A comparison of two different methods for time-motion analysis in team sports.

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Abstract

Time-motion analysis has been extensively used to provide an insight into the movement patterns of athletes in team sports. However, few studies have indicated whether analysis involved breaks in play, or all the activities within the standard clock-time. Therefore, the purpose of this study was to differentiate whether differences existing between clock-time and match-time time-motion analysis had an affect on the results. Data was collected from the Australian National Futsal Team. Analysis was initially conducted against the actual playing clock-time of 40 min, then on a match-time of 70 min including all actions and breaks in play, excluding half-time and time-out intervals. When comparing match-time to clock-time data, there was a 16% greater total overall distance covered, a 6.9% increase in the time spent in low-intensity activities, and a change in activity every 4.00 s vs. 3.28 s, respectively. There was little change in the high-intensity activities from clock-time to match-time comparison. As clock-time data may misrepresent the movement patterns of the game, it is important to establish a standard method of analysis, namely based on match-time data. This may have implications on similar sports based on clock-time such as water polo, basketball, ice hockey and handball.

Keywords: Futsal, match analysis, team sports

1. Introduction

Time-motion analysis has been used by many researchers to provide a general insight into the physiological demands and movement patterns of athletes through assessing the total distance covered, total time in discrete activities, as well as frequency of activities during match-play. This has been used in a variety of team sports based on clock-time including field hockey (Spencer et al., 2004), ice hockey (Green et al., 1976), rugby league (Kay and Gill, 2003), rugby union (Duthie et al., 2003), touch football (O'Connor, 2002), Australian Rules Football (Coutts and Reaburn, 2000; Dawson et al., 2004), Gaelic football (King and O'Donoghue, 2003), water polo (Smith, 1998), soccer (Rienzi et al., 2000; Hughes, 2003; Mohr et al., 2003; Reilly, 2003) and futsal (indoor soccer) (Oliveira, 1999; Barbero Álvarez et al., 2003a,b).

Several time-motion studies have stated that they have analysed the entire match (Coutts and Reaburn, 2000; Rienzi et al., 2000; D'Ottavio and Castagna, 2001; Castagna et al., 2004), however, many have not indicated whether this involved breaks in play (such as when the ball is kicked or hit out of the play area), or the activities within the standard clock-time. This may cause confusion and discrepancies when comparing data from previous studies, as one study may define match-play as those actions occurring within the standard clock-time, whereas another may incorporate all actions occurring from the start of play until full-time (the match-time).

The purpose of this study was to differentiate whether differences existing between clock-time vs. match-time time-motion analysis, has an affect on the results. This is significant considering that the key performance aspects assessed through time-motion analysis are important and potentially affect various components of different activities, in particular, sports specific training principles (Oliveira, 1999; Coutts and Reaburn, 2000; Krustrup et al., 2002; Bangsbo et al., 2003; Barbero Álvarez et al., 2003a,b; Duthie et al., 2003; Mohr et al., 2003; Reilly, 2003). The sport of futsal was used for this study, as despite having an official clock-time of 40 min (F.I.F.A., 2005), a match may extend to 70 – 80 min, particularly in international and national level games (Barbero Álvarez et al., 2003a), which exclude breaks in play in the running clock-time.

It was hypothesised that when analysing activities in match-time compared to clock-time, there would be an increase in the proportion of low-intensity activities (standing, walking and jogging), when compared to high-intensity activities (running and sprinting), considering that the breaks in play are made up largely of low-intensity activities. Thus, the high-intensity activities data would remain similar in both methods of analysis, and will in turn reduce the work to rest ratio in match-time when compared to clock-time.

2. Method

Participants: A total of 8 male futsal athletes participated in this study, from the Australian National Futsal Team (n = 8; 25.5 ± 3.8 yr, 1.76 ± 0.07 m, 74.8 ± 4.7 kg). These athletes were selected for this study as they were a representative sample of elite team sport athletes. No goalkeepers were included in the trial. Informed consent from the participants was obtained prior to conducting the study. The University of Technology, Sydney Human Research Ethics Committee approved the methodology and procedures used in this study.

Match Analysis: For each game assessed, match activities were monitored by means of video recording. Two digital video cameras (Panasonic, Japan and JVC, Japan) were set up, both equipped with a fish-eye lens, allowing for each camera to cover one half of the futsal court as suggested by Barbero Álvarez (2003b). The use of a fish-eye lens did not distort the view, nor misrepresent the distances or speeds in the analysis. The cameras were placed ten metres away from the sideline, approximately two metres either side of the half-way line and ten metres from ground level on the sideline of the court. Both cameras were set up on tripods 1.5 m high and angled inwards, consequentially providing a camera height of 11.5 m above the playing surface.

The players were tracked on two separate occasions, firstly on the basis of the game's clock-time, and secondly on the basis of the game's match-time. The clock-time analysis involved all locomotor actions performed from kick-off until half-time, then from half-time kick-off until full-time, with all breaks in play excluded from the analysis. This was the standard two x 20 min halves of futsal, totalling 40 min of activity. The match-time analysis involved analysing all actions performed in the game from kick-off until full-time, with all breaks included in the analysis, with the exception of half-time and time-outs intervals. This resulted in a total of 70 min of futsal activity.

The video footage from the games was transferred onto VHS to enable post-match analysis. As two cameras recorded the matches, two television sets were required. The television sets were placed side-by-side and the matches were played and timed to allow the game to be viewed as it was played. A computer program called 'Event Recorder' was designed by KB Technologies® (Sydney) specifically for this study. It comprised of 12 buttons on a small box allowing for six locomotor activities and six match activities to be tracked. One researcher was used to analyse the games, thereby eliminating any inter-individual variation in the measures.

Analysis of locomotor activities for the players was carried out considering the following categories: standing (0 $m \cdot s^{-1}$), walking (1 $m \cdot s^{-1}$), jogging (3 $m \cdot s^{-1}$) running (5 $m \cdot s^{-1}$), sprinting (7 $m \cdot s^{-1}$), and sideways/backwards movement (3 $m \cdot s^{-1}$) which included jockeying an opposing player. The locomotor activities were later divided into either low-intensity activity (those under 5 $m \cdot s^{-1}$ such as standing, walking, jogging, and sideways/backwards), and high-intensity activity (those over 5 $m \cdot s^{-1}$ such as running and sprinting). The identification of the speed of each locomotor activity was based on the researcher's subjective opinion of gait, with the velocities selected from the methodologies of several researchers in other team sports such as Krustrup et al. (2002), Barbero Álvarez et al. (2003a,b), Mohr et al. (2003) and Castagna et al. (2004).

Statistical Analysis: Following the data reduction of the match analysis, paired-samples t-tests were performed using SPSS version 11.0® between the data obtained from match one and match two on the clock-time results. These tests were designed to assess differences in performance on the dependent variables including total distance covered, total duration and total frequency of locomotor activities.

Furthermore, paired-samples t-tests were conducted between the clock-time analysis results and the match-time analysis results to assess any overall differences in performance on the same dependent variables. Significance was set at $P<0.05$, with descriptive statistics for all variables reported as mean ± standard deviation.

Reliability: No significant differences were evident for total distance covered, total duration or total frequency of locomotor activities between the players when inter-day reliability was analysed. Additionally, when the data for game one and game two were examined, there were no significant differences. Thus, it was possible to establish the mean score for the two matches in order to compare the individual and team performances.

3. Results

Locomotor Activity Distances: There was a 16% greater total overall distance covered when comparing match-time data to clock-time data (4284 ± 1033 m vs. 3582 ± 932 m, respectively) which was significant (t = -10.28). When comparing match-time data to clock-time data, there was an increase of 11% in distance covered walking (t = -10.28), and a decrease of 4.4% for running, 0.49% for sprinting and 4.6% for sideways/backwards distance covered (t = 10.59, 4.14, and 7.22, respectively) as shown in Figure 2.

When grouping the activities into low-intensity and high-intensity, it was observed that the match-time method of assessment produced an increase of 4.92% (t = -9.71) of the total distance covered when compared to the clock-time and a decrease of 4.92% in the high-intensity activities. Furthermore, there was no difference in the raw distance covered in high-intensity activities from clock-time to match-time, however, there was a mean increase of 695 m in the low-intensity activities (t = -10.44). The data for the individual and grouped locomotor activities for the clock-time and match-time analysis can be found in Tables 1 and 2, and Figures 1 and 2.

Table 1. Mean ± standard deviation of locomotor activities for clock-time and match-time analysis.

		Standing	Walking	Jogging	Running	Sprinting	Side/Back
Distance (m)	Clock-time	0.0 ± 0.0	134 ± 45.7	1340 ± 580	993 ± 330	106 ± 59.9	1008 ± 212
	Match-time	0.0 ± 0.0	635 ± 204*	1521 ± 558*	999 ± 332	106 ± 59.9	1022 ± 213*
Duration (s)	Clock-time	5.08 ± 6.9	134 ± 45.7	470 ± 244	204 ± 70.0	15.2 ± 8.6	334 ± 69.0
	Match-time	156 ± 78.2*	635 ± 204*	520 ± 212*	206 ± 71.9	15.2 ± 8.6	341 ± 71.0*
Frequency (n)	Clock-time	2.38± 3.27	48.7 ± 12.8	121 ± 26.2	73.8 ± 21.8	7.44 ± 3.34	102 ± 20.0
	Match-time	18.6 ± 7.7*	121 ± 28.7*	142 ± 26.4*	73.8 ± 21.8	7.44 ± 3.34	105 ± 18.7

* Significantly different from the clock-time analysis (P<0.05)

Table 2. – Mean ± standard deviation for the low-intensity and high-intensity locomotor activities between clock-time and match-time.

		Low-intensity	High-intensity
Distance (m)	Clock-time	2483 ± 688	1100 ± 381
	Match-time	3178 ± 808*	1105 ± 384
Duration (s)	Clock-time	943 ± 296	219 ± 77.5
	Match-time	1652 ± 455*	221 ± 79.5
Frequency (n)	Clock-time	274 ± 46.7	81.2 ± 24.5
	Match-time	387 ± 68.5*	81.2 ± 24.5

* Significantly different from the clock-time analysis (P<0.05)

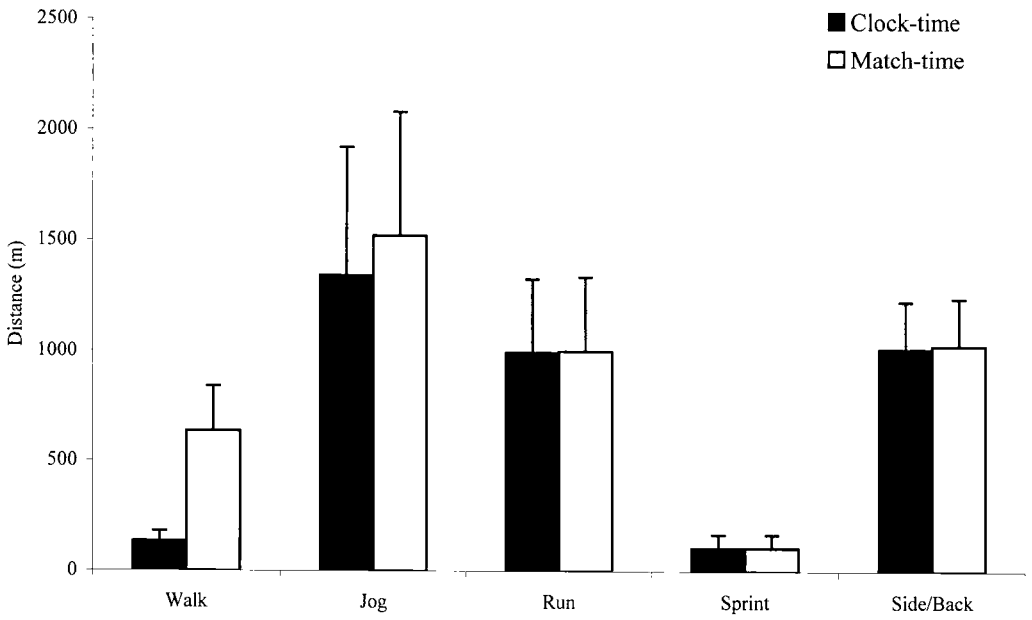

Figure 1. Mean total distance covered for locomotor activities (error bars are standard deviation).

* Significantly different from the clock-time analysis ($P<0.05$)

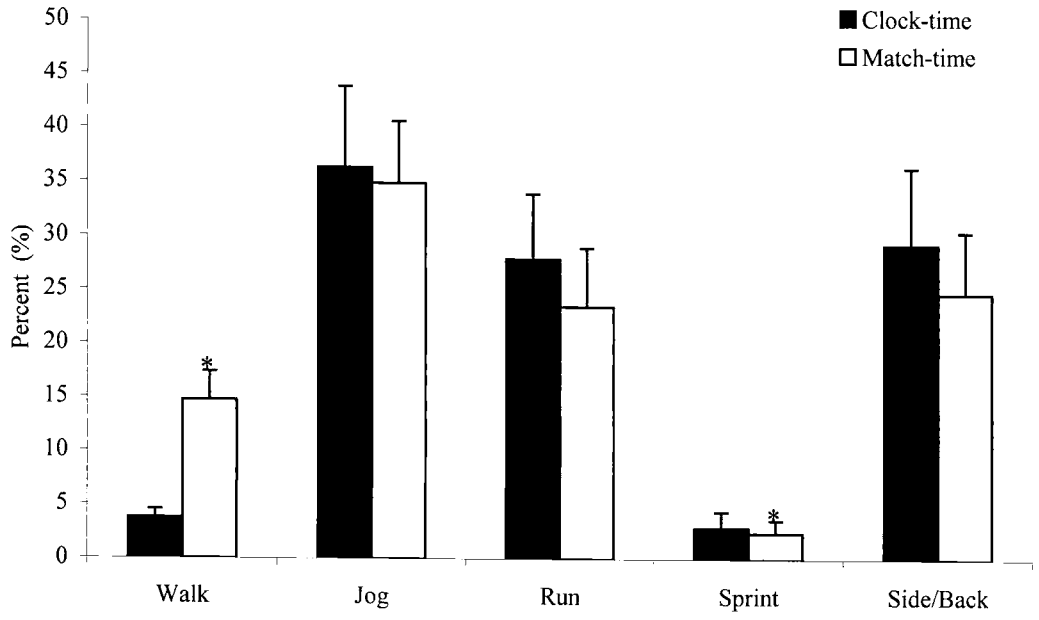

Figure 2. Relative values for total distance covered for locomotor activities (error bars are standard deviation).

* Significantly different from the clock-time analysis ($P<0.05$)

Locomotor Activity Durations: A significant difference was evident between the teams for overall playing time (t = -8.43), with the average athlete on court for 1162 ± 345 s (19.4 ± 5.75 min) in the clock-time analysis, and 1873 ± 483 s (31.2 ± 8.05 min) for the match-time analysis. Significant differences were evident for all locomotor activities in relation to the relative differences, where there was an increase in total standing (7.9%) and walking (21.9%) durations (t = -5.29, -12.70, respectively), and a decrease in total jogging (11.5%), running (6.5%), sprinting (0.47%) and sideways/backwards (11.3%) durations (t = 5.97, 9.53, 5.16 and 6.58, respectively). Furthermore, there was an increase of 6.9% of the time spent in low-intensity activities from clock-time to match-time (t = -9.43), and therefore a decrease in this variable for high-intensity activities of 6.96%. There was also a significant difference in the raw data for low-intensity duration where there was an additional 709 s in the match-time analysis compared to clock-time (t = -8.40). A summary of the durations for the locomotor activities can be found in Tables 1 and 2.

Locomotor Activity Frequencies: A total of 355 ± 57.7 locomotor activities were performed in the clock-time analysis compared to 468 ± 77.2 for the match-time analysis (t = -11.92). This resulted in a change of activity every 3.28 s or 18.3 activities per minute of clock-time, and a change of activity every 4.00 s or 15 activities per minute of match-time.

There were significant differences in all locomotor activities when observing the relative values from clock-time to match-time. This included an increase of 3.2% for standing frequency and 12.0% for walking (t = -8.93 and –15.24, respectively), and a decrease of 3.7% for jogging, 4.9% for running, 0.5% for sprinting and 6.2% for sideways/backwards (t = 4.53, 13.26, 6.28 and 10.84, respectively).

There was a significant increase of 113 low-intensity bouts from clock-time to match-time (t = -11.92). Additionally, there was an increase of 5.41% of frequency of low-intensity activities covered from clock-time to match-time which was significant (t = -12.41), and a decrease of 5.41% of high-intensity activities covered from clock-time to match-time. (Tables 1 and 2 show the comparison of the frequency of locomotor activities between the clock time analysis and the match-time analysis).

4. Discussion and Conclusion

Previous studies into time-motion analysis have demonstrated a variety of timing methods employed. The exclusion of breaks in play during analysis has been employed in studies conducted by Coutts and Reaburn on a 110 min Australian Rules Football game (2000), Rienzi et al. on a 90 min soccer game (2000), Drust et al. on a 90 min soccer game (2002), O'Connor on a 30 min touch football game (2002) and Boddington et al. on a 70 min rugby union game (2003). These authors have indicated that analysis was conducted over the entire game; however, with the exception of O'Connor (2002), they have not indicated whether this was conducted on clock-time or match-time, or whether injury time or over time was also included. Studies which have included all movement patterns and breaks in play from kick-off until full-time including injury time, with the exception of half-time, time-out or intermission periods, have been

extensive. Examples include 95 min for soccer (D'Ottavio and Castagna, 2001), 85 min for rugby union (Martin et al. 2001), 86 min for rugby league (Kay and Gill, 2003) and 118 – 126 min for Australian Rules Football (Dawson et al. 2004).

The present study analysed futsal, to compare the differences between the 40 min clock-time, and a 70 min match-time. Significant differences in many physiological variables were evident when comparing clock-time to match-time in international futsal. This included increases in total distance covered (3582 ± 932 m vs. 4284 ± 1033 m), total duration of locomotor activities (1162 ± 345 s vs. 1873 ± 483 s), and total frequency of locomotor activities (355 ± 57.7 vs. 468 ± 77.2). There were also significant differences in individual locomotor activity patterns, alongside differences between grouped low-intensity and high-intensity activities.

There was an 11% increase in the walking distance covered from clock-time to match-time, with a decrease in running, sprinting and sideways/backwards distances covered (4.4%, 0.49% and 4.6%, respectively). A futsal study conducted by Barbero Álvarez et al. (2003b) demonstrated that low-intensity activities accounted for over 75% of the total match-play distance, which is similar to that observed in this study of 74% when observing match-time data (69% for clock-time data). Furthermore, there was an increase of 695 m when analysing low-intensity activity from match-time from clock-time, whereas there was no change in the high-intensity distance covered. This suggests that clock-time data consists largely of high-intensity activities, whereas match-time data considers natural breaks in play, such as when the ball is kicked out of the court area. Athletes tend to stand or walk in order to maximise the recovery opportunity during such periods.

The analysis demonstrated that the athletes spent an average time of 19.4 ± 5.75 min on the court during the 40 min clock-time, and 31.2 ± 8.05 relative to the 70 min match-time. There was an increase in the low-intensity activity durations in the match-time analysis compared to the clock-time analysis (7.9% standing, 21.9% walking) and decreases in high-intensity activities (6.5% running, 0.47% sprinting). This resulted in a work to rest ratio of 7.4:1 for clock-time and 1.4:1 for match-time, suggesting that clock-time activities are largely spent at a high-intensity with limited rest periods available. As hypothesised, when breaks in play were considered, the opportunity for rest increased, thus reducing the work to rest ratio, allowing for a greater reliance on aerobic energy metabolism. Taking this large variation into account, it would seem appropriate that work to rest ratios are determined during match-time, as the clock-time ratio may misrepresent the nature of the game, and this can have a significant impact when the data is transferred to the training environment (Peterson et al. 2004). This is particularly important when designing a training protocol which intends to replicate a match, including rest periods.

Furthermore, it has been reported that during match-play, fatigue appears to occur towards the end of a game for most high-intensity intermittent team sports (Bangsbo, 1994; Mohr et al., 2003; Reilly, 2003). Although frequent short breaks assist with the aerobic recovery process, these are not sufficient for full recovery (deAraújo, 1996; Barbero Álvarez, 2003b; Smith, 1998). It is suggested for sports such as futsal that frequent substitutions may allow athletes to replenish their energy stores to a greater

extent on the bench or sideline (O'Connor, 2002; Duthie et al., 2003). This may allow athletes to maintain a constant level of high-intensity exercise during the entire match-play duration, and potentially a greater involvement in a game. Additionally, recovery periods and activity during pauses are important to assist in the reduction of lactate accumulation in the muscles and subsequently in the blood (Helgerud et al., 2001; Hoff et al., 2002).

In congruence with the hypothesis, the present study demonstrated that there was a significant increase in the proportion of low-intensity activities in the match-time analysis when compared to the clock-time analysis. It appears that the breaks in play were made up of predominantly standing and walking activities, with such observations recorded for total distance covered, total duration of activities as well as the total frequency of activities. Additionally, as hypothesised, there were no differences for high-intensity activities from clock-time to match-time. Conceivably these activities were completed in actual play and not when natural breaks were occurring.

The results of the current study may have implications for other clock-time based team sports, particularly those of a high-intensity intermittent nature. For example, sports such as water polo (4 x 7 min quarters) (Smith, 1998), ice hockey (3 x 20 min periods) (I.I.H.F., 2002), basketball (4 x 10 min quarters) (F.I.B.A., 2004) and handball (2 x 30 min halves) (I.H.F., 2005), exhibit differences between methods of analysis. All these sports have the potential for an extended match-time, if natural breaks in play are included, such as when the ball or playing object travels beyond the playing area perimeters (Bangsbo, 1994), and can thus produce differences within time-motion analysis, depending on the method of timing employed. With the likelihood of clock-time data misrepresenting the movement patterns of the game, it is important to establish a standard method of analysis, namely based on match-time data, as this will provide a more accurate interpretation of the performance in a game, and assist coaches, athletes and sports scientists alike.

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