Chapter 6

Stages of Technological Development in Taekwondo

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Abstract

One of the popular Olympic branches today is taekwondo. Electronic body protection systems (EBP) have undoubtedly contributed greatly to this population growth. The present study aims to review the scientific studies on electronic body protection systems and scoring used in taekwondo. The study is prepared in a compilation format. The journals in Web of Science databases were searched by using the keywords "taekwondo" and "electronic system" and "score" together. While determining the articles, no restrictions such as review, meta-analysis, research article, or year of the research were applied. However, papers were not included in this study. A total of 10 articles that met the specified conditions were analyzed. It can be said that the EBP system increases the transparency in the results of the competitions and the pleasure of watching due to its effects that push the game rules to change.

INTRODUCTION

The sports industry has gradually increased the use of technology to facilitate performance improvements. Technological innovation is on the agenda of most sports organizations because of its impact on performance (Ratten, 2020). It means that science needs innovative forms of technology to further advance society in the 21st century, where human beings have overstepped their boundaries (Ferreira, 2020). For example, it has been claimed that half of the world records in sprint sports to date are the result of changes in technology and the other half are the result of actual sporting performance (de Koning, 2010). It has been reported that technological advances have a significant effect on the performance development of cycling, 100 m sprint, javelin (Haake, 2009), pole vault (Balmer, 2011 & Satılmış,

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2023), long jump, high jump, triple jump (Balmer, 2011), amputee sprint (Dyer, 2015) and swimming (Foster, 2012 & Stefani, 2012). In Taekwondo, it encouraged athletes to throw more techniques to the head area (Jae-Ok. K, 2016). As a result, the pleasure of watching increased with high-scoring competitions.

The changes due to the most radical technological developments used in taekwondo from the past to the present have been in electronic body protector (EBP) systems equipped with sensors. It is this development in technology that has changed the fight profile, from scoring to training. However, it has been noted that there are more dynamic and intense body movements (Janowski, 2021).

This study aims to review the scientific studies on electronic body protection systems and scoring used in taekwondo.

Historical Approach to Taekwondo and Electronic Body Protectors

Taekwondo is a Korean martial art whose origins go back thousands of years. It aims to train and strengthen people physically, mentally and spiritually and over time it has turned into a sport. The World Taekwondo Federation (WT) is an official organization responsible for the enforcement of the rules and regulations of the world championships as well as the Olympic Games. WT was established in 1973 to support the development and practice of taekwondo. Under the leadership of the WT, taekwondo took part as a demonstration sport at the 1988 Seoul and 1992 Barcelona Olympic Games. Since the 2000 Sydney Olympic Games, it has been officially included in the Olympic Games program. Para Taekwondo has become an official sport for the Paralympic Games, starting with the 2020 Tokyo Games. The WT is a member of the International Olympic Committee (IOC) and the International Paralympic Committee (IPC). With more than 200 member countries, the WT is one of the most diverse international sports federations. For this reason, it is the most popular martial art today. From 1973 to 2017, the World Taekwondo Federation was called the WTF. It was branded as World Taekwondo (WT) on June 23, 2017, in order to avoid negative connotations in the digital age, to appeal to young and modern audiences and to be able to interact at the same time (WT, 2023).

Taekwondo matches are held in an area of 16 m^2. Athletes perform dynamic movements, fast change of direction, standing on one leg, jumping, and attacking the opponent's body and head with techniques and defence movements against attacks. It is a combat sport that involves the skilful application of techniques and focuses on foot techniques and dynamic foot

movements (Sing, 2017) It is a martial art that emphasises moral and spiritual values and is performed within certain rules for defence and protection.

The rules of the game in sports are being changed in order to strengthen the relevant sports discipline, increase the performance threshold, attract spectators, be the centre of attention of the media and improve the dynamics of the branch. Changing the rules is a common way to change game conditions. Rules provide a unique, distinctive character to the branch (Eaves, 2008 & Arias, 2011) With technological developments, inevitably, the rules of the game of the branch will also change. As with any sport, the rules and regulations of taekwondo have changed over the years.

Scoring decisions, manipulative behaviour and accusations of favouritism in taekwondo competitions became a major problem in the 1990s and early 2000s. There was a perception that match results were often evaluated subjectively and there was a lack of scoring transparency in general. Another problem during these periods was that it was very boring to watch taekwondo matches as athletes generally adopted a safe, defensive-oriented style of play (Moenig, 2015). In this context, the use of technological equipment in taekwondo has become widespread in order to prevent these problems and to increase the international competitiveness of the branch by taking advantage of the opportunities offered by technological services. As a result, after the year 2000, various rule changes and equipment modifications were gradually implemented. Before 2009, competitions were held by the manual system. In the manual system, the techniques effective on the opponent's safeguard and head area were subjectively evaluated by the referees. Since 2009, the WT electronic system has been implemented in competitions. Thanks to the electronic system evaluations used today, more objective scoring is made.

Development Process of Electronic Body Protective Systems and Their Reflections on the Game Rules

After the 2004 Athens Olympic Games, WT began promoting the inclusion of Electronic Body Protector (EBP) in competitions. EBP was created to protect the athlete's body and to be able to score accurately. Although EBP has been used since 2007, this technology was officially used for the first time at the World Championships (Copenhagen, Denmark) in October 2009 (Del Vecchio, 2011). With the introduction of EBP, major changes were made to the rules of the game. As of this year, the EBP system has been used in different brands and models in order to make accurate scoring and increase the pleasure of watching.

Table 1: Systems used in competitions from the year EBP started to be used until today

Competition Year	Competition Name/Location	EBP System Used
2008	European Taekwondo Championships Rome, Italy	Adidas
2008	Beijing Olympic Games	Manual
2009	World Taekwondo Championships Copenhagen, Denmark	LaJust
2010	European Taekwondo Championships St. Petersburg-Russia	Daedo
2011	World Taekwondo Championships in Gyeongju, South Korea	LaJust
2012	London 2012 Summer Olympics	Daedo
2013	World Taekwondo Championships Puebla- Mexico	Daedo
2014	Manchester World Grand Prix Series (WGPS)	Daedo
2014	European Taekwondo Championships Baku-Azerbaijan	Daedo
2015	World Taekwondo Championships Chelyabinsk-Russia	Daedo
2016	European Taekwondo Championships Montreux-Switzerland	Daedo
2016	Rio Olympic Games	Daedo
2017	World Taekwondo Championships Muju-SouthKorea	KPNP
2018	European Taekwondo Championships Kazan-Russia	Daedo
2019	World Taekwondo Championships Manchester-GreatBritain	Daedo
2020	Tokyo Olympic Games	Daedo
2021	European Taekwondo Championships Sofia-Bulgaria	Daedo
2022	European Taekwondo Championships Manchester, United Kingdom	Daedo
2022	World Taekwondo Championships Guadalajara-Mexico	Daedo
2023	World Taekwondo Championship Baku-Azerbaijan	KPNP

In 2009, the EBP used was the LaJust System. With this system, the most important changes in the rules of the game were that rotating body kicks were awarded 2 points and head kicks were awarded 3 points. To date, the EBP system and game rules have been updated gradually and systematically.

In order to better understand the subject, it is necessary to briefly mention the rules of the game.

Game Rules

Some of the game rules of taekwondo; hitting the opponent after the referee intervenes, punching the head area, punching under the body, and going out of the playing area are illegal. With the rules of the game-changing over time, falling to the ground for whatever reason now requires a penalty. While the playing field was 12x12 m square in the manual system, it became 10x10 m square, 8x8 m square and today 8x8 m octagon with the game rules change. In the manual system, punch and foot techniques to the body were evaluated as 1 (one) point and foot techniques to the head were evaluated as 1 (one) point. However, over time, with the introduction of the EBP system, major changes have been made to the game rules scoring system many times. These are;

- With the introduction of the EBP at the 2009 World Championships and the first official use of the EBP in competition, the WT has announced that the following changes to the rules of play are of major significance for taekwondo. At the same time, the video replay practice was included in the competitions in the same year.
- Punch and foot technique to the body protector 1 (one) point,
- Foot technique performed by turning to the body protector 2 (two) points,
- Foot technique made directly to the head area 3 (three) points,
- As of October 7, 2010, in addition to the above game rules, the foot technique performed by returning to the head area scored 4 (four) points;
- With the game rule change on June 1, 2018
- Punch to the body protector 1 (one) point,
- Foot technique made to the body protector 2 (two) points,
- Foot technique performed by returning to the body protector 4 (four) points,
- Foot technique made directly to the head area 3 (three) points,
- The foot technique performed by returning to the head area was evaluated as 5 (points) points. Today, this is how the score evaluation is done.

Due to the inclusion of the EBP system, hits to the head area bring more points. Scoring in Taekwondo is achieved through effective and accurate

punch and foot techniques on the body protector and effective and accurate foot techniques on the head area. The athlete who scored more points by applying foot and punch techniques to the allowed scoring fields was declared the winner of the match. If there was a tie in the score as a result of the competition, the fourth round was held and the athlete who received the first score in this round was declared the winner. However, from 2022 March onwards, the competitions are in the form of round supremacy with the changed game rules. At the end of each round, the round winner is determined. The athlete who wins two rounds in a row has already won the competition and does not need to make the third round. In case of a tie for the round winners, the third round is held and the winner is determined.

Since the introduction of the EBP system, the WT has made many game rule changes. However, not all game rule changes were mentioned in our study.

Protective Scoring Systems

The first electronic body prototypes were developed by Adidas, LaJust (based in Korea) and Daedo (based in Spain). In 2001, the WT had already started the EBP testing process. In 2005, Adidas and LaJust competed to become the first EBP provider to be officially WT certified. WT then chose the LaJust system in 2006 (Moenig, 2015). ETU strongly supported the Adidas system and used it at the 2008 European Championships in Rome (Moenig, 2015). Although the technically immature LaJust system was not ready for the 2008 Olympic Games, it was used at the World Championships in Copenhagen in 2009 (Moenig, 2015). In 2014, at the Manchester World Grand Prix Series 3, the head protector, which is part of the EBP system, used a sensor for the first time (WT, 2023). Then the electronic head protector was systematically used at the World Taekwondo Championships in 2015 (Chelyabinsk-Russia), at the Rio 2016 and 2020 Tokyo Olympic Games. As of 2019, there are only two companies capable of producing electronic PSS: Daedo and KP&P (WT, 2023).

The Adidas EBP system worked according to power and contact and did not have socks with sensors. It was a weak system as it was scored by the collision of sensors located in the knee or even the body protector. Secondly, the LaJust system was used (Tama, 2017). Sensor socks were included in the LaJust System. However, it was an extremely difficult system to score and had many problems, including cell phone interference. An additional sensor was detected in the sock of a Taiwanese athlete at the Asian Games in 2010. In order to prevent illegal situations, athletes were checked with sensors before entering the competition area (Albey, 2017). According to Albey (2017),

the best electronic scoring system available today is Daedo. Points are scored for all areas of the body protector with sensors. In addition, points are only awarded when correct contact and force are used. The Daedo system has Bluetooth wireless technology, recording 5 hits per second, the immediate reflection of the impact intensity, and a safe transmission network. It also has a password-operated system to prevent interference from spreading over an area of more than 100 m (Del Vecchio, 2011). Thanks to the sensors in the socks and head protector, it is reflected in the score when the body protector is hit at a certain intensity. WT calibrates and implements the required level of impact and sensitivity of the EBP system, taking into account weight category, gender and age groups.

METHOD

The presented study was prepared in review format and the answer to the question "How have Taekwondo technological developments been reflected in the game rules?" was sought. In order to reach the answers to this question, the journals in Web of Science databases were searched by using the keywords "taekwondo" and "electronic system" and "score" together. A comprehensive research was carried out by examining the published full-text articles (in English).

While determining the articles to be used in the study, no restrictions such as review, meta-analysis, research article, or year of the research were applied. However, papers and studies not written in English were not included. As a result, a total of 10 articles that met the specified requirements were examined (Figure 1). Since this study is a review research, it does not require ethics committee approval.

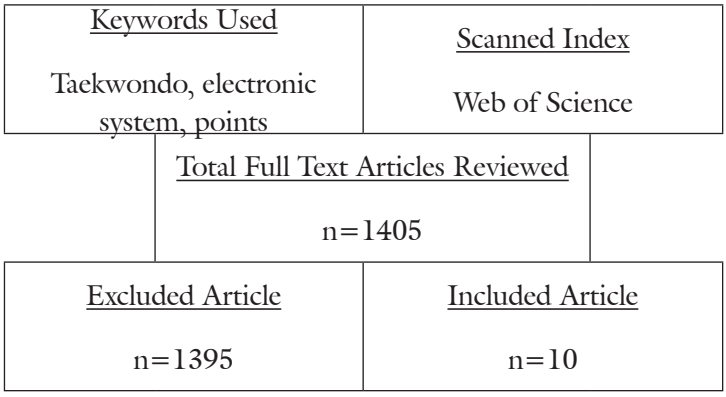

Figure 1: . Study methodology

RESULTS

In the study, 10 articles were examined in which scientific studies on electronic body protective systems and scoring used in taekwondo were investigated. General information about the articles analysed in the studies is given in Table 1.

Table 2: General information of the studies included in the review

Author/year of the study	Purpose	Method	Conclusion
Sledziewski, D., Loniewski, M., Kuder, A., Dias da Silva, R. A., Pedrosa, G. F., Couto, B. P., & Szmuchrowski, L. A. (2015).	The study examines the effects of game rule changes introduced between the Beijing Olympics (2008) and the London Olympics (2012) on athlete and competition profiles.	In the study, the competition records of the Turkish athlete who won the bronze medal in Beijing in 2008, the gold medal in London in 2012 and the Afghan athlete who won the bronze medal in both Olympic Games were examined.	As a result of the study, it was stated that the technical profile used between the Beijing Olympics (2008) and the London Olympics (2012) changed. It was found that the changed game rules increased the use of the front leg compared to the back leg and increased the number of head movements.
Păunescu, C., Piţigoi, G., & Păunescu, M. (2014).	It is based on a systematic analysis of studies published in various databases on injuries occurring during taekwondo competitions and an interpretative study with video analysis detection.	During the 2012 World Junior Championships in Egypt, a total of 732 matches were analysed, including 413 (56%) men's competitions and 319 (44%) women's competitions.	It was concluded that the reduction in the number of head injuries was due to the refereeing system and that strong hits were not necessary to earn points.
Tornello, F., Capranica, L., Minganti, C., Chiodo, S., Condello, G., & Tessitore, A. (2014).	It is the study of the technical and tactical profiles of the junior taekwondo competitions played according to the current game rules.	Technical analyses of the final and final competitions (n = 50) of the Italian Taekwondo Stars championship were performed. Video analytics software program (Dartfish Software Connect Plus 6.0; Dartfish, Fribourg, Switzerland) were used to analyze the records frame by frame (interval = 0.016 seconds).	As a result of the research, it was concluded that the athletes in the star category (a) were more prone to perform offensive actions rather than defensive actions; (b) scored mainly with single-point techniques; and (c) used the back leg more frequently. Specifically, they noted that winning athletes played less offense and more defense than non-winners.

Chong, R. W. L., & Razman, R. (2017)	The reliability of a device designed to test electronic body protectors has been studied.	The mechanical pendulum consists of metal plates and tubular mild steel profiles to simulate a kick striking the electronic body protector.	Data from the study show that the custom-made apparatus is reliable. Therefore, it was concluded that the device could be used to measure the reliability and accuracy of the taekwondo electronic body protector scoring system.
Rahmansyah, M. R., Anita, W., Istiqomah, L., Setiawan, Y. B., Juniardi, Y., Rifqi, A., & Septiani, R. (2019)	To design a wifi-based score calculation system.	A six-button Wi-Fi device consisting of three buttons for blue athletes and three buttons for red athletes was used. If the scores of each referee are the same as the value given by at least two of the three referees, the final score was given by the operator and Wi-Fi was used for data synchronization.	It was concluded that the Wi-Fi-based score calculation system seamlessly receives data from a distance of 45 m, making it easier for referees to perform their duties without the need for a LAN cable and speeding up system installation.
Choi, C. H., Oh, H., & Jeon, M. (2021)	The adequacy of the body protector and scoring system was examined.	It consisted of data from 188 matches at the 2018 Asian Games, taken from the official website of the Asian Taekwondo Federation.	It was found that the technical score effect standard set by WT of the Protective and Scoring System approved by the World Taekwondo Federation was high in all weight classes except the 58 kg weight class.
Apollaro, G., & Falcó, C (2021)	This study aimed to investigate the relationship between the colours of electronic body and head protectors and success in matches in which electronic body and head protectors were used.	1.327 competitions were recorded on DVD.	It was determined that there was no statistically significant relationship between the result of the match and the color of the winner's protectors.
Qureshi, F., &. Krishnan, S. (2022)	To analyze legal and illegal head techniques in electronic head protectors and to design head protectors.	Robustness, sensor placement and shock classification tests have been performed.	In the robustness test, it was found that both the accelerometer and the gyroscope can linearly detect impacts. It was determined that placing the sensor in the back of the head was ideal. Impacts are categorised as legal and illegal.

Apollaro, G., Moreira, P. V. S., Rodríguez, Y. Q., Morales-Sanchez, V., & Falco, C. (2022)	This study aims to investigate the relationship between the colour of electronic protectors and the result of the competition in national taekwondo competitions.	Data for 1155 competitions in 2019-2021 Italian and Uzbekistan Senior Championships from publicly available online sources (https://www.tpss.eu/ login.asp (accessed November 28, 2021) and https://www.ma-regonline.com/ (accessed December 15, 2021)	It was concluded that the electronic system body and head protector in national taekwondo competitions is a fair system and does not affect the winner and loser in the outcome of the match.
Huang, T. Y., Tang, W. T., Liu, T. T., Hamill, J., & Hu, C. (2022).	To investigate the biomechanical differences between rotating techniques with higher and lower impact magnitude using electronic body protectors.	Eighteen elite-level university Taekwondo athletes participated in the study. The Daedo system was used in the research and eight Eagle digital infrared high-speed cameras (Motion Analysis Corporation, Santa Rosa, CA) were installed to surround the athlete for the rotating technical analysis.	As a result, it has been found that elite athletes can achieve a high-impact EBP index by increasing the linear speed proximal to the thigh and leg even at the same foot speed level. To establish a valid score, post-impact leg momentum as well as the pre-impact velocity of the proximal part of the leg was found to be a key performance indicator.

CONCLUSION

Although the development of EBP systems, which developed gradually, dates back to the 1990s, it was first introduced in 2008. It can be said that LaJust prioritizes the EBP system. Initially, the system consisted only of an automatic, electronically scored body protector. This was an incomplete and hybrid structure. Due to several failures, it was not continued. The Daedo system is believed to have been a success at the 2012 London Olympic Games and contributed significantly to the inclusion of taekwondo in the next two Olympic Games. On the other hand, it has shown a performance that shows that it will maintain its place in the EBP for a long time. It was also concluded that the EBP system increased the pleasure of watching the effects of the competition results that pushed transparency and game rules change.

The format of the score evaluation of the punch technique to the body has not changed since the manual system. In the Daedo system used today, the punch technique is evaluated by the referees. The Daedo system currently in use is in gen2 form. WT is trying to develop the gen3 form of this system and is trying to place sensors in gloves to enable electronic evaluation of the punch technique in the future.

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