high speeds during intermittent exercise. This pattern of activity may also be reflected in the reduced high-speed distances observed following periods of intense activity in team sports (Bradley and Noakes, 2013; Mohr, Krustrup, and Bangsbo, 2003). Similar to team sport analysis, the high-speed distances observed in each of the small-sided games examined decreased over time, with the greatest rate of decline observed in the 24 × 1 minute game (Coutts, Quinn, Hocking, Castagna, and Rampinini, 2010; Mohr, Krustrup, and Bangsbo, 2003; Waldron, Highton, Daniels, and Twist, 2013). Such changes are consistent with the analogous decrease in power output and neuromuscular activity observed during repeated sprints employing all-out, fast paced, or very fast pacing (Mendez-Villanueva, Hamer, and Bishop, 2008; St Clair Gibson, Schabort, and Noakes, 2001). The rate of decline was thus dependent on the quantity of high-speed running performed in the early stages of game-play, and is consistent with studies from high-intensity, intermittent team sports (Bradley and Noakes, 2013; Waldron, Highton, Daniels, and Twist, 2013). The reduced capacity to perform high-speed running across the four quarters may therefore be attributed to neuromuscular fatigue, a declining muscle pH, and depleted phosphocreatine stores, yet one should recognise that these factors may influence pacing via a peripheral feedback mechanism for the regulation of neural drive (Kent-Braun, 1999; Mendez-Villanueva, Edge, Suriano, Hamer, and Bishop, 2012; Mendez-Villanueva, Hamer, and Bishop, 2008).

Increased high-speed movement during games of shorter bout duration is perhaps unsurprising knowing that repeated sprint activities are influenced by the duration of rest between sprints (Balsom, Seger, Sjödin, and Ekblom, 1992). However, in this investigation, sprints were extracted from 24-minute games, a substantial and continuous aerobic demand thus underpinned the intermittent patterns of movement and appropriate pacing was necessary to optimise high-speed activity. Recruiting participants of a similar age was crucial when one considers that age can influence sprint performance and pacing (Harley et al., 2010; Micklewright et al., 2012). However it was also recognised that chronological age does not reflect physical maturity, (Malina, Eisenmann, Cumming, Ribeiro, and Aroso, 2004) thus the speed zones in this investigation were relative to each individual. A flying 10-20m sprint time was chosen as peak speed considering the pitch dimensions applied in the small-sided games, relevance to team sport sprint distances and previous application to junior team sport athletes (Gabbett, 2012; Harley et al., 2010; Spencer, 2005).

The increased distances at moderate, high and very high-speeds during games of shorter bout duration, did not affect the total distance covered during the 24 minute period of game-play. Games consisting of bouts greater than 2 minutes displayed a relatively even distribution of speed and acceleration activities across the four quarters which may indicate constant pacing (Foster, Schrager, Snyder, and Thompson, 1994; St Clair Gibson, 2006). Moderate reductions were observed in the distance covered at moderate and high-speeds during the third, and or final quarter of the 1 × 24 minute; 2 × 12 minute; and 4 x 6 minute games. However, this does not detract from a constant pacing model as a relative decline in the final stages is not uncommon (Foster, Schrager, Snyder, and Thompson, 1994). The concept of constant pacing during longer, and all out pacing during shorter bout durations reflects the regulation of effort relative to the time demand for exercise and is consistent with theoretical pacing models constructed for longer and shorter race distance events (van Ingen Schenau, De Koning, and De Groot, 1992). However, pacing throughout the 24 minute period may simply have been made more difficult by the intervention of rest, leading to the sharp decline in moderate-to-very high intensity movement observed in the final quarters of the 1 × 24 minute game. Despite the increased high intensity of movement during games of shorter bout duration, games with longer bout durations displayed increased average heart rates and ratings of perceived exertion. This is consistent with previous comparisons between continuous and repeated bout small-sided games (Hill-Haas, Rowsell, Dawson, and Coutts, 2009). However, in addition to the report of Hill-Hass et al. the present investigation highlights a progressive reduction in cardiovascular and RPE responses from longer to shorter bout durations. The cardiovascular responses observed in this investigation were therefore influenced by the duration of continuous physical exertion, and were not distance dependent as previously reported (Esteve-Lanao, Lucia, and Foster, 2008).

It has been proposed that a rating of perceived exertion may reflect the available fuel sources during exercise and may be used to assist athletes select the most appropriate pacing strategy (Tucker, 2009). Thus, the present results suggest that RPE may provide an appropriate mechanism by which to regulate activity during longer duration team sport activities. However, RPE’s were influenced by the frequency of planned rest periods in the current study and may not reflect the potential accumulation of metabolic by-products and depletion of fuel sources that appeared evident in the reduced moderate- to very high-speed running in the final quarter of shorter duration games. Future investigations including post-game assessments of neuromuscular fatigue (Duffield, Murphy, Snape, Minett, and Skein, 2012), with respect to the model applied in this investigation would provide interesting evidence to support or reject this notion.

No other obvious pacing strategies were evident. High-speed movement was increased during the fourth quarter of the 4 × 6 minute game, such that no significant difference was detected between the first-fourth quarters and may be considered evidence of an 'end-spurt', or variable pacing (St Clair Gibson, 2006). Considering the relatively increased moderate to high-speed distances observed during bouts comprised of one- and two-minutes, it was surprising to see the lowest distances covered at these speeds during the 8 × 3 minute game. However, when interpreting the present results, it should be considered that high-intensity intermittent team sports are played in a volatile environment with substantial variability in running activities between games (Gregson, Drust, Atkinson, and Salvo, 2010). For example, the frequency of high-speed and very high-speed running can be dependent on the quality of the opposition and on playing position (Bradley and Noakes, 2013; Gabbett, 2012; Mohr, Krustrup, and Bangsbo, 2003). In addition, the impact of situational, tactical and technical interactions which are known to effect high intensity movement in team sport were not directly assessed (Dellal, Lago-Penas, Wong, and Chamari, 2011; Lago, Casais, Dominguez, and Sampaio, 2010). Attempts were made in this investigation to combat some of the known variability by comprising teams of the same players, matched for position, and consistently playing games against the same opposition. Furthermore, the game assessed in this investigation involved ball carrying which may not impact upon movement velocity in the same manner that has been shown in soccer when ball-foot control is required (Dellal, Lago-Penas, Wong, and Chamari, 2011). However extraneous variability cannot be discounted.

5.0 Conclusion

This investigation has shown that differential pacing strategies in team sports may be selected if there is an opportunity to provide knowledge of a time-dependent exercise end-point. Small-sided games differing in bout duration may therefore be used by team-sport athletes to gain appropriate knowledge and experience to assist in the development of an effective pacing strategy. High-speed distances, and their subsequent decline over time was greatest during game-based activities of repeated one-minute bouts. The activity patterns were indicative of a fast-start or 'all-out' pacing strategy. In contrast, during games longer than two minutes in duration, pacing appeared more constant. These findings suggest that conditioning programs incorporating small-sided games should consider the different pacing strategies employed alongside the cardiovascular and high-speed activity profiles observed during long and short bout durations. However, although these findings may be taken as evidence of time-dependent pacing during intermittent team sports, our results also suggest that the variability observed in high-speed activity during team sports should be considered. Further examination of the influence such variability may have on the current findings is warranted.

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Figure Captions:

Figure 1: Average distance covered in each of the four speed bands during the first, second, third and fourth quarters of each game. [a] significantly different to the first quarter; [b] significantly different to the second quarter; [c] significantly different to the third quarter; [d] significantly different to the fourth quarter.

Figure 2: Average distance covered in each of the three acceleration zones during the first, second, third and fourth quarters of each game. [a] significantly different to the first quarter; [b] significantly different to the second quarter; [c] significantly different to the third quarter; [d] significantly different to the fourth quarter.