ORIGINAL ARTICLE

Appropriateness of setting kick scoring impact by taekwondo certified Protector and Scoring Systems: comparison of difficulty of male and female weight class applying Rash model

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background and Study Aim: The tools used in sports games (competition training) are one of the important factors for the athletes and leaders who perform the games and combat sports because they have a direct relation to the athletic performance of the athletes as well as the results of the games. The purpose of this study was the knowledge about the appropriateness of setting the kick impact of taekwondo Protector and Scoring Systems (PSS) by calculating and comparing the difficulty level of the kick scoring impact setting for each weight class of men and women.

Material and Methods: Specifically, kick impact of men's (n = 104) and women's (n = 84) 10 weight classes (men: 104 games; women: 84 games) of the 2018 Jakarta Asian Games was used to confirm the difficulty level of the kick scoring impact setting for each weight class. When the difficulty of Rash model was calculated using Excel and Winsteps 3.65.0 software, differential item functioning was applied to check the difference in difficulty level by weight class.

Results: First, comparing the difficulty of setting the kick scoring impact of each weight class, −68kg showed the highest difficulty and −80kg showed the lowest difficulty in men's group. In women's group, the difficulty was the highest at −49kg and the lowest at +67kg. Second, comparing the difficulty of setting the kick scoring impact difference of each weight class, in the male group, there was a difference between every weight classes except −80kg and +80kg. Also, the difference was found between two weight classes (−53kg and −57kg, −57kg and −67kg) in the women's group.

Conclusions: The calculated kick impact by weight class is similar and that the difference in difficulty level of setting the kick scoring impact exists has been confirmed. Therefore, this can be used as meaningful information to activate Taekwondo PSS. However, in this study, there are limitations that only the results of the appropriateness were calculated without providing the standard of setting the kick scoring impact. Also, the result can be interpreted to be limited to a specific country or region by the fact that only the data from Asian Games were used. Therefore, future studies will be able to produce more meaningful results by analyzing and using the PSS data applied at the World Championships or the Olympic Games.

Keywords: combat sports • performance • subjective judgement

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Athlete – *noun* **1.** someone who has the abilities necessary for participating in physical exercise, especially in competitive games and races **2.** a competitor in track or field events [17].

Competition training – *noun* athletic training that specifically prepares the athlete for the competition situation [17].

Game – *noun* **1.** a sporting or other activity in which players compete against each Rother by following a fixed set of rules **2.** an occasion when a competitive game is played **3.** in sports such as tennis, a subsection of play that goes towards making up a set or match **4.** the total number of points needed to win a contest [17].

Kick – *verb* **1**. to strike a ball with the foot **2.** to strike something or somebody with the foot, e.g. in martial arts **3.** to make a thrashing movement with the legs, e.g. when fighting or swimming **4.** (*in cricket*) to bounce up high and quickly [17].

Kick – *noun* **1.** a blow with the foot, e.g. in martial arts **2.** a thrashing movement with the leg when swimming **3.** the striking of a ball with the foot [17].

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [17].

INTRODUCTION

In the field of sports, various tools are applied to the competition according to the characteristic of each sport. The tools used in sports games (competition training) are one of the important factors for the athletes and leaders who perform the games and combat sports because they have a direct relation to the athletic performance of the athletes as well as the results of the games. Accordingly, the tools being used in sports games are being continuously studied and developed to enhance the fairness and objectivity of the field.

Especially, for the taekwondo, which is one of the sports events, Protector and Scoring System (PSS) was developed as a scoring system to perform a fair game, and it has been introduced since 2007 (the official World Taekwondo Federation competition) [1]. In the existing taekwondo competition, fairness was discussed as the criterion of the decision was not clear in such a way that the person(the referee) calculates the score based on the subjective judgement [2]. The World Taekwondo has developed and introduced the PSS as one of the methods to ensure the objectivity and fairness of the judgement since fairness appeared to be essential for sports games.

In the taekwondo competition, PSS is a system that sets the scoring criteria according to the impact of the kick in advance by men's and women's weight classes, and the score is calculated by hitting the scoring area with the kick impact higher than the set impact [3]. At this time, the kick scoring impact is set to be higher when the weight class is higher. This method has been used as a tool with more objectivity in calculating.

Although the introduction of PSS in taekwondo competition is contributing to the development of taekwondo as a part of the global sport, on the other hand, there are also negative aspects. In the prior research, the introduction of the PSS has raised the problems of the technical degeneration of the kicks, the PSS error [4], and the setting of the kick scoring impact according to manufactures approved by the World Taekwondo Federation [5]. Especially, it is necessary to set the scoring impact of PSS more carefully as one of the important factors in evaluating the performance of athletes.

However, two questions can be raised in setting the kick scoring impact of PSS currently applied. First, it is setting off the kick scoring impact based on subjective judgement. Currently, the World Taekwondo Federation is determining whether the player scores by arbitrarily setting the kick scoring impact [6]. Since the kick scoring impact is set by subjective judgement, it is necessary to set the kick scoring impact by providing an objective basis to the players and the leaders. Second, is the interval of the setting the kick impact according to the weight class. In the PSS, the higher the weight class, the higher the core of the kick scoring impact, but there is no consistency in the setting interval. For example, in the case of male's −58kg, the scoring criterion, according to the PSS is 18 level, −63kg: 20 level, −68kg: 21 level. Despite the same 5kg difference, the difference between −58kg and −63kg is 2 level, while the difference between −63kg and −68kg is 1 level. This may raise the questions about setting the kick scoring impact.

The research on the validity and reliability of the PSS [7, 8], sensors of the PSS area [9, 10] and a study on PSS satisfaction [11, 12] have been reported until now. However, one of the problems of the PSS is that there is a shortage of research on the setting of the kick scoring impact.

Therefore, in order to verify the appropriateness of the setting of kick scoring impact in taekwondo PSS, a comparative analysis was conducted by calculating the difficulty of setting the kick scoring impact for each weight class. In order to specifically verify the difficulty of setting the kick scoring impact for each weight class, the difficulty was calculated using the kick impact of 10 weight classes of male and female from Asian Games in Jakarta, 2018. By doing so, the difficulty of setting the kick scoring impact of which weight class is high and low was confirmed.

The purpose of this study was the knowledge about the appropriateness of setting the kick impact of taekwondo PSS by calculating and comparing the difficulty level of the kick scoring impact setting for each weight class of men and women.

MATERIAL AND METHODS

Participants and Research Data

The main research task was to compare the difficulty level of each weight class in order to confirm the appropriateness of the PSS scoring impact of taekwondo. For this procedure, data on the PSS kick impact of each weight class were collected using the 2018 Jakarta Asian Taekwondo

Competition. Specifically, PSS impact calculated from 5 men's weight classes (total male athletes 104): −58kg 24 games, −63kg 25 games, −68kg 21 games, −80kg 20 games, +87kg 14 games and 5 women's weight classes (total female athletes 84): −49kg 16 games, −53kg 17 games, −57kg 19 games, −67kg 15 games, +67kg 17 games were collected as a research material.

Data acquisition procedure

In this study, PSS kick impacts applied in the 2018 Jakarta Asian Taekwondo Games were used as research data. Records of KP&P PSS kick impacts were provided from the Asian Taekwondo Federation and KP&P Company as a research data. PSS of KP&P is a company that has signed a public service contract with the World Taekwondo Federation (official contract on October 23, 2012), which is being used as an official PSS in taekwondo competitions.

The data for taekwondo PSS impact was classified according to the scoring (when striking with the kick impact above scoring criterion) and valid strike (when striking with the kick impact below scoring criterion) according to the scoring impact standard of each weight classes (men's −58kg 18 level, −63kg 20 level, −68kg 21 level, −80kg 23 level, +80kg 25 level, women's 49kg 16 level, 53kg 17 level, −57kg 18 level, −67kg 20 level, +67kg 22 level).

For example, in the case of −58kg, if the kicking impact is 18 level, the score is recorded. If the level is 17, it is recorded as a valid strike. Besides, in order to calculate the difficulty level for setting the kick impact of PSS by weight classes, the frequency of occurrence of kick impact by weight classes was equalized.

The weight class with the least occurrence frequency was set as a standard (men's +80kg 264 times, women's −49kg 174 times) because he frequency of PSS kick impact occurrence has different limit point according to the weight classes.

Data processing method

In this study, Excel 2013 was used to calculate the frequency and percentage of valid strike and scoring, percentage based on the PSS kick impact of each taekwondo weight classes. Also, the Rasch model was applied to calculate the difficulty of PSS kick impact of each weight classes. The Rasch model is generally used to estimate the difficulty of the item and whether the ability of the subject is high or low [13]. In this study, the Rasch model was applied to determine whether the difficulty of setting a PSS kick impact is high or low according to the weight classes. For the difficulty calculation, the valid strike is recorded 0, and the scoring is recorded 1, and it can be interpreted that the higher the difficulty value (logit), the lower the difficulty level of setting the standard of kick scoring impact. Also, in order to check the difference of difficulty of the PSS scoring impact by weight class, the differential item functioning was applied. The formula to verify the difference of scoring difficulty is as follows.

A formula 1 is for verification the difference of difficulty based on PSS kick impact by weight class [14, 15], and "d" calculated from the formula is verified by the z distribution ("d" value was more than ±1.96 in the 95% confidence, and it was considered to be statistically significant difference [14]). Excel 2013 and Winsteps 3.65.0 software were used to test difficulty calculation and difference of difficulty, and statistical significance level was set to .05.

$$\Delta\hat{b} = \widehat{b_F} - \widehat{b_R}$$

$$S_{\Delta\hat{b}} = \sqrt{S_F^2 + S_R^2}$$

$$d = \frac{(\acute{b_f} - b_r)}{SE_{(b_f - b_r)}} = \frac{\Delta\hat{b}}{S_{\Delta\hat{b}}}$$

$\Delta\hat{b}$= difference in difficulty value between group 1 and group 2
$S_{\Delta\hat{b}}$= standard error for $\Delta\hat{b}$

RESULT

Analysis of taekwondo PSS scoring and valid strike according to weight class

A result, −63kg (116 times, 43.9%) showed the highest in the scoring frequency, and +80kg (222 times, 84.1%) showed the highest frequency in a valid strike. The scoring frequency showed relatively low in the high weight classes (−80kg, +80kg) in the men's PSS scoring frequency (Table 1).

A result, −49kg (82 times, 47.1%) showed the highest in the scoring frequency, and +67kg (145 times, 83.3%) showed the highest frequency in a valid strike. The scoring frequency also showed relatively low in the high weight classes (−67kg, +67kg) in the women's PSS scoring frequency (Table 2).

Table 1. Analysis result of scoring and valid strike frequency of men' s (n = 104) weight classes.

Weigh classes	Scoring(%)	Valid strike(%)
−58kg	99 (37.5)	165 (62.5)
−63kg	116 (43.9)	148 (56.1)
−68kg	93 (35.2)	171 (64.8)
−80kg	79 (29.9)	185 (70.1)
+80kg	42 (15.9)	222 (84.1)

Table 2. Analysis result of Scoring and valid strike frequency of women's (n = 84) weight classes.

Weight classes	Scoring(%)	Valid strike(%)
−49kg	82 (47.1)	92 (52.9)
−53kg	57 (32.8)	117 (67.2)
−57kg	79 (45.4)	95 (54.6)
−67kg	36 (20.7)	138 (79.3)
+67kg	29 (16.7)	145 (83.3)

Analysis of difficulty of setting taekwondo PSS kick impact by weight classes

A result, the highest difficulty value was calculated at −68kg (logit 0.77) and the lowest at −80kg (logit −0.51) or men. In other words, it can be interpreted that the criteria for setting the PSS scoring impact in the −80kg are set to be relatively high than the −68kg (Table 3).

For women, the highest difficulty value was calculated at −49kg (logit 0.86) and the lowest at +67kg (logit −1.00) or women. It was confirmed that the difficulty rankings were low in the high weight classes for both men and women. In addition, it can be interpreted that the higher the weight class for women, the higher the standard for setting the kick scoring impact (Table 4).

Table 3. Difficulty result of setting the Taekwondo PSS kick impact of men's (n =104) weight classes.

Weight classes	Logit	S.E	Logit Rank
−58kg	0.43	0.15	2
−63kg	−0.30	0.16	3
−68kg	0.77	0.15	1
−80kg	−0.51	0.17	5
+80kg	−0.38	0.16	4

Note: the higher the logit value, the lower the difficulty of 'the PSS kick impact setting standard value'

Table 4. Difficulty result of setting the taekwondo PSS kick impact of women's (n = 84) weight classes.

Weight classes	Logit	S.E	Logit Rank
−49kg	0.86	0.18	1
−53kg	0.76	0.18	2
−57kg	0.07	0.18	3
−67kg	−0.69	0.20	4
+67kg	−1.00	0.22	5

Note: the higher the logit value, the lower the difficulty of 'the PSS kick impact setting standard value'

Analysis of difficulty difference (DIF) of a setting criterion of PSS kick impact

There was no statistically significant difference between −80kg and +80kg (d = −0.557) in the male part by analyzing the difficulty difference of setting the standard of taekwondo PSS kick impact by weight classes. Moreover, there was a statistically significant difference in the difficulty level between the weight class of −58kg and −63kg (d = 3.329), −68kg and −80kg (d=5.646). In the female group, there was no statistically significant difference between the two weight classes (−49kg and −53kg (d = 0.393), −67kg and +67kg (d=1.043). On the other hand, there was a statistically significant difference in difficulty level between the weight classes of −53kg and −57kg (d = 2.711), −57kg and −67kg (d = 2.825) (Table 5).

DISCUSSION

In the taekwondo competition, setting a PSS kick impact is one of the significant tools for evaluating the performance of athletes. The setting of PSS kick impact is a criterion for determining whether to score or not, which directly affects the win or loss of the game. Therefore, in this study, the difficulty level of each weight class was analyzed using the 2018 Jakarta Asian Taekwondo Competition to confirm the appropriateness of the criteria for setting the PSS kick impact.

First, as a result of analyzing the frequency of scoring and valid strike according to the male and female weight, both male and female showed low scoring in the heavyweight class. Also, the analysis of difficulty showed that the difficulty setting the kick scoring impact was found to be high in heavyweight class (male −80kg, female +67kg) similar to frequency analysis. Through these results, it can be judged that the PSS kick impact of heavyweight class (male −80kg, +80kg, female −67kg, +67kg) was set to be relatively higher than the lightweight class (male −58kg, −63kg, −68kg, female −49kg, −53kg, −57kg) in taekwondo competition.

In addition, as a result of confirming the difficulty difference of setting the kick scoring impact by the weight classes, it was found that there was a difference in difficulty level between every male weight classes except the class of −80kg and +80kg. For female, a difference in difficulty level was shown between the two classes except for −49kg and −53kg, −67kg and +67kg. This can be interpreted that regarding the setting of kick scoring impact, the difference in difficulty exists according to the weight class, so it is necessary to reaffirm the setting of kick scoring impact. In the previous study, it has been reported that the kick scoring criteria should be reset, citing problems with setting the kick scoring impact by weight class [6].

On the other hand, if we look at the kick scoring impact of men's weight classes, there is a gap of 7 levels, ranging from at least 18 level (−58kg) to a maximum of 25 level (+80kg). However, it is interesting to note that by analyzing the average PSS kick impact by weight class, there is no significant difference in the average kick impact by weight class according to the result of 18.4 level at −58kg, 18.7 level at +80kg (utilization of materials from Jakarta Asian game 2018). In other words, despite the fact that the kick scoring impact was set considering the weight class, it is suggested that there is no big difference in kick impact average between lightweight class and heavyweight class. In general, it is predicted that the higher the weight, the higher the kick impact would be calculated. However, as a result of analyzing the actual data, the kick impact was similar regardless of the weight class.

Table 5. Result on difficulty difference (DIF) of setting criterion of PSS kick impact.

Men (n = 104)			Women (n = 84)		
Weight classes		**d**	**Weight classes**		**d**
−58kg	−63kg	3.329*	−49kg	−53kg	0.393
−63kg	−68kg	−4.879*	−53kg	−57kg	2.711*
−68kg	−80kg	5.646*	−57kg	−67kg	2.825*
−80kg	+80kg	−0.557	−67kg	+67kg	1.043

*p<0.05

This phenomenon can be explained by the change of the scoring method to perform the scoring in taekwondo competition. In past competitions, the scoring was judged by the sound and sight of the strike, which means 'how accurately and strongly strike' [16]. Therefore, most taekwondo athletes generally performed strong kicks to gain scores. However, with the introduction of PSS, the importance of hitting the scoring area accurately through the kick has increased, rather than performing the scoring through the strong kick. In the case of PSS, it has the characteristic that it is recognized as scoring when striking above the standard of kick scoring impact because the importance weighs on the accurateness of striking the scoring area rather than strength. Then, the kick impact appears to be similar regardless of weight class.

CONCLUSIONS

The calculated kick impact by weight class is similar and that the difference in difficulty level of setting the kick scoring impact exists has been confirmed. Therefore, this can be used as meaningful information to activate taekwondo PSS. However, in this study, there are limitations that only the results of the appropriateness were calculated without providing the standard of setting the kick scoring impact. Also, the result can be interpreted to be limited to a specific country or region by the fact that only the data from Asian Games were used. Therefore, future studies will be able to produce more meaningful results by analyzing and using the PSS data applied at the World Championships or the Olympic Games.

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