Paper

Cross Validity and Factorial Validity of the Expanded Soccer Attacking Skill Scale (SASS)

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The purpose of this study was to examine the factorial validity and cross validity of an expanded soccer attacking skill scale (Expanded SASS) measured by the location of players in soccer games using multiple-group analysis by structural equation modeling. The samples were 388 attacking performances in the final of the FIFA World Cup Korea/Japan 2002™, the final of the 27th all Japan University Prime Minister's Cup, and the final of the 18th Japan Club Youth Football Championship which were measured by five-point interval scales by distance, and number of players. From the result of confirmatory factor analysis (CFA) that was constructed using one of the samples that were randomly split into two groups, the same model as was used in a previous study, except for an addition of correlated uniqueness, was accepted. The result of cross-validation by the other sample accepted the model with equality constraints of all parameters across samples. These results confirmed that the Expanded SASS was highly cross-validated. Nevertheless, there were two items that were interpreted as low factor loading; therefore, we need to add evidence of validity according to the intended use of the Expanded SASS.

Key words : Structural equation modeling, confirmatory factor analysis, multiple-group analysis, team skills

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1. Introduction

In order to design training programs that meet team performance goals, it is essential to ascertain team skill through the objective measurement of game performance. However, analysis of game performance until now has been limited to description and has failed to yield factorial explanations of game performance (e.g. Hughes, 1996). Therefore, the evaluation of team skill reflected in training programs has depended on the subjective judgment of coaches (Hughes & Franks, 1997).

From the viewpoint of training, methods used in the evaluation of team skills should be objective, rather than the subjective methods employed by coaches and specialists, and standardized for use by coaches. Hughes & Bartlett (2002) described the need to develop multidimensional qualitative indicators that are recognized by managers and coaches. In other words, in order to develop the indicators to measure overall team skill through performance, we need to clarify the structure of game performances that are recognized by coaches and specialists from the factorial viewpoint and identify the causal correlation of each factor.

The Soccer Attacking Skill Scale (SASS) developed by Suzuki & Nishijima (2002) is an indicator that satisfies the above-mentioned conditions. SASS evaluates attacking skill directly from performance in soccer games. Suzuki and Nishijima examined the reliability and factorial validity of this scale and confirmed the validity of 8 measurement items that explain 3 techniques associated with the attacking phase.

However, in conventional game performance analysis, attacking performances measured by SASS are limited to performances in which the last pass was kicked, regardless of whether shooting was attempted, and the ball is surrendered to the defending side. Therefore, during games hypothesizing that an attack has begun, the creating-space phase and the launching-of-attack phase are present, but attacking performances that fail to reach the breaking-up-defense phase were excluded from the object of measurement (see Footnote 1 for the definitions of each phase). For example, attacking performance in which the last pass is not passed to the attacking side due to the team's missed kick cannot be the object of measurement. Generally speaking, the attacking defined by many conventional studies (e.g., Takii, 1995; Yamanaka, 1994), including Wade (1967), indicates the state of ball possession. Therefore, SASS does not measure entire game performances that are generally defined as attacking performances.

Basing attacking skill measurements on only a part of the entire attacking performance exhibited during the game leads to systematic errors in evaluation. Measurement of unsuccessful attacking performances is also essential due to the deep correlation between points lost and balls lost at the middle third of the pitch prior to deep attacking toward the team's goal. Considering the use of the scale during the soccer coaching situations, this scale must enable the evaluation of not only the performances that have gone through the breaking-up-defense phase but also of the performances that did not go through the breaking-up-defense phase. Furthermore, samples used in the conventional study were 20 to 30 attacking performances. In the verification of changes in the attacking performances of teams for each game, the more attacking performances used for measurement in one game, the more the reliability of the estimation of team-attacking skill increases.

Messick (1989) recommended the collection of several pieces of evidence to confirm the validity of the test. SASS was designed in view of application to various age groups. Specifically for individuals in the junior-youth age group, coaching is conducted with a focus on development rather than on wining or losing. Therefore, SASS must enable the objective evaluation of the attacking skill of this age group. Suzuki and Nishijima (2002) applied SASS to teams participating in the Olympic Games and the conclusion was generalized within the range of the samples. Further examination of possible SASS application to the junior-youth age and other groups is also required.

The validity of SASS was examined by structural equation modeling. The validity of measurement items examined by structural equation modeling is emphasized by cross-validation (Cudeck & Browne, 1983). Specifically when a hypothesis model is corrected, whether the corrected model is data driven based on the samples used for the analysis or whether it is possible for the correction to be interpreted in general must be determined, and it is possible to generalize the results by conducting cross-validation using the different samples (Cudeck & Browne, 1983). When conducting reanalysis using different samples in the cross-validation procedure in conventional and typical factor analyses, a visual determination of the number of extracted factors and the similarities between factors and measurement items was used. As can be seen from Bentler's (1980) introduction of this method as *loose cross-validation*, this method fails to meet the statistical criteria for direct comparison; therefore, it is not accurate for cross-validation. When conducting group comparison after quantifying the construct as the linear coupling of measurement items, having differences of factor loading in each group means the estimated equations for quantification are different; therefore, it is impossible to compare with values obtained by the different estimate equations. MacCallum et at. (1994) showed cross-validation procedures based on statistic criteria by multi-sample analysis and introduced examination methods from the loose cross-validation level to visually confirm the replicability of the model to the tight cross-validation level whose estimated values are equal among groups. Applying this procedure makes it possible to examine accurate cross-validity. The purpose of this study was to examine the factorial validity and cross-validity of SASS with expanded attacking performance measurement objects (hereafter referred to as expanded SASS).

2. Methods

2.1 Samples

Targeted games were, in consideration of the need for coverage of a variety of age groups, the Brazil National Team (Brazil) and the Germany National Team (Germany) in the final game of the 2002 FIFA World

Cup Korea/Japan™, the Komazawa University Team (Komazawa University) and the Hannan University Team (Hannan University) in the final game of the 27th Prime Minister's Prize of the All Nippon University Soccer Tournament, FC Tokyo U-15 (FC Tokyo) and United Ichihara Junior Youth Maihama (JEF Ichihara) of the18th All Nippon Club Youth Soccer Championship. Collected data used in the analysis were 388 attacking performances, including 126 performances that reached shooting, and 262 performances that did not reach shooting or last pass. The attacking performance ratio of each team was as follows: 54 times by Brazil (13.9%), 83 times by Germany (21.4%), 73 times by Komazawa University (18.8%), 52 times by Hannan University (13.4%), 78 times by FC Tokyo (20.1%) and 48 times by JEF Ichihara (12.4%). When we divided the field into 3 areas (see Footnote 2), the occurrence rate of attacking performance was 30.2% in the Attacking Third, 51.3% in the Middle Third and 18.6% in the Defending Third. In addition, in the case of limiting the attacking performances to attacking that did not reach to shooting or last pass the occurrence rates were 23.3% in the Attacking Third, 53.4% in the Middle Third and 23.3% in the Defending Third.

2.2 Data collection

Images used for this analysis were of the Brazil vs Germany game broadcast by digital system over Communication Satellite (CS) on June 30th, 2002, the Komazawa University vs Hannan University game played at Nagai Stadium on July 13th, 2003 and the JEF Ichihara vs FC Tokyo game played at J Village Stadium on August 17th, 2003 recorded by digital video camera recorder (DCR-VX2100; Sony Corporation). The images included the balls used and all the players on the field of play.

2.3 Attacking performances targeted as the objects of measurement

The objects of measurement in the study by Suzuki & Nishijima (2002) were attacking performances that reached shooting or last pass; however, performances in which attacking ended before entering the breaking-up-defense phase and attacking in which the ball did not go to the defending side although the last pass was kicked at the breaking-up-defense phase were added to the measurement objects of this study. This made possible the measurement of performances which are generally defined as attacking performances.

2.4 Measurement methods

We followed the methods employed by Suzuki & Nishijima (2002) for the measurement of attacking performances that reach shooting or last pass. For the measurement of the attacking performances added to this study, we also followed the methods by Suzuki & Nishijima (2002) for items measured at the creating-space phase. The time points of 2 items measured at the launching-of-attack phase were a point when the attacking side was the closest to the defending side just before the ball was taken in cases that the ball was taken before the establishment of launching-of-attack phase, and we followed the existing measurement methods for cases in which the launching-of-attack phase was established. Two items measured at the breaking-up-defense phase were determined to be the lowest measurement value 1, regardless of cases of ending the attacking at the launching-of-attack phase. For cases in which the creating-space phase was established and the ball was taken before the establishment of the next breaking-up-defense phase, the time point when the attacking side was closest to the defending side before the ball was taken away was measured.

2.5 Expanded SASS analysis model

Fig. 1 is a reproduction of the initial model examined by Suzuki & Nishijima (2002). In a previous study, the error correlation of measurement items to this initial model was adopted as the final model. In this previous study, we evaluated the appropriateness of the correction from the tactical viewpoint of soccer; and in this study, we set the initial model as shown in Fig. 1 in order to examine the universality of the corrections statistically and confirmed the universality of the model correction. This study expanded the measurement objects for attacking performances to a greater degree than in the previous study. Selecting this model assures the validity of the attacking skill measurement utilizing these measurement items even when expanding the measurement objects.

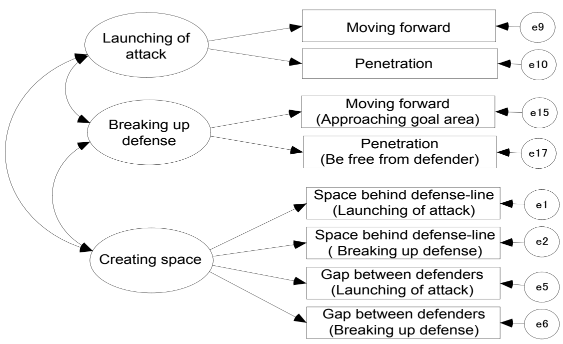


Figure 1 Initial model of Expanded SASS

2.6 Statistic analysis

We used the confirmatory factor analysis model to examine the factorial validity and cross validity of expanded SASS.

Two samples are required for the examination of cross validity. However, when only one sample is available, as in this case, it is recommended that the method of evaluating the cross validity by dividing the sample into two samples by random assignment be used (Conroy & Motl, 2003). Therefore, applying this method to this study, samples were randomly divided into 2 groups by select cases function of SPSS11.5J. One that was divided into two samples was set as the calibration sample (sample A) and used to establish the confirmatory factor analysis model of expanded SASS (separate analysis). The confirmatory factor analysis model finally adopted by utilizing sample A was determined as the baseline model for the examination of the cross validity of an expanded SASS.

The conformity of the model in the other randomized sample (cross-validation sample: sample B) was examined in a preliminary analysis of the multi-sample analysis for the examination of cross validity (Byrne, 1989). Examination of the cross validity was conducted by multi-sample analysis. Utilizing the procedures outlined by MacCallum et al. (1994) for cross validity by multi-sample analysis, the model was examined by the following procedures. In this case, the population is defined as 2 groups including sample A and B, and equality constraints are those between these samples: ① examining the equivalence of variance-covariance matrices; ② configural invariance model; ③ equivalent model of factor loading (partial cross-validation); ④ equivalent model of loading and factor covariances (partial cross-validation); ⑤ equivalent model of loading, factor covariances and error variances (partial cross-validation); and ⑥ equivalent model of all parameters (tight cross-validation).

Byrne (1989, p.127; 2001, p.175) suggested in his book that it is unnecessary to examine the equivalence of variance-covariance matrices. However, it is thought that the possibility of adopting the same model between groups will be shown for cases in which the examination is not rejected, and that such would serve as evidence to indicate the difference of the influence of its unique factor for cases in which the influence of the common factor is the same if it is rejected. Although this does not affect the determinate evaluation of variance, we added it to the analysis procedures in consideration of the possibility of its utilizing as data. SPSS11.5J and Amos 4.0J were used for statistical analysis, and the statistically significant level was set at 5%.

3. Results

Table 1 shows the descriptive statistics of samples which were randomly divided into two groups. On the distribution of each item, the kurtosis of sample A is between -1.40 and 0.15, skewness is between -1.06 and 0.76, the kurtosis of sample B is between -1.31 and 0.04 and skewness is between -1.11 and 0.45; therefore, no extreme deviation from the normal distribution was found. Multivariate kurtosis of Mardia showed 2.05 in sample A (C.R. = 1.13, $p > 0.05$) and 1.27 in sample B (C.R. = 0.70, $p > 0.05$), satisfying the conditions of the normal distribution of multivariate.

3.1 Separate analysis utilizing sample A

Table 2 shows the fitness of confirmatory factor analysis model utilizing sample A. Improper solutions with negative values (-0.14, standard error = 0.32) of error variance in moving forward were indicated in the initial model. The descriptive statistics of this measurement item showed that the absolute value of kurtosis was 1.40 and that this was the highest value among 8 items. It was found that influence on factor analysis (see Footnote 3) of univariate normality was greater in kurtosis than in skewness (Ihara & Matsuura, 1991). Therefore, in order to push the distribution of moving forward (in the launching-of-attack phase) (especially kurtosis) closer to the normal distribution, we conducted angular transformation by arcsine function as follows:

In the case that the value within root becomes 1, we used expedient ratio and used the following formula (Tanaka & Yamagiwa, 1992).

$$\text{Angular transformation value} = \sin^{-1}\sqrt{\frac{\text{value of data}}{\text{upper limit}}}$$

Upper limit is 5 because this case employs a 5-point scale.

$$\sin^{-1}\sqrt{\frac{\text{upper limit -0.25}}{\text{upper limit}}}$$

Confirming the improvement of kurtosis after angular transformation to -0.43 and reestablishing a model utilizing the angular transformed value, the proper solution was indicated; however, the model fit index did not satisfy the criteria of adoption. Finally, the model hypothesizing correlation of error terms whose content can be interpreted along with the modified index showed the highest fitness and all the fit indices of the model satisfied the criteria of adoption (Table 2).

Fig. 2 shows the standardized solution of the confirmatory factor analysis model utilizing sample A. Correlation in the initial model was added to error terms for the measurement items in the launching-of-attack phase and breaking-up-defense phase of each item measuring the space behind the defense-line and the gap between defenders that have the error correlation of the same measurement method. Correlation was also added to error terms (e1-e17) in penetration (be free from defender) and space behind the defense-line (launching-of-attack phase) that are not hypothesized in the model of Suzuki & Nishijima (2002). Meanwhile, error correlation (e1-e9) between moving forward and space behind the defense-line (launching-of-attack phase), error correlation of penetration and penetration (be free from defender) (e10-e17) and error correlation between penetration (be free from defender) and space behind the defense-line (launching-of-attack phase) (e5-e10) were excluded.

The difference in the results for path coefficient obtained by the previous study was as follows: the

Table 1. Descriptive statistics for 8 expanded SASS across ramdom samples

Item	Sample A (n = 194)			Sample B (n = 194)		
	Mean±SD	Kurtosis	Skewness	Mean±SD	Kurtosis	Skewness
Space behind defense-line (Launching of attack phase)	4.01 ± 1.28	-.07	-1.06	4.08 ± 1.31	-.22	-1.11
Gap between defenders (Launching of attack phase)	2.35 ± 1.33	-.59	.76	2.68 ± 1.41	-1.13	.42
Space behind defense-line (Breaking up defense	3.48 ± 1.44	-1.22	-.42	3.75 ± 1.38	-1.07	-.60
Gap between defenders (Breaking up defense	2.49 ± 1.21	-.52	.58	2.66 ± 1.36	-.98	.45
Moving forward[a]	3.48 ± 1.49	-1.40	-.42	3.53 ± 1.48	-1.31	-.43
Penetration	2.58 ± 1.11	-.62	.30	2.52 ± 1.10	-.53	.32
Moving forward (Approaching goal area)	3.38 ± 1.53	-1.31	-.36	3.45 ± 1.51	-1.27	-.43
Penetration (Be free from defender)	3.99 ± 0.85	.15	-.64	3.98 ± 0.84	.04	-.55

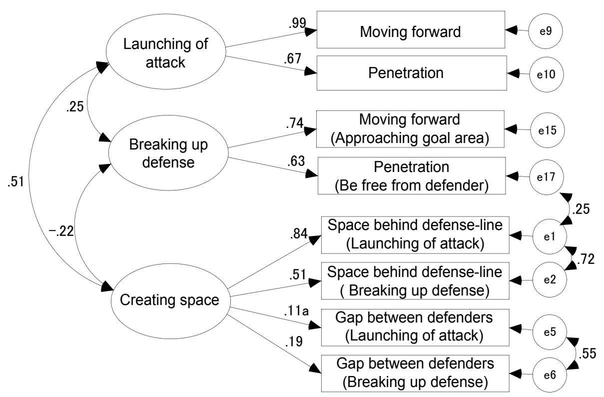
Note . a: The values after angular transformation were -.43 (kurtosis), -.94 (skewness) for sample A, and -.24 (kurtosis), -.99 (skewness) for sample B.

Table 2. Fit indices of three models in sample A

Model	χ^2	*df*	AGFI	TLI	CFI	RMSEA	90% CI	AIC
Initial[a]	90.269	17	.803	.748	.847	.149	.120 - .180	128.269
Angular transformation	90.300	17	.803	.747	.846	.149	.120 - .181	128.300
Angular transformation and add correlation[b]	15.764	14	.951	.993	.996	.026	.000 - .076	59.764

Note. AGFI = adjusted goodness of fit index; TLI = Tucker and Lewis index; CFI = comparative fit index; RMSEA = root mean square error of approximation; 90% CI = 90 percent confidence interval for RMSEA; AIC = Akaike information criterion.
a Improper solution.
b The correlated uniquenesses posited were e5-e6, e1-e2, and e1-e17 (Final model).

correlation between laundhing-of-attack skill and breaking-up-defense skill was low at 0.25; the correlation between creating-space skill and breaking-up-defense skill showed a change from a positive value to -0.22; path coefficients for 2 items measuring the gap between defenders among the measurement items of creating-space skill showed lower than 0.40, the general standard level of the validity of the test utilizing factor analysis showing 0.11 path coefficient for the gap between defenders (launching-of-attack phase) and 1.9 path coefficient for the gap between defenders (breaking-up-defense phase) (Fig. 2).



χ^2 = 15.764, p = .328 (df = 14) AGFI = .951 CFI = .996 TLI = .993
AIC = 59.764 RMSEA = .026(90% CI = .000-.076)
Note. All path coefficients were significant except for a(p < .05).

Figure 2. Final model of confirmatory factor model of Expanded SASS in Sample A

3.2 Cross validity of expanded SASS

Table 3 shows the examination results of the cross validity of the confirmatory factor analysis model in sample A and B. We examined the model fit index of sample B in the final model selected by analysis utilizing sample A prior to multi-sample analysis. As is the same with sample A, measurement items of moving forward were angular-transformed in advance. As a result, a model identical to sample A satisfied the criteria for adoption. Then, simultaneous analysis between samples A and B was conducted utilizing this model (Fig. 2), and it showed that all the models from the least limited model to the most limited model showed the appropriate solution and high model fitting that satisfy the criteria of adoption as models. The absolute evaluation index of the model showed the highest value for the M_{LCU} model that adjusted all the values equally between samples, with the exception of error correlations. AIC, a model comparison index, showed the lowest value in the model all of whose population parameters were adjusted equally between samples (M_{ALL}), and there was no significant difference seen in the chi-square values between 2 models.

4. Discussions

Suzuki & Nishijima (2002) confirmed the factorial and cross validity of SASS. However, the problems regarding to existing SASS measurement methods were

Table 3. Fit indices of confirmatory factor analysis model for cross-validation across random samples

Model	χ^2	*p, df*	AGFI	TLI	CFI	RMSEA	90% CI	AIC
Sample B	25.876	.056, 14	.924	.965	.983	.062	.011 - .102	68.229
M_F : same form across random samples								
	39.993	.066, 28	.937	.977	.989	.033	.000 - .055	127.993
M_L : same factor loading across random samples								
	45.716	.129, 36	.944	.986	.991	.026	.000 - .047	117.716
M_{LC} : same factor loading and factor covariance across random samples								
	46.741	.184, 39	.948	.990	.993	.023	.000 - .044	112.741
M_{LCU} : same factor loading and factor variance/covariance across random samples								
	50.840	.325, 47	.953	.996	.996	.015	.000 - .037	100.840
M_{ALL} : same all across random samples								
	56.697	.239, 50	.952	.993	.994	.019	.000 - .039	100.697

Model comparisons	χ^2_{diff}	df_{diff}	*p*
M_L - M_F	5.723	8	*ns*
M_{LC} - M_L	1.025	3	*ns*
M_{LCU} - M_{LC}	4.099	8	*ns*
M_{ALL} - M_{LCU}	5.856	3	*ns*

Note . AGFI = adjusted goodness of fit index; TLI = Tucker and Lewis index; CFI = comparative fit index; RMSEA = root mean square error of approximation; 90% CI = 90 percent confidence interval for RMSEA; AIC = Akaike information criterion; Test of variance/covariance homogeneity across groups: χ2(36) =22.723, p >.05.

that the measurement objects did not cover all attacking performances and that the number of samples obtained for 1 game was insufficient. Therefore, confirming that the expanded SASS has a similar structure to SASS increases the utility value of SASS at actual soccer performances. Confirming the cross validity of the SASS model in the samples obtained by expanding the measurement object of attacking performances also assures the generalization of measurement objects for SASS application.

The structure of the confirmatory factor analysis model utilizing sample A obtained by randomly dividing all samples into two groups showed different results of analysis in error correlation from the previous study. In the previous study, 3 error correlations were hypothesized including the error correlation between moving ahead and space behind defense-line (launching-of-attack phase) (e1-e9), the error correlation between penetrations (be free from defender) (e10-e17) and the error correlation between penetration and gap between defenders (launching-of-attack phase) (e5-e10); however, the model added the error correlation between penetration (be free from defender) and space behind defense-line (launching-of-attack phase) (e1-e17) was selected as a final model. Although Suzuki & Nishijima (2002) suggested that the reason the error correlations of e1-e9, e10-e17 and e5-e10 were added was because the attacking third accounts for a high proportion, it is thought that the rate of the attacking third of all samples used in this study was 30.2% and lower than that of the samples in the previous study (44.4%); therefore, error correlations were not added.

The reason that e1-e17 were newly added is related to the fact that analysis of the correlation between breaking-up-defense skill and creating-space skill showed a positive value in the previous study; however, it changed to a negative value (-0.22) in this study. The change in value from positive to negative indicates that the more the space is created, the more it becomes difficult to initiate a launch of attack, and this does not match with the actual situation in games. However, I suspect that the increase in the rate of the attacking performances that started at the defending third and the change of the measurement methods were both related to the change of value from positive to negative as a result the decrease in the rate of the attacking third and the increase in the rate of the defending third in this study compared with the previous study whose samples were limited to the attacking performances that did not reach shooting or the last pass.

When attacking from the defending third (backcourt), the defense line of the opposing team is inevitably located around the center line, and the space in the back expands. When attacking from the offense side backcourt, long passes are often used in order to move into the attacking third. Long passes have a higher chance of being intercepted by the defense side than do short passes. Passes intercepted by defenders were not included in samples in the existing measurement method; however, they are included in samples in this study, extending the range of the object of measurement. When the passes are intercepted by defenders, the measurement item in the breaking-up-defense phase should be 1, the lowest value. These facts are thought to have had an influence on the change of the value from positive to negative. It is also thought that the positive correlation matching with the actual situation in games revealed in the results of analysis of the previous study appeared complementarily as the error correlation (0.25) between penetration (breaking-up-defense phase) for measuring the breaking-up-defense skill and space behind defense-line (launching-of-attack phase) for measuring the creating-space skill.

Furthermore, I suspected that setting the measurement value in the breaking-up-defense phase to 1 when the passes are intercepted by defenders has an influence on the lowering of the correlation coefficient between laundhing-of-attack skill and breaking-up-defense skill. The last point of difference from the results of the analysis in the previous study is that the path coefficients of 2 items of the gap between defenders to measure the creating-space skill were below 0.04, which is used as a value to indicate the validity of the test utilizing factor analysis. The result shows that the items are not appropriate for measuring the creating-space skill. However, when considering the actual situation of games, the low factor loading is quite understandable. It is effective for creating the space necessary for the success of launching-of-attack and breaking-up-defense not only to create the space behind the defense-line but also to pull out defenders from the danger area in front of the goal (Wade, 1967).

In order to pass the ball to the danger area in front of the goal, passing the ball to the space behind the defense-line is more effective than creating a gap between defenders through the attacking performances from the defending third. It is required to pass the last pass to the space behind the defense-line as soon as possible, decreasing the time between intercepting the ball and kicking the goal in order to break the highly organized defense, especially in the current attacking styles in soccer (JFA, 2002). In other words, while the attacking performances from the defending third tend to cause larger variance in measurements of creating space behind defense-line, the variance in measurement of creating gap between defenders decreases. It is thought that most of the attacking performances from the defending third show certain values. Therefore, in this study, using more samples of the attacking from defending third than in the previous study, the path coefficients of 2 items of creating-space skill and creating gap between defenders show low values.

Results obtained from the randomly selected sample A satisfied the criteria of adoption until the equivalent models of all parameters were adjusted equally by cross-validation with randomly selected sample B. In the absolute criteria index of the model, the equivalent models of all parameters except error correlation showed the highest fit index. Although there was no significant difference of the model fit seen in chi-square values, it showed there were few differences in error correlations. However, when comparing attacking performances between samples by SASS, the measurements do not change and the relations between factors satisfy the equality level, therefore, such differences are rendered insignificant.

However, error correlation in the confirmatory factor analysis model has relations similar to the influence of factors on measurement items. Originally in the position of developing scales for measurements of construct and capability, it is necessary to measure different factors in each item and construct by as small a number of items as possible in order to measure each concept comprehensively due to the possibility of items with strong relations measuring the same factors. Therefore, it is desirable to have fewer common traits (correlations) with the exception of the common parts of the construct of each item. However, SASS for the measurement of the attacking performance is obtained from game performance. Game performances are revealed as a result of interaction with an opposing team; therefore, many factors are intricately involved (Lees & Nolan, 1998). Furthermore, as is mentioned above, error correlations show the factors involved in measurement methods and the characteristics of samples. Therefore, it is thought to be possible to measure attacking performances without overestimating the level of influence of lower-level performance to measurement items by expressing these factors as error correlations.

The expansion of attacking performance measurement objects revealed certain points to be considered in the application of SASS. When expanding the range of the use of the test, generally cross-validation is conducted due to the specificity of the validity coefficient to the condition in which the coefficient is obtained (APA et al., 1974, p.36). In this study, validity coefficients, which are here referred to as path coefficients, of 2 items for measuring the gap between defenders dropped to lower values by the expansion of the objects of measurement. A disproportionate emphasis should not be placed on situational specificity and universalization (generalization) of the validity should not be limited to increase the validity coefficients (Messick, 1989). Although the elimination of the items with low validity coefficients was also taken into a consideration, lowering the validity coefficient values was an extremely understandable change. It was the change in the validity coefficients of 2 items for measuring the gap between defenders by the areas where attacking started. Concepts of situational specificity and generalization are incompatible. However, it is possible to utilize the benefit of each concept through the usage of the scales.

For example, in the case of evaluating by specializing each game, it is required to establish a model for each area where attacking starts utilizing the findings of this study. However, in the case of comparing the average skills between the groups that have similar distributions of the areas where attacking started, it is possible to analyze utilizing general models. In addition, from the viewpoint of mathematical statistics, models with only 2 items for each factor tend to yield unstable solutions due to problems of identification (Anderson & Rubin, 1956; Kano, 2002) (see Footnote 4).

Considering the above, I adopted a model retaining items with low path coefficients. Furthermore, generalization of the model could be assured by confirmation of the cross-validity of the model. However, because there are some items that do not satisfy the general standards of factorial validity, discussion and an examination of validity corresponding to the purpose of the use of an expanded SASS are necessary.

In consideration of the above, except 2 items for measuring creating-space skill, expanded SASS with the expanded attacking performance measuring objects has high factorial validity and shows non-changing basic-level skills in different groups. Therefore, it is thought that the expanded SASS can be adapted to different groups and has high cross-validity.

5. Conclusion

This study was conducted for the purpose of examining the factorial validity and cross-validity of SASS whose objects of measurement for attacking performance were expanded (expanded SASS), and the following results were obtained:

1) Except 2 items for measuring creating-space skill, expanded SASS with the expanded objects for measurement for attacking performance has high factorial validity and shows non-changing basic level skills in different groups. Therefore, expanded SASS can be adapted to different groups and has high cross-validity.

Footnote

1: Suzuki & Nishijima (2002) constructed attacking performances with 3 phases: creating-space phase, launching-of-attack phase and breaking-up-defense phase. The three phases are defined as follows: creating-space phase is defined as the time from when the member of the team receives the ball after stealing the ball from the other team and passes the first pass until the time when the person possessing the ball dribbles toward penetration to the goal line of the other team by leaving defenders behind, or until the time immediately before starting the vertical pass; the launching-of-attack phase is defined as the time from when creating-space phase has been completed until the time immediately before the last pass, including crossing pass and wall pass, is kicked; the breaking-up-defense phase is defined as the time from when the last pass is kicked until the time when kicking the goal, or when the last pass is kicked and the ball goes to a member of the kicker's own team without reaching the point of kicking the goal.

2: Among 3 areas divided by 2 parallel lines to the goal line, 1/3 in the other team goal is called the attacking third, 1/3 in one's own team goal is called defending third, and the middle part is called middle third (Worthington, 1980).

3: Strictly speaking, it is the influence on estimation error of estimation of exogenous variance and estimation of factor loading.

4: In the references cited here, the indefiniteness of the solution in exploratory factor analysis was discussed; however, the meaning of the indefiniteness of the solution is the same as in confirmatory factor analysish.

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