High-intensity running is one of the determinants for achieving score-box possession during soccer matches

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Time motion analysis has shown that high-intensity running (HIR) during soccer games is one of the important actions for achieving high performance. However, it is unclear whether HIR is needed and how much the player should perform HIR for achieving score-box possessions which is defined as successful team possessions. This study aimed to quantify the distance covered at HIR with relation to classification of team possession. Eighteen collegiate male soccer players performed five official soccer games. During the games, x- and y- coordinates were determined by using a global positioning system. Total distance (D_{SUM}) and the distance covered over 5.0 m/s (D_{HIR}) were calculated from the two coordinates. Team possessions during games was classified from the films obtained by camera, score-box possession (SBP) vs. no score-box possession (NSBP), and counter attack vs. elaborate attack, and state of the opponent defenders (balanced vs. imbalanced). D_{HIR} in counter attack was longer in SBP than NSBP, regardless of opponent defender's state. D_{HIR} in elaborate attack with balanced was greater in SBP than in NSBP. The current results demonstrate that D_{HIR} in score-box possession is superior to that in no score-box possession, indicating that D_{HIR} is one of the determinants for achieving score-box possession during soccer games.

Keywords: time-motion analysis, GPS, counter attack, elaborate attack

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1. Introduction

Soccer is performed in 11-a-sides and a ball game that one team with higher scores wins within a predetermined time. Offensive phase in which players move to get a score and defensive phase in which players move to take possession of the ball are classified in soccer. Some studies have revealed effective team possessions by using the location of players (Harris and Reilly, 1988) and the number of passes (Bates, 1988; Huges and Franks, 2005; Reep and Benjamin, 1968) when scoring goals. In soccer, there are two team possessions; counter attack designed to move the ball quickly to the opponent goal and elaborate attacks designed to move the ball slowly to the opponent goal while maintaining possession. Tenga et al. (2010) have examined effective team possessions to achieve score-box possession (SBP), defined as team possession in which a ball reaches into score box, with relation to state of defense team for Division 1 of the Norwegian Soccer League. They showed that counter attack before the opponent defense is collectively set is superior to elaborate attack for achieving SBP.

Recently, time motion analysis using automatic tracking system with videos and global positioning system (GPS) has made it possible to calculate number of player's movement and distance covered (Aughey, 2011). Previous studies have examined total and high-intensity distance covered during games with relation to competition level (Mohr et al., 2003, European Champions League level vs. Denmark League level) and the ranking of the Division 1 of the Italian Soccer League (Serie A) (Rampini et al., 2009). Mohr et al. (2003) reported that distance covered at high intensity during games (4.17 m/s) was greater in top-class players than moderate players. On the other hand, the distance covered at high intensity (5.5m/s) was greater in mid- and lower ranking teams than upper ranking teams in the Division 1 of the England Soccer League (Premier League) (Di Salvo et al., 2009). In addition, Rampini et al. (2009) have focused on offensive phase during games, and revealed that total distance covered and distance covered at high intensity (3.9m/s) were greater in upper ranking teams than in lower ranking teams.

However, distance covered at over 4 m/s and 5.5 m/s during team possession are not different between the players involved in the teams ranked 10 or higher by FIFA and the players of the team involved in one of the European leagues (Bradley et al., 2010).

As noted above, counter attacks and elaborate attacks are used in soccer games (Tenga et al., 2010). The discrepancy of the earlier findings may be due to the difference in type of attacks among teams. In the earlier study (Faude et al., 2012), the most frequent movement in scoring is straight running with maximal effort. Considering this finding, we expected that distance covered at high-intensity running was greater in SBP compared to other possessions. To the best of our knowledge, however, it is unclear whether the difference in the distance covered during games are found between counter and elaborate attacks. Therefore, this study aimed to quantify the distance covered with relation to classification of team possession for achieving SBP using time motion analysis.

2. Methods

2.1. Experimental protocol

Data was corrected from September to November in 2014. We recorded the video images and coordinate data for five games in Division 1 of a regional collegiate male soccer league. The examined team adopted the formation of 1-4-4-2, and was ranked first in the league series. Opponents were ranked from second to sixth. The examined team outranked the second ranked team by four points, and the sixth ranked team by 29 points. Eighteen players were analyzed, and nine of these joined professional teams after graduating from their university. All players trained approximately two hours per day, five days per week. Prior to the experiment, an obtained subjects' consent to participate. This study was approved by the Ethical Committee of the National Institute of Fitness and Sports in Kanoya.

2.2. Time-motion analysis

We measured x- and y-coordinates of each player during games with GPS (SPI-Pro, GPSports, Australia), which is capable of recording total distance covered and distance covered in different velocity zones during games, and is with high reliability in outdoor fields (Johnston et al., 2012). The data obtained from the measurement was sampled at 5 Hz, and interpolated at 15 Hz using specialized software (Team AMS, GPSports, Australia) when downloading to a computer. Players wore specialized vests capable of storing a GPS sensor when playing games. The obtained data was corrected for latitude and longitude and the origin coordinate (0, 0) measured by GPS set downward a corner flag of a pitch, and then the location of each player was relatively expressed in the pitch. **Figure 1** shows accordance between the video images and trajectory of a player calculated by GPS data. We calculated the total distance covered and distance covered at each velocity zones in eleven players during offensive phase. Velocity zones were categorized in four zones; <1.6 m/s, 1.6 to 3.3 m/s, 3.3 to 5.0 m/s, and over 5.0 m/s (Hill-Haas et al., 2009). Since the velocity zone used for time-motion analysis differs among the earlier studies (Bradley et al., 2009; Mohr et al., 2003; Rampini et al., 2007), we quantified the velocity of straight running and running with changes of direction prior to this study. The results revealed that the velocity of intermittently repeated straight running was 5.0 m/s and greater, and that of running with changes of direction (5 m×5 m) was less than 5.0 m/s (**Figure 2**). Based on these results, we defined running at the velocity of over 5.0m/s as high-intensity running (HIR). All analyses were conducted with Matlab (MATLAB R2011b, Math Works, USA)

Total distance covered (D_{SUM}) and distance covered at HIR (D_{HIR}) of eleven players in each offensive phase were summed and averaged in each team possession described below. Since the time taken for completing each team possession differed between counter attacks and elaborate attacks, we calculated the percentages of D_{HIR} in D_{SUM} ($\%D_{HIR/SUM}$).

2.3. Classification of offensive situations

We recorded videos for the examined games with a digital video camera (HDR-CX270, Sony, Japan) (frame rate: 30 Hz). Team possession was consisted of series of passes or at least single pass between players within the examined team or at least single pass.We determined the starting point of every team possession to be the time when passing the ball from one player to another player within the examined team after taking the ball from opponent or restarting

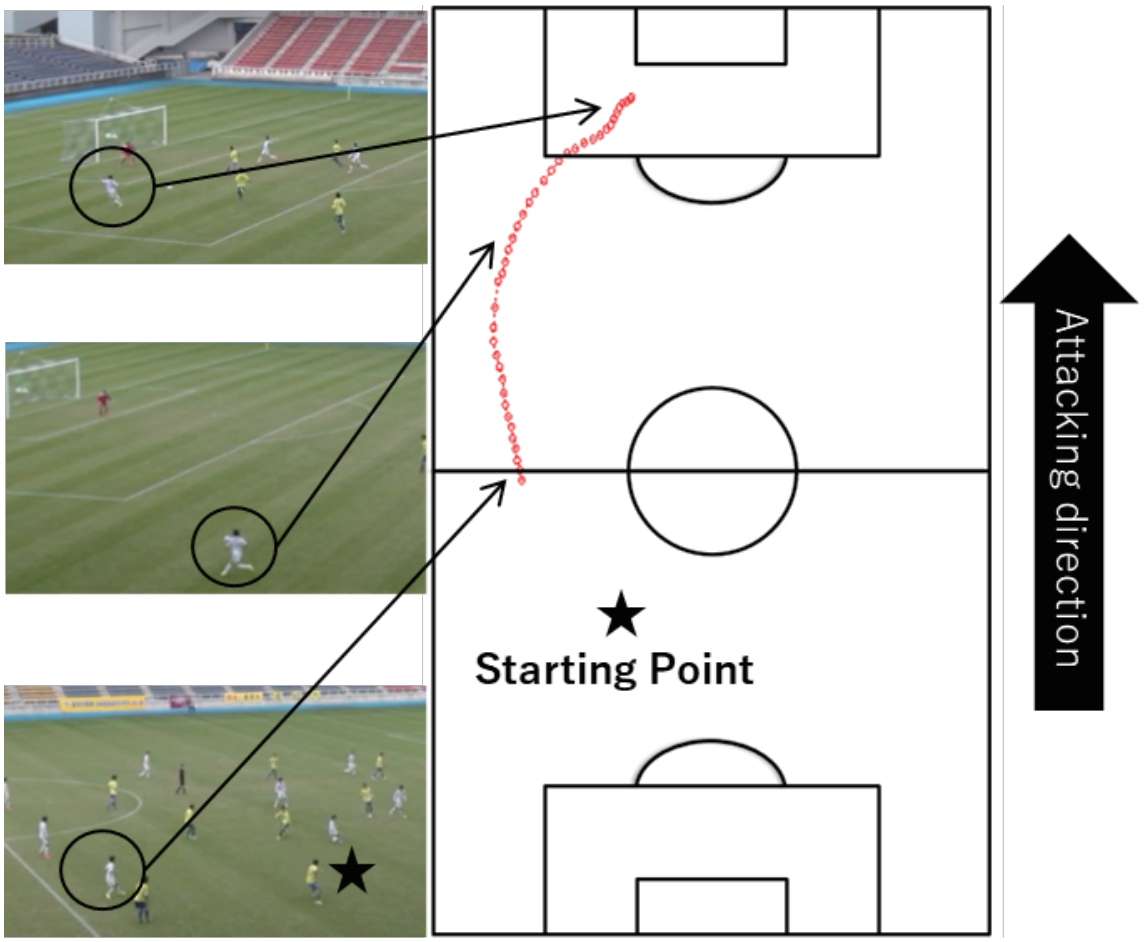

Fig 1 A player's tracking obtained from GPS and camera's images.

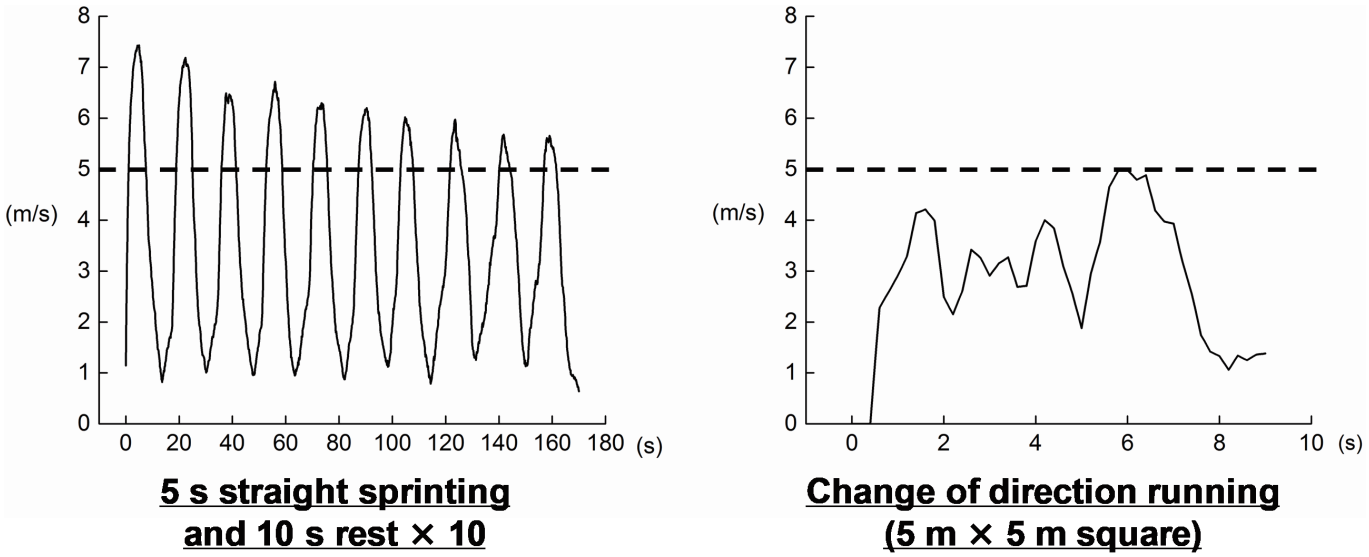

Fig 2 Velocity during sprinting and change of direction running determined using GPS.

of play exluding cornerkick and freekick which is set near to the goal, or the time when a player who took the ball from opponent team before touches the ball twice or more. The finishing point of every team possession was defined as the time when the ball is taken by the opponents, or the time when play stops due to out-of-play or foul. According to the method reported by Tenga et al. (2010), we classified the team

possessions observed in games into 12 patterns based on three variables; type of team possession (counter vs. elaborate attacks), opponent's defensive situation (imbalanced vs. balanced vs. imbalanced & balanced), and outcome of team possessions (SBP vs. no score-box possession (NSBP)) (**Table 1**). SBP was defined as ball possessions in which the examined team was able to keep a ball inside the score box (**Figure 1**) while NSBP was defined as ball possessions in which the team was unable to keep the ball inside the score box (Tenga et al., 2010). Opponent's defensive situation was evaluated on the criteria of three items; defensive pressure, numerical advantage of defenders, and defensive covering. Scales was assigned to three (bad situation, 1; a combination of good and bad situation, 2; good situation, 3). Based on a total score of the three items, we assigned opponent's defensive situation to three situations (imbalanced, <5; mixed imbalanced and balanced, 6; balanced, >7). A penetrative pass is one of the determinants for achieving SBP (Tenga et al., 2010) because offense players often run to receive the ball behind opponents without offside. Therefore, we identified team possessions employing penetrative passes (Tenga et al., 2010), and estimated the percentages of the team possessions including penetrative passes in number of counter attacks and elaborate attacks, respectively.

To confirm the reliability of the measured variables, we measured the same plays in five games twice with an interval of one month. Cohen's kappa coefficients (<0.00: Poor agreement, 0.01-2.00: Slight agreement, 0.21-0.40: Fair agreement, 0.41-0.60: Moderate agreement, 0.61-0.80: Substantial agreement, 0.81-1.00: Almost perfect agreement) were 0.65 for type of team possession, 0.71 for outcome of team possessions, 0.43 for opponent's defensive situation and 0.75 for team possessions with penetrative passes.

2.4. Statistical processing

Descriptive data are expressed as means and standard deviations. To compare the proportion of SBP with that of NSBP in total of possessions in all games, chi-square test was conducted. When chi-square values were significant, residual analysis was conducted. Homoscedasticity was not proven in obtained variables. To test the differences in D_{SUM}, D_{HIR}, and $\%D_{HIR/SUM}$ among patterns of team possessions, therefore, the Kruskal-Wallis test was performed. When H values were significant, we conducted multiple comparison with the Dunn method (Dunn, 1964). To examine the effects of opponents' teams on D_{SUM}, D_{HIR}, and D_{HIR} and $\%D_{HIR/SUM}$, we used one way ANOVA and post hoc comparison. The significance was set at less than 5%. All statistical processing was conducted with statistical analysis software (SPSS Statistics 20.0, IBM, Japan).

3. Results

3.1. Descriptive data of the type of team possession, opponent's defensive situation, and outcome (Table 2)

There were 569 team possessions in all games. The number of type of team possessions were 249 times (44%) for counter attacks and 320 times (56%) for elaborate attacks. In the defensive situations, number

Table 1 Classification of team possessions.

outcome	Type of team possession (*Counter attack* & *Elaborate attack*)		Defensive situation
Score-box possession	**・Counter attack with imbalanced when SBP**	**・Elaborate attack with imbalanced when SBP**	*Imbalanced*
	・Counter attack with mix when SBP	**・Elaborate attack with mix when SBP**	*Mix*
	・Counter attack with balanced when SBP	**・Elaborate attack with balanced when SBP**	*Balanced*
No score-box possession	**・Counter attack with imbalanced when NSBP**	**・Elaborate attack with imbalanced when NSBP**	*Imbalanced*
	・Counter attack with mix when NSBP	**・Elaborate attack with mix when NSBP**	*Mix*
	・Counter attack with balanced when NSBP	**・Elaborate attack with balanced when NSBP**	*Balanced*

SBP, Score-box possession; NSBP, No score-box possession; Imbalanced, Imbalanced defense; Mix, Mixed defense; Balanced, Balanced defense.

Table 2 Descriptive data for offensive and defensive variables in team possessions

Variable	*N*	%	Score box (times)	Score-box (%)	*P**
Offensive variables					
Team possession type					
Counter attack	249	44	70	28	0.37
Elaborate attack	320	56	101	32	
Pass penetration					
Penetrative pass	8	1	7	88	＜0.00
Mixed	144	25	64	44	
Non-penetrative pass	417	73	100	24	
Team possession outcome					
Score-box possession	172	30			
No score-box possession	397	70			
Defensive variables					
Defensive pressure					
Loose (‘‘imbalanced’’)	70	12	18	26	＜0.00
Mixed	410	72	145	35	
Tight (‘‘balanced’’)	89	16	8	9	
Defensive backup					
Absent (‘‘imbalanced’’)	311	55	71	23	＜0.00
Mixed	237	42	99	42	
Present (‘‘balanced’’)	21	4	1	5	
Defensive cover					
Absent (‘‘imbalanced’’)	7	1	3	43	＜0.00
Mixed	73	13	53	73	
Present (‘‘balanced’’)	489	86	115	24	
Overall defensive score					
Imbalanced defense	95	17	44	46	＜0.00
Mixed	219	38	58	26	
Balanced defense	255	45	69	27	

Note: Overall defensive score is calculated from summarizing the scores of “Defensive pressure”, “Defensive backup”, and “Defensive cover”.

*Pearson chi-square.

of imbalanced and balanced defensive plays were 95 times (17%) and 255 times (45%), respectively. In outcome of team possessions, number of SBP and NSBP were 172 times (30%) and 397 times (70%), respectively.

As the result of Chi-square test, the proportion of SBP to all team possessions was higher compared to that of NSBP when penetrative passes (7 times,

Table 3 Time-motion analysis for team possessions during games

	Counter attack				Elaborate attack			
	Imbalanced defense		Balance defense		Imbalanced defense		Balance defense	
	SBP	NSBP	SBP	NSBP	SBP	NSBP	SBP	NSBP
D_{SUM} (m)	376 ± 188	229 ± 147*	420 ± 202	152 ± 142*†	453 ± 296	302 ± 176	643 ± 332	456 ± 394*†
D_{HIR} (m)	122 ± 74	53 ± 68*	100 ± 73	26 ± 49*	55 ± 40	24 ± 25	67 ± 56	31 ± 37*
$\%D_{HIR/SUM}$ (%)	31 ± 15	17 ± 15*	21 ± 2	10 ± 12*	13 ± 6	7 ± 6	10 ± 7	6 ± 7*

Values are presented as means ± SDs.

Score-box possession: SBP

No score-box possession: NSBP

* Significant difference SBP and NSBP within same within same type and defensive situation of team possession

† Significant difference counter attack and elaborate attack within same outcome and defensive situation of team possession

88%) and imbalanced opponent defensive situations (44 times, 46%) were included in team possessions. Proportion of SBP to all team possessions was 31% for wins and 26% for losses with no significant difference. The ratio of penetrative passes during SBP in counter attack with both imbalanced and balanced opponent defensive situations was greater than those during NSBP.

3.2. Distance covered in team possessions

For field players, total distance covered per game, and that at HIR, and the ratio of HIR to total distance covered were 10,976 ± 316 m, 1161 ± 63 m, and 11 ± 1%. During team possessions, D_{SUM}, D_{HIR} and $\%D_{HIR/SUM}$ were 4399 ± 599 m, 586 ± 81 m, and $D_{HIR/SUM}$ 51 ± 7%.

3.3. Comparison of high-intensity running between SBP and NSBP (Table 3)

In counter attack with both imbalanced and balanced opponent defensive situations, D_{SUM}, D_{HIR}, and $\%D_{HIR/SUM}$ during SBP were greater than those during NSBP. Furthermore, in elaborate attack with balanced opponent defensive situations, D_{SUM}, D_{HIR}, and $\%D_{HIR/SUM}$ during SBP were greater than those during NSBP. D_{SUM} in elaborate attack with balanced opponent defensive situations during NSBP was greater than that in counter attack with balanced opponent defensive situations during NSBP, but there were no significant differences in D_{HIR} and $\%D_{HIR/SUM}$, regardless of type of team possession and opponent defensive situations. No significant differences in D_{SUM}, D_{HIR} and $\%D_{HIR/SUM}$ were found, regardless of opponent teams (**Figure 3**).

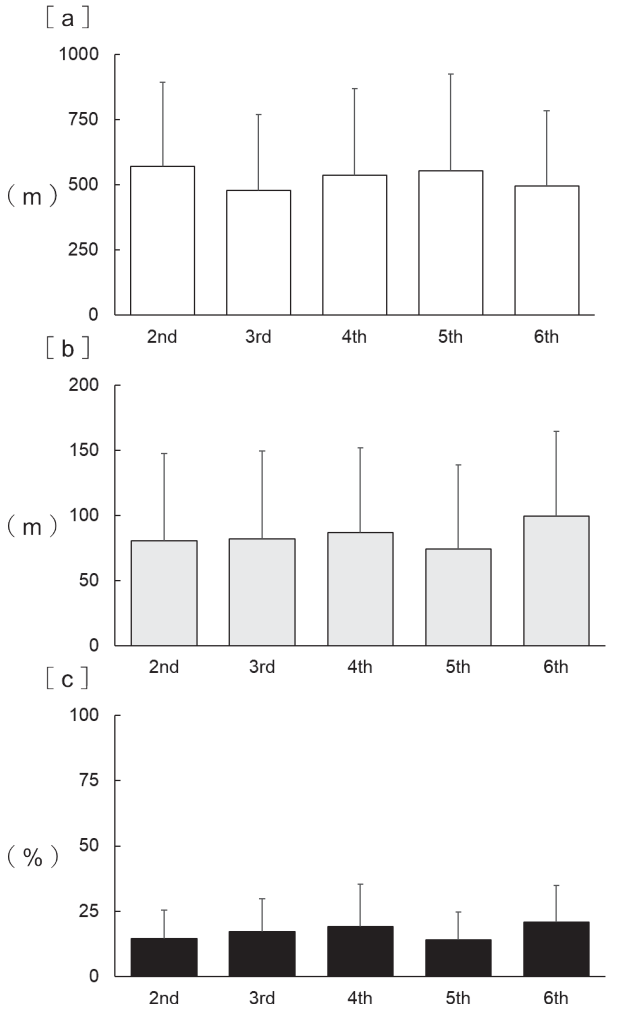

Fig 3 Effects of different opponent's teams on D_{SUM} (a), D_{HIR} (b), and $\%D_{HIR/SUM}$ (c).

4. Discussion

The finding obtained here was that D_{HIR} and $\%D_{HIR/}$

$_{SUM}$ in counter attack with both imbalanced and balanced opponent's defensive situations were greater in SBP than in NSBP. In addition, no significant differences in D_{HIR} and $\%D_{HIR/SUM}$ were found with relation to type of team possession and opponent defensive situations. These results indicate that distance covered at high intensity was greater in team possessions to achieve SBP.

Total distance covered per game in this study was 10,976 ± 316 m and distance covered at HIR was 1161 ± 63 m. Total distance covered was within the range of professional soccer players reported in earlier studies, and the percentage of distance covered at HIR in total distance covered was greater (total distance covered: 10,000-11,000m; percentage of distance covered at HIR in total distance covered: 7-9%) (Bangsbo, 1991; Bradley et al., 2009, 2010; Folgado et al., 2015; Lago-Peñas et l., 2011; Rampini et al., 2007). These findings suggest that the players examined here could move at the same as or greater than international professional soccer players during games.

Movement at 5.0 m/s or greater, which was defined as HIR in this study, is close to straight running (**Figure 2**). This suggests that more frequent D_{HIR} means large distance covered by straight running. Faude et al. (2012) demonstrated that the most frequent movement on scoring was straight running at maximal effort. This study revealed that D_{SUM}, D_{HIR} and $\%D_{HIR/SUM}$ during SBP in counter attack with both imbalanced and balanced opponent defensive situations were greater than those during NSBP. The ratio of penetrative passes during SBP in counter attack with both imbalanced and balanced opponent defensive situations was also greater than that during NSBP. A penetrative pass is a pass moving behind opponent defense. Therefore, players that receive the ball must run behind the defenders without an offside. This suggests that players move at HIR to receive a penetrative pass and that such a locomotion helps to achieve SBP.

In this study, D_{HIR} during SBP in counter attack with both imbalanced and balanced opponent defensive situations was greater than that during NSBP. Tenga et al. (2010) reported that an imbalanced opponent defensive situation made it easier to achieve SBP than did a balanced opponent defensive situation requiring the creation of space by moving defenders. This study revealed that the distance covered at HIR was longer during SBP than NSBP with both imbalanced and balanced opponent defensive situations. This implies that appearance of HIR in counter attack may increases the possibility of achieving SBP.

D_{HIR} during SBP in elaborate attack with balanced opponent defensive situations was greater than that during NSBP. For elaborate attack, the ratio of penetrative pass in SBP was similar to that in NSBP. This may be considered that the player possessing the ball was unable to execute a penetrative pass because opponent defensive situation was balanced. On the other hand, it is possible that players without the ball may move at HIR to create an imbalanced opponent defensive situation. We cannot determine this point in this study. As seen in **Figure 4**, however, the direction of HIR was often toward the opponent goal when the opponent's defensive situations were imbalanced. When the opponent's defensive situations were balanced, the direction was not toward the goal well. This can be speculated that the players without the ball move at HIR to create an imbalanced opponent defensive situation.

No difference in D_{HIR} and $\%D_{HIR/SUM}$ was found, regardless type of team possession (counter and elaborate attacks) or opponent defensive situation (imbalanced and balanced). This suggests that the effects of type of team possessions and opponent defensive situations on HIR in SBP was less. Furthermore, the difference in each team's point gained through the league indicates that competition level of opponent teams seemed to be different. These current results revealed that no significant differences in D_{HIR} and $\%D_{HIR/SUM}$ were found with relation to competition level of opponent teams. This suggests that HIR to achieve SBP may be insusceptible to competition level of opponent teams.

In this study, there was no significant difference in the proportion of SBP to a total of team possessions between wins and losses. SBP is a team possession that creates more scoring opportunities (Tenga et al., 2010), but it does not necessarily lead to scoring. Meanwhile, number of SBP was greater in wins than in losses. This suggests that the examined team got more chances to make a goal and could lead to scoring, resulting in winning games.

As stated above, HIR is necessary to achieve SBP, and is not influenced by the difference in competition level of opponent teams or type of team possession and opponent defensive situations in this study. However, it is still unknown whether this would be the case with different teams. Since this study

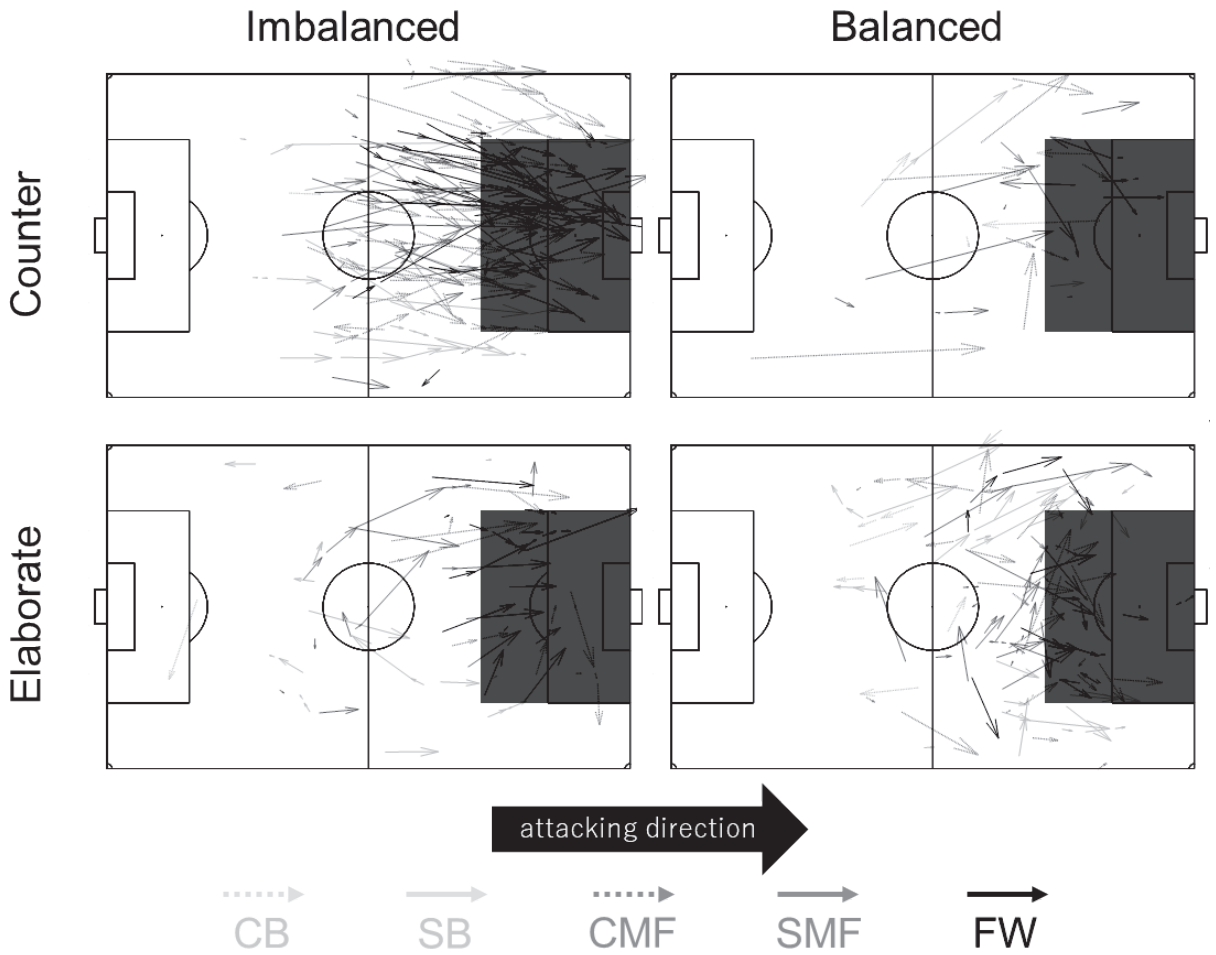

Fig 4 Location and direction of HIRs in score-box possession for five matches (1st half).

examined one team, the data may reflect tactical characteristics of the target team. It is paid attention to consider the interpretation of the current results of this study. In the future, it is necessary to increase the number of teams and players for generalizing the current findings.

5. Conclusion

In this study, we conducted time-motion analysis for team possessions during soccer games to quantify the distance covered in association with classification of team possessions designed to achieve SBP. As the results, 1) D_{HIR} during SBP in counter attack with both imbalanced and balanced opponent defensive situations was found more often than that during NSBP; 2) D_{HIR} during SBP in elaborate attack with balanced opponent defensive situations was found more often than that during NSBP; 3) The difference in $\%D_{HIR/SUM}$ was also similar to those of D_{HIR}; and 4) no significant difference in D_{HIR} was found with relation to type of team possession and opponent defensive situations. The current results demonstrate that HIR is performed more often in SBP than in NSBP regardless of the type of team possession and opponent defensive situations, suggesting that HIR is one of the factors for achieving SBP during games.

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