Title
Development of Criterion-Referenced Measurement Items of Defensive Transition in Soccer Games from Tracking Data

Running Title
Criterion-referenced items of defensive transition in soccer

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Abstract

The purpose of this study was to develop criterion-referenced measurement items of defensive transition in soccer games from tracking data. The research procedure comprised three steps, 1) construction of transition items from tracking data based on qualitative analysis, 2) analysis of the success criteria of transition items by decision tree analysis and 3) analysis of item and test characteristics for criterion-referenced measurement using item response theory (IRT). 158 defensive transition plays in two games of the J-league in 2016 were used for the analysis. Twenty-two transition items were constructed from tracking data based on qualitative analysis. Success criteria of all items for classifying successful defensive transition were investigated. Subsequently, 16 criterion-referenced measurement items for measuring defensive transition were selected via IRT (with a two-parameter logistic model – 2PLM). The item difficulty parameter (M= -0.88, SD=1.00), the item discrimination parameter (M=0.92, SD=0.66) showed the accepted range of values. The goodness-of-fit analysis showed all 16 items fitted to the 2PLM (p>=0.05). The invariance of the item difficulty parameter (r=0.89, p<0.05) and the item discrimination parameter (r=0.76, p<0.05), the defensive transition score (r=0.59, p<0.05) are found. In conclusion, this study constructs 22 defensive transition items based on qualitative analysis processed by tracking data and 16 of them are criterion-referenced measurement items for defensive transitions.
1. Introduction

A moment of transition is a crucial moment for offensive success. Reep and Benjamin (1968) reported that 30% of attacks from ball gain lead to goal scoring. Tenga et al. (2010a; 2010b) showed that counter-attack against imbalanced defence increased the goal scoring and score box possession. Barreira et al. (2014) showed that offensive transition by tackling is a significant defence ball action that leads to goal scoring. Hughes and Lovell (2019) reported offensive transition by tackling and forward progression of the initial two ball actions after ball gain increased scoring opportunity. Those studies suggest that the moment of transition is one of the key phases of offensive success.

As well as offensive transition, defensive transition is a crucial moment for the ball-lost team, the defensive transition team, to prevent the opponent counter-attack and then re-gain the ball possession quickly (Vogelbein et al., 2014; Casal et al., 2016). Vogelbein et al. (2014) studied the time to recover ball possession in the German Bundesliga, and they found that the successful team showed a shorter time to recover the ball possession compared with unsuccessful teams. Casal et al. (2016) investigated key variables in defensive transitions in FIFA World Cup 2010. They found that the area in which the ball was lost, the position of the defensive line, and time taken to recover the ball after losing possession were items associated with the
outcome of a defensive transition, especially time taken to recover the ball after losing possession within 15 seconds, which was significantly related to a successful defensive transition. Those studies suggest that highly skilled teams played well at defensive transition and prevented the opponents' counter-attack and re-gain the ball possession quickly. However, they only used the time to recover the ball possession as a significant variable to measure defensive transition, and it was impossible to measure achievement of defensive transition in the soccer game.

The criterion-referenced measurement test allows measuring the achievement of performance using items with predetermined performance standards and the coaches be able to diagnostically evaluate achievement of specific performance (Morrow et al., 1995). Item response theory (IRT) has been applied to the scaling of criterion-reference test for sports skills. Recently, Ando et al. (2018a) used a two-parameter logistic model (2PLM) and constructed a criterion-referenced test of soccer tactical skill. This result was used for the computer-based adaptive test (CAT) of soccer tactical skill (Ando et al., 2018b). The limitation of the use of IRT was that it was only applicable to binary scales data. However, Matsuoka et al. (2020) constructed items in ratio scale from game performance data, tracking data and ball-touch data, and developed criterion-referenced items for soccer defence skill. They analysed success criteria, as performance standards, of ratio scale items by a decision tree analysis to convert ratio
scale items to binary scale items. Thus, it is possible to develop criterion-referenced items of defensive transition from game performance data.

The purpose of this study was to develop criterion-referenced items of defensive transition in soccer games from tracking data. Defensive transition items were developed from tracking data using qualitative analysis, and item characteristics and test characteristics of defensive transition items were analysed.
2. Methods

2.1. Research procedure

The first step was the construction of items from tracking data based on the qualitative causal structure of transition. The second step was to identify the success criteria of the items to classify successful defence transition. The final step was to identify criterion-referenced items for defensive transitions. This study was approved by the Research Ethics Committee at Faculty of Health and Sport Sciences, University of Tsukuba (Project No. 30-54).

2.2. Data and Sample

Ball touch data and player tracking data for the two games of the 2016 J-League Championship Finals (Rounds 1 and 2), collected by DataStadium Inc. based on business contracts with professional soccer leagues, were used. These matches were used as they concerned the knock-out stages whereby both teams aimed to win without the benefit or disadvantage of the home and away effect. Ball-touch data included match ID, half ID, time, possession team name, player name, ball action name (e.g. pass, shot, tackle), and ball XY positions. The data were collected by the trained staffs in the sports analytics company (Kato, 2016). Tracking data included player XY position recorded in every video frame (1/25 fps). TRACAB (ChyronHego, NY, USA)
was used to collect tracking data.

The 158 defensive transition plays were collected. The start of defensive transitions was defined when the team lost ball possession (Vogelbein et al. 2014). The defensive transitions were the defence plays of the defensive transition team corresponding to the first 2 opponent player ball actions because it was reported that the first 2 ball actions were crucial moments (Hughes and Lovell, 2019). Moreover, defensive transition at the offensive-midfield, the zone of the field from the central line of the pitch to the line 30m from the opposing goal, was collected because the highest number of the ball lost were recorded in this zone (Barreira et al., 2014; Casal et al. 2016).

The results of defensive transitions, “Transition against the opponent fast attack”, “Transition against the opponent possession attack”, or “Transition to press opponents”, were classified depending on the ball position at the opponents’ third ball action. The successful defensive transition was defined as “transition against the opponent possession attack” and “transition to press the opponent.” “Transition against the opponent fast attack” was considered as a failure of defensive transition leading to counter-attack of the opponents.

2.3. Development of defensive transition items

Defensive transition skill was one of a specific tactical skill and the tactical skill in
soccer games was measured by game performance data (Suzuki and Nishijima, 2004; 2005; Tenga et al., 2009; Matsuoka et al., 2020). As Tenga et al. (2009) insisted that the game performance should be measured with the consideration of the opponent interaction. For example, they measured the opponent interaction and found counter-attack is a more effective offence against the opponents’ imbalanced defence. Therefore, defensive transition skill was measured by the items of game performance of the defensive transition team, and the items of game performance of the opposing team which were affected by the defensive transition team.

The items were constructed via the cause and effect analysis with the Delphi method by developing the qualitative causal structure of defensive transition. The Delphi method was applied to extract the knowledge of 4 soccer experts, two coaches, an analyst, and a professional soccer player. Two coaches had coaching experience more than 10 years. The analyst had experience as a performance analyst in the academy of the professional soccer team and had expert knowledge of soccer game data analysis. A professional soccer player had experience of the national team and gained medals in International competitions. A researcher had interviews with each soccer expert separately and asked components of defensive transition play with consideration of the defensive transition team and the opponent team. Based on the extracted information, the qualitative causal structure of transition play was shown on
the cause and effect diagram. Then the result was feedbacked to the participants, and this process was repeated until new components were obtained.

2.4. Statistical analysis

2.4.1. Success criteria of defensive transition items

Success criteria of transition items were investigated by decision tree analysis to convert the ratio scale to binary scale for all items (Matsuoka et al., 2020). The dependent variable was the result of defensive transitions, and the independent variables were 22 items. The analysis was completed for each item. For the algorithm, the CART was used (Breiman et al., 1984). The Gini index was used to split the independent variables. The split value of the first branch at the root node was used as the success criteria. IBM SPSS ver23 was run.

2.4.2. Criterion-referenced measurement items of defensive transition

A two-parameter logistic model (2PLM) was used to analyse item characteristics and test characteristics. Unidimensionality, goodness-of-fit to the item characteristic curve, invariance of item parameters (difficulty and discrimination) and ability parameters, test reliability, goodness-of-fit to the test characteristic curve (TCC), and test validity were analysed.
Exploratory factor analysis was used to analyse unidimensionality. The principal factor solution was applied to the tetrachoric correlation matrix among the items. One factor was extracted, and the scree-test was applied to find the significant contribution rate of the first eigenvalue compared with the contribution rate of the second eigenvalue. An item of the strongest negative value of the 1st factor loading was deleted. Then unidimensionality was analysed again until only the items in the positive value of the 1st factor loading were left.

The equation of the 2PLM model as shown below

\[ P(\theta) = \frac{1}{1 + \exp(-Da(\theta-b))} \]  

(1)

Where “P(\theta)” is the probability that a defensive transition play (\theta) is correct in a certain item, “D” is a scaling factor (1.7), “a” is the item discrimination parameter, and “b” is the item difficulty parameter. The item difficulty parameter represents the level of difficulty of the items. The item discrimination parameter represents how the items can differentiate the defensive transition with a high and low score (\theta). Selection criteria of valid items were set as the theoretical range of the item difficulty parameter (-4.0 to 4.0) (Baker, 2001) and item discrimination parameter (over 0.2). The maximum likelihood method was used to estimate item parameters.

The invariance of the item parameters and defensive transition score was analysed by Pearson’s correlation coefficients. For the invariance of item parameters, the sample
was divided into two groups randomly, and the item parameters were estimated. Then, the correlation coefficients between the two groups for each parameter was estimated. For the invariance of defensive transition score, the items were divided into two groups and the defensive transition score was estimated. Then, the correlation coefficient between the two item groups was estimated. The Chi-square test was used to analyse the goodness-of-fit of the items to the 2PLM. p >= 0.05 was used as the significant level of the statistical hypothesis test.

The test information function (TIF) is used to analyse the test reliability. At first, Item information function (IIF) is calculated from the item information function in the equation shown below.

\[ I_j(\theta) = D^2 * a_j^2 * P_j * Q_j \]  

(2)

Where “I_j” is the item information amount of item_j, “\theta” is the defensive transition score, “D” is the scaling factor (1.7), “a_j” is the item discrimination parameter of item_j, “P” is the percentage of correctness at item_j, and “Q” is the percentage of incorrectness at item_j.

TIF is calculated using the formula shown below.

\[ T(\theta) = \sum I_j(\theta) \]  

(3)

Where “T” is test information amount, and “I” is the item information amount of item_j.

The reliability coefficient is calculated as below.
\[ \rho(\theta) = \frac{1}{1 + \frac{1}{T(\theta)}} \]  \hspace{1cm} (4)

Where “\( \rho \)” is the reliability coefficient, and “\( T \)” is the test information amount.

The goodness-of-fit of the test was confirmed visually using a scatter plot of the test score and defensive transition score (\( \theta \)) with the item characteristics curve.

The validity of the test was analysed by the criterion-related validity and the comparison of the defensive transition score in the results of transition. The criterion-related validity was analysed using Pearson’s correlation coefficient between the test score and the defensive transition score. The defensive transition score was then compared using a Kruskal-Wallis H test, and a Mann-Whitney U test with Bonferroni adjustment was used for each transition type. \( p < 0.05 \) was set as the significant level of the statistical hypothesis test.

Bilog-MG ver 3.0 was used to analyse IRT, Mplus ver 3.0 was used to analyse unidimensionality, and SPSS ver 23 was used for other statistical tests.
3. Results

3.1. Development of defensive transition items

Figure 1 showed the cause and effect diagram of transition utilizing the Delphi method. The structure of transition consisted of the opponent team and the defensive transition team play. The opponent team had three components of plays; “Escaping from defensive pressure”; “Transferring the ball forward”; “Breaking the opponents”. “Escaping from defensive pressure” consisted of 1st ball control and attacking support. “Transferring the ball forward” consisted of invasion into the opponents’ half and invasion with the attacking support. “Breaking the opponents” consisted of breaking the opponents’ DFL. The defensive transition team also had three components of plays, “Approaching the ball holder”; “Marking the offence players”; “Controlling Defence line (DFL) position”. “Approaching the ball holder” consisted of an approach to the ball. “Marking the offence players” consisted of marking players located near the ball. “Controlling DFL position” consisted of line control and line balance. Twenty-two items, 13 items for the defensive transition team and 9 items for the opponent team, were processed from tracking data (Table 1).

[Figure 1 near here]
3.2. Success criteria of defensive transition items

Table 2 showed the success criteria of transition items. Success criteria showed the branch value of the items contributing to an increased proportion of successful defensive transition. For example, the success criterion of “v01 Distance between the ball and the 1st defender” indicated that the 1st defender needs to be closer than 9.88m to the ball holder. The success criterion of “v14 ball direction” indicated that if the ball holder of the opponent team transferred the ball in a sideways or backwards direction, which meant the defensive transition team successfully prevented the quick progression of the opponent team.

3.3. Item characteristics and test characteristic of defensive transition items

Sixteen items of twenty-two items were selected via single factor analysis and IRT analysis. In the analysis of unidimensionality, the first eigenvalue was 6.31 which explained 39.43% of the total variance, while the contribution rates of the second and subsequent eigenvalues were 18.24% or less. The first factor loading of 16 items showed positive ($M = 0.55$, $SD = 0.26$, $Max = 0.92$, $Min = 0.09$).

The achievement rate, item parameters, and results of the goodness-of-fit test of 16
transition items were analysed (Table 2). Mean of the achievement rates was 68.39% 
\(SD = 19.70\%\). Mean of the item difficulty parameter was -0.88 \(SD = 1.00, \text{Max} = 0.76, \text{Min} = -2.87\). Mean of the item discrimination parameter was 0.92 \(SD = 0.66, \text{Max} = 2.61, \text{Min} = 0.25\). The goodness-of-fit test of the items using the Chi-squared test showed that all 16 items fitted the model \(p >= 0.05\).

The invariance of the item difficulty parameter and the item discrimination parameter were \(r(16) = 0.89, p < 0.05\) and \(r(16) = 0.76, p < 0.05\), respectively. The invariance of the defensive transition score estimated from the two divided groups of items was \(r(158) = 0.59, p < 0.05\).

[Table 2 near here]

The highest reliability coefficient was 0.92 at the defensive transition score -1.5. The range of defensive transition score with a reliability coefficient of over 0.8 was defensive transition score between -2.0 to -0.5, and its of over 0.7 was between -2.5 to 0.0.

Figure 2 is a scatter plot of the total test score and defensive transition score with TCC. The criterion-related validity shows \(r(158) = 0.97, p < 0.05\). The goodness-of-fit of the data to TCC was confirmed visually, as transition was plotted on the TCC.
Table 3 showed the result of a Kruskal-Wallis H test and it showed that the defensive transition score is significantly different in the results of defensive transitions ($H(2) = 28.16, p < 0.05$). Post-hoc Mann-Whitney tests with a Bonferroni adjustment were used to compare all pairs of groups. Defensive transition score in transition to press the opponent (Median = 0.25, IQR = 0.74) and the score in transition against the opponent possession attack (Median = 0.05, IQR = 1.57) were significantly higher ($p < 0.05$) than the score in transition against the opponent fast attack (Median = -1.94, IQR = 1.13).

The players’ position on the pitch during the transition was shown in figure 3. Figure 3 (right) showed the players’ position at the best defensive transition score. The defensive transition score was 1.33 and test score was 15 of 16 items. It showed that players in the defensive transition team close to the ball holder, with no free space for the opponent team. Figure 3(left) showed the players’ positions at the worst defensive transition score. The defensive transition score was -2.60 and test score was 0 of 16
items. The ball holder in the opponent team had plenty of space, and the defensive shape of the defensive transition team is very unbalanced.

[Figure 3 near here]
4. Discussions

4.1. Development of defensive transition items

The twenty-two transition items are developed from tracking data based on qualitative causal structure. Although previous studies use several items such as area of ball lost, the position of the defence line, time to recover the ball possession for measuring situation or outcome of defensive transition (Vogelbein et al., 2014; Casal et al., 2016), this study measures the defensive transition as tactical behaviour. This study investigates 22 items of 3 domains, “Approaching the ball holder”, “Marking the opponent players”, “Controlling DFL position”, of the defensive transition team play and 3 domains, “Escaping from defensive pressure”, “Transferring the ball forward”, “Breaking the opponents” of the opponents’ team play.

Transition moment is the most vulnerable moment for the defensive transition team (Tenga et al. 2010a; 2010b; Turner and Sayers, 2010; Hughes and Lovell, 2019). The approaching of the defender to the ball holder is a defence principle to delay the opposing progression (Wade, 1998; da Costa, 2009), and the defensive transition team enable to gain the time to re-structure defensive organisation (Wade, 1998). “Approaching the ball holder” for delaying, “Marking the opponent players” for the re-structuring the defence organisation in the ball-side, and “Controlling DFL position” for the re-structuring the defence organisation in the non-ball-side are following the
defence principles.

On the other hand, it is reported that speed up of the build-up (Turner and Sayers, 2010), the forward progression (Kempe et al., 2014; Hughes and Lovell, 2019), the breaking the opponents’ DFL (Frencken et al., 2011; 2012; Memmert and Lemmink, 2016) are important for counter-attacks for offensive transitions. The domains, “Escaping from defensive pressure”, “Transferring the ball forward”, “Breaking the opponents” of the opponents’ team play, are similar to the components of the counter-attack in the previous studies. The defensive transition team needs to control those domains of the opponent by their defence performance at their defensive transition. This study constructs the defensive transition items with the consideration of the opponent interaction based on qualitative causal structure.

Finally, the significance of this study is that the items are constructed from tracking data, measuring with CGS scales such as meter and kilometre, and those items are based on the qualitative structure of the defensive transitions. Although a limited number of studies measures speed (Turner and Sayers, 2010) or distance of movement of the offence team (Kempe et al., 2014), most of studies measures distance of 1st defender or distance of defence coverage, marking distance with categorical scale (Suzuki and Nishijima, 2004; 2005; Tenga et al., 2009; 2010a; 2010b; Lago-Ballesteros et al., 2012). This would bring deeper understanding of game
performance. Thus this study develops 22 transition items with satisfactory content validity from tracking data.

4.2. Success criteria of defensive transition items

The success criteria of items for a successful defence transition in the defensive transition team are performance standards. It is successfully converted the ratio scale items processed from tracking data to binary scale items that measure whether the items have been achieved. This binary scale data is an achievement pattern data of defensive transition play and it is possible to apply IRT for constructing the criterion-referenced test items (Matsuoka et al., 2020).

The success criteria of defensive transition for preventing the opponent counter-attack are analysed. For the item “v01 Distance of the 1st defender to the ball”, the 1st defender needed to be closer than 9.88m to the ball holder. Although this distance is farther distance compared to measurement criteria of categorical scale in previous studies (Suzuki and Nishijima, 2004; 2005; Tenga et al., 2009), most instances of defensive transition (93.7%) achieves this criterion and it can be considered to be an essential play of 1st defender. In another example, the success criterion of “v14 Ball direction” is the square pass or backward pass of the opponent. This means that the defensive transition team successfully prevents the opponent forward progression.
This supports the investigation of Hughes and Lovell (2019), as they note that a forward pass after turnover is crucial to successful counter-attacks.

It is necessary to note that the success criteria in this study are hard to generalise because the number of unsuccessful defensive transition was 10 plays. It is not applicable to the hold-out validation method. If the definition of successful defensive transition is changed to such as to refer to when the ball is gained from defensive pressure or from forcing a shot from a pressing defence, it might be possible to analyse with a hold-out validation given that the pressing style of defence has become popular in the J-league in 2021, along with the fact that the number of samples change. However, the pressing style of defence is not very popular in the J-league 2016, so the success criteria for defending opponent counter-attack is chosen. Therefore, further research is necessary to investigate the success criteria of defensive transitions with the hold-out validation; however, the findings in this study are still valuable given that the success criteria show the performance standard of defensive transition in the J-league throughout 2016.

4.3. Item characteristics and test characteristic of defensive transition items

Sixteen items of twenty-two items were selected via single factor analysis and IRT analysis. Estimated item parameters and a result of the goodness-of-fit test satisfies the accepted range of item parameters and the goodness-of-fit to the model. For
example, minimum value of item parameter a is 0.25, maximum value of item parameter b is 0.76, minimum value of it is -2.87, and minimum $p$-value of the goodness of fit test is 0.14. In addition, the invariance of the difficulty parameter and discrimination parameter are high and the invariance of the defensive transition score are moderates.

The criterion-related validity coefficient of the defensive transition score is significantly high, and the comparison of defensive transition score between the outcome of defensive transition shows a significant difference (Table 3). As Hughes and Lovell (2019) state that ball gain in the offensive third increases scoring opportunity, “Transition to press opponents” which forces the opposing team back to their third shows the highest defensive transition score. Figure 3 (right) shows players’ position at the transition with the highest score. It is interpreted that defence players pressed the ball holder. On the other hand, the lowest defensive transition score is for “the transition against the opponent fast attack”. Figure 3 (left) shows players’ position at the transition with the lowest score; no defenders is pressing the ball holder, and defensive organisation is very imbalanced. The defensive transition score reflects the pitch situation and makes it possible to interpret not only the defensive transition score but also the players’ position visually. Overall, the sixteen items are valid for the measurement of defensive transition.
4.4. Practical implications

Results of this study suggest that defensive transition skill is measured by the 16 criterion-referenced items of defensive transitions with the same performance standards with J-league. The defensive transition score (θ) and item parameters are estimated independently in IRT (Zhu and Yang, 2016). This is why sixteen defensive transition items enable to apply for any gender and age group to measure the achievement of defensive transition play as same standards as J-league level in 2016. However, it is required to analyse the success criteria if the pitch size (e.g. 8v8) or the definition of successful defensive transition is different from this study.

4.5. Limitations of research

There are at least three potential limitations concerning the results of this study. The first limitation concerns with the sample in this study because a sample in research should be selected randomly from population. This study used 158 defensive transitions at the offensive-midfield in the finals of J-league championship 2016 and this means the sample in this study was not selected randomly from all defensive transition plays in all soccer games. Further research is necessary by sampling from the soccer big data such as the data from all soccer games in the seasons.
The second potential limitation is the measurement items used in this study because the items should be properly selected in order to measure the construct of the defensive transition. This study developed the defensive transition items satisfying content validity by qualitative analysis. Tactical trends in professional soccer are continuously evolving (Wallace and Norton, 2014) and the measurement items of the defensive transitions might change in the future. Further research is necessary to renew the defensive transition items depending on the changes of transition tactics.

The third limitation concerns the statistical methods to develop reliable and valid measurement items. This study used IRT with two parameters logistic model and constructed reliable and valid defensive transition items for the criterion-referenced measurement of the defensive transitions. Further research is necessary to investigate the reliable and valid items with different assumption by using different statistical methods.

Although it is necessary to consider whether it would be possible to generalize the findings in this study within the limitations imposed on the research, this study successfully measured defensive transition play at the offensive-midfield from soccer game data based on the knowledge of soccer experts.
5. Conclusions

The purpose of this study was to develop criterion-referenced items of defensive transition in soccer games from tracking data and concluded as this study constructs 22 defensive transition items based on qualitative analysis processed by tracking data and 16 of them are criterion-referenced measurement items for defensive transitions.

Conflict of Interest

The authors declare that they have no conflict of interest in the authorship and publication of this contribution.

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Intermediate and Advanced Statistical Analyses for Sport and Exercise Scientists (pp57-77). Singapore: Wiley.
Table 1

Definition of transition items

| Teams | Transitions | No/Item name | Definition | Unit |
|-------|-------------|--------------|------------|------|
| Defensive Approaching to the ball holder | v01 | Distance of the 1st defender to the ball | Distance between the 1st defender and the ball | Meter |
| | v02 | Running speed of the 1st defender | Running speed of the 1st defender | Kms/h |
| | v03 | Angle between the ball and the 1st defender | Angle between the line connecting the ball and the defence team goal, Degree and the line connecting the ball and the 1st defender | |
| Marking to the opponent players | v04 | Number of defenders (5m) | Number of defenders positioned within 5m from the ball | People |
| | v05 | Number of defenders (10m) | Number of defenders positioned within 10m from the ball | People |
| | v06 | Marking distance to the opponent support player 1 | Distance from the nearest defender to the support player 1 | Meter |
| | v07 | Marking angle to the opponent support player 1 | Angle between the line connecting the ball and the 1st defender, and the Degree line connecting the ball and the support player 1 | Degree |
| | v08 | Marking distance to the opponent support player 2 | Distance from the nearest defender to the support player 2 | Meter |
| | v09 | Marking angle to the opponent support player 2 | Angle between the line connecting the ball and the 1st defender, and the Degree line connecting the ball and the support player 2 | Degree |
| Controlling defence line | v10 | Distance moved by defence line | Distance of the vertical movement of the defence line from the current ball action to the next ball action | Meter |
| | v11 | Speed of defence line | Distance moved by defence line divided by the time between the ball actions | Kms/h |
| | v12 | Width of defence line | Distance of the right sided defence line player and the left sided defence line player | Meter |
| | v13 | Variability of defence line | Standard deviation of vertical distance of defence line players | Meter |
| Opponent team | Escaping from defensive pressure | v14 | Ball direction | Definition of the Ball direction is following to Fernandez-Navarro et al. (2016). The ball direction is categorised as “forward”, “square”, or “backwards” directions. | |
| | v15 | Number of opponent players | Number of the opponent players positioned between the ball and the People defence goal | |
| Transferring the ball to forward | v16 | Distance moved by the opponent offence line | Distance of the vertical movement of the opponent offence line from the current ball action to the next ball action | Meter |
| | v17 | Speed of the opponent offence line | Distance moved by the opponent offence line divided by the time between the ball actions | Kms/h |
| | v18 | Distance moved of the opponent support player 1 | Distance moved by the opponent support player 1 from the current ball action to the next ball action | Meter |
| | v19 | Running speed of the opponent support player 1 | Distance moved of the opponent support player 1 divided by the time between the actions | Kms/h |
| | v20 | Distance moved of the opponent support player 2 | Distance moved by the opponent support player 2 from the current ball action to the next ball action | Meter |
| | v21 | Running speed of the opponent support player 2 | Distance moved of the opponent support player 2 divided by the time between the actions | Kms/h |
| Breaking the opponents' | v22 | Distance of defence line and opponent offence line | Vertical distance from the defence line and the opponent offence line | Meter |

Note. The 1st defender = the closest player to the ball in the ball-lost team, the defensive transition team; Defenders = the players in the defensive transition team; The support player 1= the closest non-ball holding player to the ball in the opponent team; The support player 2= the second closest non-ball holding player to the ball in the opponent team; The defence line = the closest defender to the defensive transition team goal; The defence line players = the defenders positioned within 6 meter from the defence line; The opponent players = the players in the opponent team; The opponent offence line = the closest player to the defence team goal in the opponent team.
### Table 2

Success criteria and item characteristics of transition items

| No Items | Criteria | Unit | Achievement Rate (%) | Difficulty (SE) | Discrimination (SE) | Goodness-of-fit test |
|----------|----------|------|-----------------------|----------------|---------------------|---------------------|
| v01      | Distance of the 1st defender to the ball | < 9.88 meter | 93.70 | -2.87 (0.81) | 0.65 (0.21) | 5.50 0.14 |
| v02      | Running speed of the 1st defender | <= 14.26 km/h | 75.90 | -1.40 (0.45) | 0.57 (0.16) | 6.30 0.62 |
| v03      | Angle between the ball and the 1st defender | <= 102.12 degree | 65.80 | -1.69 (0.72) | 0.25 (0.07) | 14.70 0.14 |
| v04      | Number of defenders (5m) | > 0.5 people | 72.80 | -1.39 (0.45) | 0.49 (0.13) | 8.30 0.41 |
| v06      | Marking distance to the opponent support player1 | <= 3.18 meter | 36.70 | 0.63 (0.24) | 0.62 (0.15) | 4.10 0.77 |
| v10      | Distance moved by defence line | > -3.59 meter | 86.70 | -1.13 (0.28) | 1.87 (1.26) | 0.00 1.00 |
| v11      | Speed of defence line | > -6.41 km/h | 89.20 | -1.43 (0.31) | 2.61 (1.84) | 0.20 0.90 |
| v12      | Width of defence line | <= 21.62 meter | 51.90 | -0.09 (0.23) | 0.55 (0.13) | 6.80 0.65 |
| v13      | Variability of defence line | <= 1.47 meter | 34.20 | 0.76 (0.25) | 0.62 (0.16) | 5.90 0.43 |
| v14      | Ball direction | Square, category Backward | 62.00 | -0.87 (0.42) | 0.37 (0.10) | 8.90 0.45 |
| v15      | Number of opponent players | > 2.5 people | 53.20 | -0.13 (0.20) | 0.74 (0.18) | 1.59 0.45 |
| v18      | Distance moved of the opponent support player1 | <= 7.33 meter | 78.50 | -0.96 (0.22) | 1.55 (0.51) | 3.30 0.50 |
| v19      | Running speed of the opponent support player1 | <= 13.18 km/h | 75.90 | -1.15 (0.38) | 0.75 (0.20) | 3.10 0.93 |
| v20      | Distance moved of the opponent support player2 | <= 9.73 meter | 83.50 | -1.16 (0.24) | 1.53 (0.50) | 1.80 0.77 |
| v21      | Running speed of the opponent support player2 | <= 22.95 km/h | 91.80 | -1.84 (0.35) | 1.24 (0.43) | 1.80 0.62 |
| v22      | Distance of defence line and opponent offence line | > 2.64 meter | 42.40 | 0.58 (0.43) | 0.32 (0.09) | 0.19 0.91 |

M: 68.39 -0.88 0.92 4.53 0.61
SD: 19.70 1.00 0.66 3.94 0.27
Max: 93.70 0.76 2.61 14.70 1.00
Min: 34.20 -2.67 0.25 0.00 0.14
Median: 74.35 -1.14 0.64 3.70 0.62
Table 3

Difference of ability score between defensive transitions

| Defensive transitions                          | Defense transition Score (median±IQR) | H(2) | p       |
|-----------------------------------------------|---------------------------------------|------|---------|
| Transition to press the opponent (n = 106)   | 0.25 ± 0.74a                          | 28.16| 0.00    |
| Transition against the opponent possession attack (n = 42) | 0.05 ± 1.57b                          |      |         |
| Transition against the opponent fast attack (n = 10) | -1.94 ± 1.13 ab                      |      |         |

Note. Median ± IQR with different subscripts differ at the p < 0.05 level with a Mann-Whitney U test with Bonferroni adjustment.
Figure 1.

Causal-effect (fish-bone) diagram of defensive transitions
Figure 2.

Test validity and goodness-of-fit of defensive transition items

Note. Each dot represents an individual defensive transition play. Defensive transition score is estimated from IRT 2PLM by 16 defensive transition items. TCC is a test characteristic curve of the 2PLM. Test score is a sum of achievement items of 16 items.
Figure 3

Positions of players at the best defensive transition play and the worst defensive transition play.

Note. This figure demonstrates the player position, a defensive transition score, a test score with the highest defensive transition score (right) and the lowest defensive transition score (left). In the highest defensive transition score, the players in the ball-lost team (dark circle) positions closer to the ball (black diamond) while in the lowest defensive transition score, no player (dark circle) positions around the ball (black diamond).
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Main Works
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Matsuoka, H., Tahara, Y., Ando, K., and Nishijima, T. (2020). Development of Defence and Offence Play Items for Deep Learning Model of Offence Play Analysis in Soccer Game. Football Science, 17: 69-85.
Membership in Learned Societies

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