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Application and Evolution of Leg Technique in the Finals and Semi-Finals of Taekwondo Olympic Games from 2008 to 2020

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Abstract

Background and Aims: During the 2008 Olympics, the regulations saw major revisions to modernize and improve fairness. Electronic scoring methods were used to assess points objectively, eliminating the need for subjective referee judgment. Thus, the purpose of this study is to investigate taekwondo athletes from 2008 to 2020, including 64 athletes in total, with divisions into men's taekwondo (under 58 kg, under 68 kg, over 80 kg, and over 80 kg) and women's taekwondo (under 49 kg, under 57 kg, under 67 kg, and over 67 kg), each group comprising 32 athletes. Among them, the male athletes were 25 ± 3 years old, and the female athletes were 24 ± 2 years old.

Methodology: This study employs video analysis to examine the frequency of use, scoring instances, points scored, usage rate, number of fouls, and opponent fouls among various taekwondo techniques (front kick, spinning kick, back leg spinning kick, front leg axe kick, back leg axe kick, side kick, hook kick, double kick, back kick, spinning back kick, tornado kick, straight punch). It assesses the usage of leg techniques in the Olympics and analyzes the frequency of different leg methods to evaluate the changes in taekwondo leg technique application since the introduction of electronic protective gear.

Results: Video analysis has shown that, following the introduction of electronic protective gear at the 2012 London Olympics, there has been a yearly increase in the use of sidekicks, hook kicks, and the total number of techniques by taekwondo athletes. Notably, the frequency of front-leg axe kicks among male athletes and the use of straight punches to the head among female athletes have significantly increased, while no significant trends have been observed in the use of other techniques. Therefore, in taekwondo training, prioritizing the use of front-leg axe kicks, sidekicks, straight punches to the head, and hook kicks are recommended to enhance scoring rates, reduce fouls, and provoke opponent fouls.

Conclusion: The use of electronic protection equipment has sparked a remarkable transformation in taekwondo methods, with a strong emphasis on strategic moves including front-leg axe kicks, sidekicks, direct punches to the head, and hook kicks, as demonstrated by film analysis since the 2012 London Olympics. This change emphasizes how crucial it is to use customized training methods to maximize scoring rates, reduce fouls, and purposefully cause mistakes by opponents.

Keywords: Electronic Protective Gear; Techniques and Tactics; Video Analysis

Introduction

Before the 2008 Olympic Games, taekwondo athletes wore traditional protective gear, with referees scoring based on the strength and sound of kicks landing with the correct technique. The scoring relied heavily on subjective judgment and consensus among two or more referees. However, with technological advancements, electronic protective gear equipped with an induction chip was developed by South Korea. In such technology, a score gets displayed on a monitor through wireless transmission when the induction chips of an athlete's foot cover and the protective gear make contact and reach a set force coefficient value for different levels. Such electronic protective gear started to be deployed in intercontinental events or higher-level competitions for the first time at the 18th Asian Taekwondo Championships. Nowadays, electronic protective gear is used in various competitions, changing traditional manual subjective scoring into a method that combines objective scoring for hits to the torso and head with subjective scoring for hits to the torso by judges. Consequently, the use of electronic protective gear has brought changes to taekwondo competition rules, techniques and tactics, and athlete training methods (Bae, 2013; Qureshi & Krishnan, 2022). Although electronic protective gear was currently being widely used in taekwondo events, a comprehensive understanding of this gear, along with grasping the changes it brought about to game rhythm, timing, rules, and technical movements, was crucial for developing suitable training plans, aiming for excellent results. At the recently concluded Tokyo 2020 Olympic Games, taekwondo competitors unfortunately failed to win a gold medal; a downturn from previous years where at least one Olympic gold medal had been secured from 2000 through to the 2016 games. This disappointing outcome warrants an in-depth exploration of our training and preparation - Did we miss something about this electronic protective gear? Had there been a misunderstanding of game rules? A failure to adjust to the game rhythm, or were there

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issues regarding athletes' physiological, psychological, and technical aspects? These questions aim to adjust the competitive situation of the Chinese Taekwondo team as soon as possible and secure higher achievements in the future (Zhang & Yi, 2014).

This paper takes male and female athletes from the 2008, 2012, 2016, and 2020 Olympic Games events as research objects, along with Chinese participants. The collected and collated application and features of relevant techniques and tactics aim to elaborate on the trends of taekwondo competition rule changes, the overall state of our athletes' techniques and tactics, physical fitness, and daily training. The goal was to ensure comprehensive technical reserves preparation for further refinement and to provide a theoretical reference for scientific training, thereby promoting the athletic performance of our taekwondo athletes in future Olympic Games.

Objectives

The purpose of this study is to investigate the use of leg techniques by taekwondo athletes at the Olympic Games from 2008 to 2020 and analyze the changes in the frequency of male and female athletes using leg techniques after the introduction of electronic protective gear at the 2012 London Olympics, to assess the evolution of taekwondo leg technique use since the introduction of electronic protection.

Literature Review

Application and Evolution of Leg Technique in Taekwondo

Taekwondo, a traditional Korean martial art, has undergone significant evolution in its techniques and strategies over the years. Central to its practice are various leg techniques, which play a crucial role in both offensive and defensive maneuvers. This paper explores the application and evolution of leg techniques in taekwondo, examining how advancements in training methodologies, competition rules, and technology have influenced the utilization and refinement of these techniques.

Historical Context: Traditionally, taekwondo leg techniques were predominantly based on the use of kicks such as front kicks, roundhouse kicks, and side kicks, emphasizing power, speed, and precision. These techniques were honed through rigorous training methods and practical application in combat scenarios. However, with the evolution of taekwondo as an Olympic sport and the introduction of electronic scoring systems, there has been a shift towards more strategic and diverse employment of leg techniques. Athletes now incorporate a wider range of kicks, including spinning kicks, hook kicks, and axe kicks, to outmaneuver opponents and score points effectively.

Impact of Technological Advancements: The introduction of electronic scoring systems in taekwondo competitions has revolutionized the sport, leading to changes in training approaches and tactical strategies. These systems provide instant feedback on the accuracy and impact of kicks, incentivizing athletes to develop innovative techniques to exploit scoring opportunities. Video analysis has also become a valuable tool for coaches and athletes to study and refine leg techniques, identifying areas for improvement and strategic adjustments. Moreover, advancements in training equipment, such as specialized kicking pads and sensors, have facilitated more targeted and realistic practice sessions, enhancing the effectiveness of leg techniques.

Training Methodologies and Coaching Strategies: In response to the evolving demands of taekwondo competitions, training methodologies, and coaching strategies have adapted to prioritize the development of versatile and adaptable leg techniques. Emphasis is placed on enhancing agility, balance, and flexibility, enabling athletes to execute complex kicks with precision and control. Progressive training drills and sparring exercises simulate competitive scenarios, allowing athletes to refine their timing, footwork, and decision-making under pressure. Coaches also play a pivotal role in analyzing opponents' tactics and devising strategic game plans to capitalize on weaknesses and maximize scoring opportunities through effective leg techniques.

The application and evolution of leg techniques in taekwondo reflect the dynamic nature of the sport, driven by advancements in technology, changes in competition rules, and innovations in training methodologies. As athletes continue to push the boundaries of performance, the strategic utilization of leg techniques will remain a cornerstone of success in taekwondo competitions. By embracing new training approaches, leveraging technological advancements, and maintaining a commitment to skill

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development, practitioners can adapt to the evolving landscape of taekwondo and excel on the international stage.

Conceptual Framework

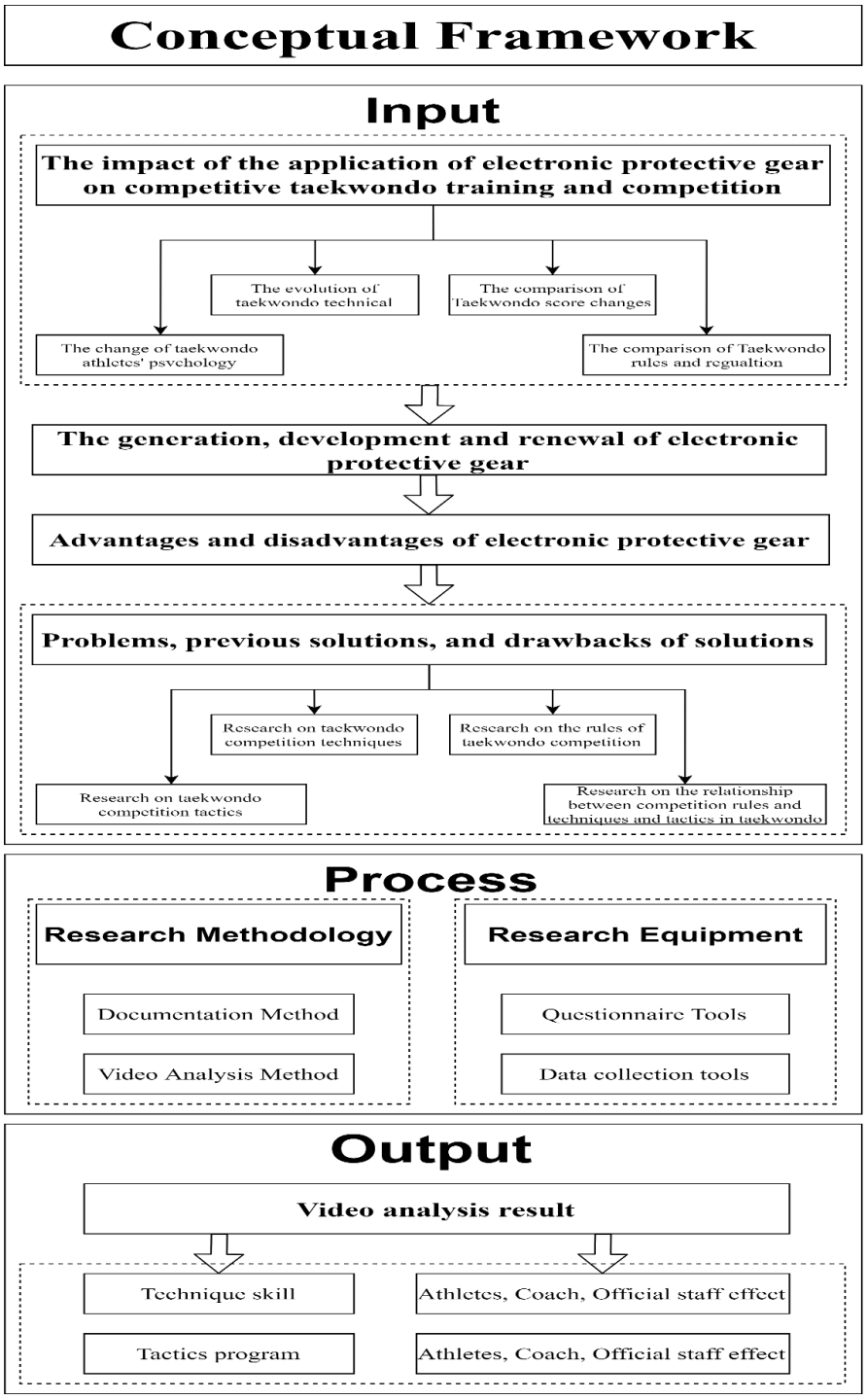

Figure 1 Conceptual Framework

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Methodology

A comprehensive study of the scoring techniques and tactics employed by athletes in the final matches across four weight categories in both men's (up to 58 kg, up to 68 kg, 80 kg, over 80 kg) and women's (up to 49 kg, up to 57 kg, up to 67 kg, over 67 kg) taekwondo at the Olympic Games from 2008 to 2020 was carried out. This consisted of 32 matches involving 64 athletes. It was divided into the men's group in 2008, the men's group in 2012, the men's group in 2016, the men's group in 2020, and the women's group in 2008, the women's group in 2012, the women's group in 2016, and the women's group in 2020.

Through an internet search and official resources, video observation of approximately 32 final games across the four competition levels of men's and women's Taekwondo from the 2008 to 2020 Olympic Games was conducted. Using Excel analysis software, collect data on the following leg technical indicators: Number of Technical indicators Uses, Number of Uses scores, Number of Scored Instances, Score, Rate of Use (%), scoring rate (%), number of fouls, number of fouls submitted by opponents, etc. Study and quantify the impact of traditional and electronic protective equipment on athlete technology and tactics.

Results

Symbols used in data analysis

To obtain all the videos of the finals and semifinals of 32 matches for the following categories in Taekwondo at the Olympic Games from 2008 to 2020: Men's (under 58kg, under 68kg, over 80kg, and over 80kg) and Women's (under 49kg, under 57kg, over 67kg, and over 67kg), you can use the Migu Video and CCTV Video client applications. Once you have the videos, you can utilize the video editing software Adobe Premiere Pro CC2020 to repeatedly watch and analyze the required technical and tactical indicators for your research. By carefully observing and analyzing the footage, you can accurately collect data on various indicators with a scientific and rigorous approach, providing precise statistics for your research.

The symbols used in this article include technical indicators and athletes' leg techniques, number of uses, i.e., the number of times the leg technique is used in a competition, scoring examples, i.e., the athlete uses the leg technique and earns points, scoring, which is the total number of points scored by the athlete using a leg technique, usage rate, which is the ratio of the number of times an athlete uses the leg technique in a match to the total number of times the sport uses the taekwondo technique, scoring rate, which is the ratio of the number of leg techniques scored by the athlete to the number of leg techniques used, the number of fouls, and the number of fouls committed by the opponent。

Order of presentation of research results

Video Analysis Results for Male Taekwondo Athletes in 2008

The video analysis investigated various technical indicators, including the usage and success rates of different kicking techniques such as front-leg and back-leg roundhouse kicks, axe kicks, side kicks, hook kicks, double kicks, back kicks, spinning back kicks, twisting kicks, and punches. Based on the video analysis of the 32 matches that occurred in the finals and semifinals between 2008 and 2020, the results were presented in the following table:

Table 1 Video Analysis Results for Men's Taekwondo Athletes in 2008

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	37	4	6	20.70	10.80	1	0
Back-leg roundhouse kick	100	15	15	56.10	15	3	2
Front-leg axe kick	4	0	0	2.20	0	0	0

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Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Back-leg axe kick	8	0	0	4.40	0	0	0
Side kick	3	0	0	1.60	0	0	0
Hook kick	0	0	0	0	0	0	0
Double kick	11	1	0	6.10	9.00	1	0
Back kick	6	1	0	3.30	16.60	1	0
Spinning back kick	4	0	0	2.20	0	1	0
Tornado kick	2	0	0	1.10	0	0	0
Straight punch	3	0	0	1.60	0	0	0
Total number of techniques	178	21	22	1	11.70	0	0

According to Table 1, the most frequently used technical indicator in terms of usage was the back-leg roundhouse kick, which was used 100 times, accounting for 56.1% of the overall technical usage. The next most used technical indicator was the front-leg roundhouse kick, which was used 37 times, accounting for 20.7% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the double kick, back-leg axe kick, back kick, front-leg axe kick, spinning back kick, side kick, straight punch, tornado kick, and hook kick. They were used 11 times, 8 times, 6 times, 4 times, 4 times, 3 times, 3 times, 2 times, and 0 times, respectively, accounting for 6.1%, 4.4%, 3.3%, 2.2%, 2.2%, 1.6%, 1.6%, 1.1%, and 0% of the overall technical usage.

In terms of scored instances and scoring rate, only the front-leg roundhouse kick, back-leg roundhouse kick, double kick, and back-kick resulted in scores, while the rest of the techniques did not score. The backkick had the highest scoring rate with 1 scored instance and a scoring rate of 16.6%. The back-leg roundhouse kick had 15 scored instances and a scoring rate of 15%. The front-leg roundhouse kick and double kick had 4 scored instances and 1 scored instance, with scoring rates of 10.8% and 9.0% respectively. Overall, the scored instances accounted for 11.7% of the total technical usage.

Regarding fouls and fouls committed by the opponent, fouls were committed in the back-leg roundhouse kick, front-leg roundhouse kick, double kick, back kick, and spinning back kick. The number of fouls for each technique was 3, 1, 1, 1, and 1 respectively. Only the back-leg roundhouse kick resulted in fouls committed by the opponent, with a total of 2 instances.

Table 2 Video Analysis Results for Women's Taekwondo Athletes in 2008

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	42	1	1	22.70	2.30	4	1
Back-leg roundhouse kick	89	2	7	48.10	2.20	2	1
Front-leg axe kick	14	0	0	7.50	0	0	1
Back-leg axe kick	1	0	0	0.50	0	0	1
Side kick	17	1	1	9.10	5.80	0	1
Hook kick	0	0	0	0	0	0	0
Double kick	4	0	0	2.10	0	0	0
Back kick	11	1	1	5.90	9.00	0	0

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Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Spinning back kick	4	0	0	2.10	0	0	0
Tornado kick	0	0	0	0	0	0	0
Straight punch	5	0	0	2.70	0	0	0
Total number of techniques	185	5	10	1	2.70	0	0

According to Table 2, the most frequently used technical indicator in terms of usage was the back roundhouse kick, which was used 89 times, accounting for 48.1% of the overall technical usage. The next most used technical indicator was the front-leg roundhouse kick, which was used 42 times, accounting for 22.7% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the side kick, front-leg axe kick, back kick, straight punch, double kick, spinning back kick, back-leg axe kick, hook kick, and tornado kick. They were used 17 times, 14 times, 11 times, 5 times, 4 times, 4 times, 1 time, 0 times, and 0 times, respectively, accounting for 9.1%, 7.5%, 5.9%, 2.7%, 2.1%, 2.1%, 0.5%, 0%, and 0% of the overall technical usage.

In terms of scored instances, scoring rate, and scoring situation, only the front-leg roundhouse kick, back-leg roundhouse kick, side kick, and back kick resulted in scores, while the rest of the techniques did not score. The backkick had the highest scoring rate with 1 scored instance and a scoring rate of 9.0%, earning 1 point. The sidekick had 1 scored instance and a scoring rate of 5.8%, also earning 1 point. The front-leg roundhouse kick and back-leg roundhouse kick had 1 scored instance and 2 scored instances, with scoring rates of 2.3% and 2.2% respectively, earning 1 point and 7 points respectively. Overall, the scored instances accounted for 2.7% of the total technical usage.

Regarding fouls and fouls committed by the opponent, fouls were committed in the front-leg roundhouse kick and back-leg roundhouse kick, with 4 fouls and 2 fouls respectively. The front-leg roundhouse kick, back-leg roundhouse kick, front-leg axe kick, back-leg axe kick, and side kick resulted in fouls committed by the opponent, each with 1 instance.

Table 3 Video Analysis Results for Men's Taekwondo Athletes in 2012

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	104	35	4	22.70	33.60	1	0
Back-leg roundhouse kick	169	41	21	36.80	24.20	1	1
Front-leg axe kick	10	6	1	2.10	60.00	0	1
Back-leg axe kick	7	3	3	1.50	42.80	0	0
Side kick	91	11	3	19.80	12.00	0	3
Hook kick	7	1	0	1.50	14.20	1	0
Double kick	28	7	3	6.10	25.00	0	1
Back kick	19	3	2	4.10	15.70	0	0
Spinning back kick	8	2	0	1.70	25.00	0	0
Tornado kick	5	3	0	1.00	60.00	0	1
Straight punch	9	1	1	1.90	11.10	0	0

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Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Total number of techniques	458	113	38	1	24.60	0	0

According to Table 3, the most frequently used technical indicator in terms of usage was the back-leg roundhouse kick, which was used 169 times, accounting for 36.8% of the overall technical usage. The next most used technical indicator was the front-leg roundhouse kick, which was used 104 times, accounting for 22.7% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the side kick, double kick, back kick, front-leg axe kick, straight punch, spinning back kick, back-leg axe kick, hook kick, and tornado kick. They were used 91 times, 28 times, 19 times, 10 times, 9 times, 8 times, 7 times, 7 times, and 5 times, respectively, accounting for 19.8%, 6.1%, 4.1%, 2.1%, 1.9%, 1.7%, 1.5%, 1.5%, and 1.0% of the overall technical usage.

In terms of scored instances, scoring rate, and scoring situation, only the hook kick, spinning back kick, and tornado kick did not score, while the rest of the techniques scored. The highest scoring rate was achieved by the front-leg axe kick and tornado kick, with 6 scored instances and 3 scored instances respectively, both with a scoring rate of 60.0%, earning 1 point and 0 points respectively. The back-leg axe kick had 7 scored instances and a scoring rate of 42.8%, earning 3 points. The front-leg roundhouse kick, double kick, spinning back kick, back-leg roundhouse kick, back kick, hook kick, side kick, and straight punch had 35, 7, 2, 41, 3, 11, 1 scored instances, with scoring rates of 33.6%, 25.0%, 25.0%, 24.2%, 15.7%, 14.2%, 12.0%, and 11.1% respectively, earning 4 points, 3 points, 2 points, 21 points, 2 points, 0 points, 3 points, and 1 point respectively. Overall, the scored instances accounted for 24.6% of the total technical usage. Among them, the back-leg roundhouse kick had the highest number of scored instances, followed by the front-leg roundhouse kick.

Regarding fouls and fouls committed by the opponent, fouls were committed in the back-leg roundhouse kick, front-leg roundhouse kick, and hook kick, with 1 foul each. The back-leg roundhouse kick, front-leg axe kick, side kick, double kick, and tornado kick resulted in fouls committed by the opponent, with 1 foul for each technique except for the side kick, which had 3 fouls.

Table 4 Video Analysis Results for Women's Taekwondo Athletes in 2012

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	103	6	8	25.00	5.80	0	0
Back-leg roundhouse kick	105	12	18	25.40	11.40	1	1
Front-leg axe kick	21	0	0	5.00	0.00	0	0
Back-leg axe kick	6	1	3	1.40	16.60	0	0
Side kick	136	7	7	33.00	5.10	3	5
Hook kick	3	0	0	0.70	0	0	0
Double kick	5	1	1	1.20	20.00	0	0
Back kick	9	0	0	2.10	0	0	0
Spinning back kick	11	0	0	2.60	0	0	0
Tornado kick	4	1	2	0.90	25.00	0	0
Straight punch	9	5	5	2.10	55.50	0	0

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Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Total number of techniques	412	33	44	1	8.00	0	0

According to Table 4, the most frequently used technical indicator was the sidekick, which was used 136 times, accounting for 33.0% of the overall technical usage. The next most used technical indicators were the back-leg roundhouse kick and the front-leg roundhouse kick, which were used 105 times and 103 times respectively, accounting for 25.4% and 25.0% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the front-leg axe kick, spinning back kick, back kick, straight punch, back-leg axe kick, double kick, tornado kick, and hook kick. They were used 21 times, 11 times, 9 times, 9 times, 6 times, 5 times, 4 times, and 3 times respectively, accounting for 5.0%, 2.6%, 2.1%, 2.1%, 1.4%, 1.2%, 0.9%, and 0.7% of the overall technical usage.

In terms of scored instances and scoring rate, the straight punch achieved the highest scoring rate with 5 scored instances and a scoring rate of 55.5%. The spinning back kick had 1 scored instance and a scoring rate of 25.0%. The double kick, back-leg roundhouse kick, front-leg roundhouse kick, front-leg axe kick, and side kick had 1, 1, 12, 6, and 1 scored instances, with scoring rates of 20.0%, 16.6%, 11.4%, 5.8%, and 5.1% respectively. Overall, the scored instances accounted for 8.0% of the total technical usage. Among them, the back-leg roundhouse kick and the front-leg roundhouse kick had the highest number of scored instances, earning 18 and 8 points respectively.

Regarding fouls and fouls committed by the opponent, fouls were committed in the side kick and the back-leg roundhouse kick, with 3 fouls and 1 foul respectively. Only the side kick and the back-leg roundhouse kick resulted in fouls committed by the opponent, with 5 fouls and 1 foul respectively.

Table 5 Video Analysis Results for Men's Taekwondo Athletes in 2016

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	177	2	9	26.80	1.10	3	2
Back-leg roundhouse kick	96	1	2	14.50	1.00	0	5
Front-leg axe kick	48	0	0	7.20	0.00	0	0
Back-leg axe kick	36	4	9	5.40	11.10	3	1
Side kick	203	7	8	30.80	3.40	4	4
Hook kick	12	0	0	1.80	0	1	0
Double kick	23	6	8	3.40	26.00	1	0
Back kick	13	0	0	1.90	0	2	0
Spinning back kick	14	1	4	2.10	7.10	0	1
Tornado kick	10	0	0	1.50	0	0	0
Straight punch	26	3	3	3.90	11.50	0	0
Total number of techniques	658	24	43	1	3.60	0	0

According to Table 5, the most frequently used technical indicator was the sidekick, which was used 203 times, accounting for 30.8% of the overall technical usage. The next most used technical indicator was the front-leg roundhouse kick, which was used 177 times, accounting for 26.8% of the

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overall technical usage. The back-leg roundhouse kick was the third most used technical indicator, with 96 instances and accounting for 14.5% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the front-leg axe kick, back-leg axe kick, straight punch, double kick, spinning back kick, back kick, hook kick, and tornado kick.

In terms of scored instances and scoring rate, the double kick achieved the highest scoring rate with 6 scored instances and a scoring rate of 26.0%. The straight punch had 3 scored instances and a scoring rate of 11.5%. The back-leg axe kick, spinning back kick, side kick, front-leg roundhouse kick, and back-leg roundhouse kick had 1, 1, 7, 2, and 1 scored instances respectively, with scoring rates of 3.6%, 3.6%, 11.4%, 5.8%, and 5.1% respectively. Overall, the scored instances accounted for 3.6% of the total technical usage. Among them, the front-leg roundhouse kick, back-leg roundhouse kick, side kick, and double kick had the highest number of scored instances, earning 9, 9, 8, and 8 points respectively. The spinning back kick, straight punch, and back-leg axe kick earned 4, 3, and 2 points respectively.

Regarding fouls and fouls committed by the opponent, the sidekick, front-leg roundhouse kick, back-leg axe kick, and back-kick had the highest number of fouls committed, with 4, 3, 3, and 2 fouls respectively. The back-leg roundhouse kick, side kick, front-leg roundhouse kick, back-leg axe kick, and spinning back-kick resulted in fouls committed by the opponent, with 5, 4, 2, 1, and 1 fouls respectively.

Table 6 Video Analysis Results for Women's Taekwondo Athletes in 2016

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	32	8	12	10.70	25.00	3	6
Back-leg roundhouse kick	57	6	10	19.00	10.50	2	1
Front-leg axe kick	17	4	12	5.60	23.50	0	1
Back-leg axe kick	10	1	1	3.30	10	1	0
Side kick	137	11	13	45.80	8.00	1	5
Hook kick	13	2	6	4.30	15.30	1	1
Double kick	1	0	0	0.00	0	0	0
Back kick	10	1	3	3.40	10	1	1
Spinning back kick	13	0	0	4.30	0	1	0
Tornado kick	4	0	0	1.30	0	0	0
Straight punch	5	0	0	1.60	0	0	0
Total number of techniques	299	33	57	1	11.00	2	0

According to Table 6, the most frequently used technical indicator was the sidekick, which was used 137 times, accounting for 45.8% of the overall technical usage. The next most used technical indicators were the back-leg roundhouse kick and the front-leg roundhouse kick, which were used 57 times and 32 times respectively, accounting for 19.0% and 10.7% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the front-leg axe kick, hook kick, spinning back kick, back kick, back-leg axe kick, straight punch, tornado kick, and double kick.

In terms of scored instances and scoring rate, the front-leg roundhouse kick achieved the highest scoring rate with 8 scored instances and a scoring rate of 25.0%. The front-leg axe kick had 4 scored instances and a scoring rate of 23.5%. The hook kick, back-leg roundhouse kick, back-leg axe kick,

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International Journal of Sociologies and Anthropologies Science Reviews
Volume 4 Issue 4: July-August 2024: ISSN 2985-2730
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back kick, and side kick had 2, 6, 1, 1, and 11 scored instances respectively, with scoring rates of 9.5%, 10.5%, 2.3%, 2.3%, and 8.0% respectively. Overall, the scored instances accounted for 11.0% of the total technical usage. Among them, the side kick, front-leg roundhouse kick, and front-leg axe kick had the highest number of scored instances, earning 13, 12, and 12 points respectively. The back-leg roundhouse kick, hook kick, back kick, and back-leg axe kick earned 10, 6, 3, and 1 point respectively.

Regarding fouls and fouls committed by the opponent, the front-leg roundhouse kick and the back-leg roundhouse kick had a higher number of fouls committed, with 3 fouls and 2 fouls respectively. The front-leg roundhouse kick and the side kick resulted in the highest number of fouls committed by the opponent, with 6 fouls and 5 fouls respectively.

Table 7 Video Analysis Results for Men's Taekwondo Athletes in 2020

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	147	10	22	22.00	6.80	6	3
Back-leg roundhouse kick	116	19	40	17.40	16.30	0	0
Front-leg axe kick	54	0	0	8.10	0	2	0
Back-leg axe kick	10	2	6	15.00	20	0	0
Side kick	256	7	21	38.40	2.70	1	5
Hook kick	42	6	15	6.30	14.20	1	0
Double kick	0	0	0	0	0	0	0
Back kick	9	2	8	1.30	22.20	0	0
Spinning back kick	8	2	5	1.20	25	2	0
Tornado kick	0	0	0	0	0	0	0
Straight punch	24	7	7	3.60	29.10	0	0
Total number of techniques	666	55	124	1	8.20	0	0

According to Table 7, the most frequently used technical indicator was the sidekick, which was used 256 times, accounting for 38.4% of the overall technical usage. The next most used technical indicators were the front-leg roundhouse kick and the back-leg roundhouse kick, which were used 147 times and 116 times respectively, accounting for 22.0% and 17.4% of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the back-leg axe kick, front-leg axe kick, hook kick, straight punch, back kick, and spinning back kick.

In terms of scored instances and scoring rate, the straight punch achieved the highest scoring rate with 7 scored instances and a scoring rate of 29.1%. The spinning back kick and the back kick had 2 scored instances each, with scoring rates of 25.0% and 22.2% respectively. The back-leg axe kick, back-leg roundhouse kick, hook kick, front-leg roundhouse kick, and side kick had 2, 19, 6, 10, and 7 scored instances respectively, with scoring rates of 10.4%, 9.5%, 6.3%, 15.0%, and 8.0% respectively. Overall, the scored instances accounted for 8.2% of the total technical usage. Among them, the back-leg roundhouse kick, front-leg roundhouse kick, side kick, and hook kick had the highest number of scored instances, earning 40, 22, 21, and 15 points respectively. The back kick, straight punch, back-leg axe kick, and spinning back kick earned 8, 7, 6, and 5 points respectively.

Regarding fouls and fouls committed by the opponent, the front-leg roundhouse kick, back-leg axe kick, and spinning back kick had a higher number of fouls committed, with 6 fouls, 2 fouls, and 2

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fouls respectively. The side kick and the front-leg roundhouse kick resulted in the highest number of fouls committed by the opponent, with 5 fouls and 3 fouls respectively.

Table 8 Video Analysis Results for Women's Taekwondo Athletes in 2020

Technical indicators	Number of Uses	Number of Scored Instances	Score	Rate of Use (%)	Scoring Rate (%)	Number of Fouls	Number of Fouls Committed by Opponent
Front-leg roundhouse kick	86	9	18	17.00	10.40	10	10
Back-leg roundhouse kick	40	8	16	7.90	20	1	3
Front-leg axe kick	4	2	6	0.70	50	1	0
Back-leg axe kick	6	1	3	1.10	16.60	1	0
Side kick	301	7	15	59.70	2.30	1	1
Hook kick	37	4	9	7.30	10.80	0	1
Double kick	0	0	0	0	0	0	0
Back kick	2	1	3	0.30	50	0	0
Spinning back kick	4	0	0	0.70	0	0	0
Tornado kick	0	0	0	0	0	0	0
Straight punch	24	6	6	4.70	25	1	0
Total number of techniques	504	38	76	1	7.50	2	2

According to Table 8, in terms of the usage of technical indicators, the most frequently used indicator was the sidekick, which was used 301 times, accounting for 59.7 of the overall technical usage. The next most used technical indicator was the front-leg roundhouse kick, which was used 86 times, accounting for 17.0 of the overall technical usage. The remaining technical indicators, in descending order of frequency, were the back-leg roundhouse kick, hook kick, straight punch, back-leg axe kick, front-leg axe kick, spinning back kick and back kick.

In terms of scored instances and scoring rate, the front-leg axe kick and the back kick achieved a scoring rate of 50 with 2 scored instances and 1 scored instance respectively. The straight punch and the back-leg roundhouse kick had 6 scored instances and 8 scored instances, with scoring rates of 25 and 20 respectively. The back-leg axe kick, hook kick, front-leg roundhouse kick, and side kick had 1, 4, 9, and 7 scored instances respectively. Overall, the scored instances accounted for 7.5 of the total technical usage.

Among the scored instances, the front-leg roundhouse kick, back-leg roundhouse kick, side kick, and hook kick had the highest scores, earning 18, 16, 15, and 9 points respectively. The front-leg axe kick, straight punch, back-leg axe kick, and back kick earned 6, 6, 3, and 3 points respectively.

Regarding fouls and fouls committed by the opponent, the front-leg roundhouse kick had the highest number of fouls committed with 10 fouls. The front-leg roundhouse kick and the back-leg roundhouse kick resulted in the highest number of fouls committed by the opponent, with 10 fouls and 3 fouls respectively.

Conclusion

In this section, we examine the video analysis results of male Taekwondo athletes in the year 2008. These analyses have groundbreaking significance for the development of training patterns designed for Taekwondo athletes, particularly considering the subtle differences brought about by the use of

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electronic scoring systems in competitions. These results were based on a study of 32 matches that took place in the semifinals and finals between 2008 and 2020.

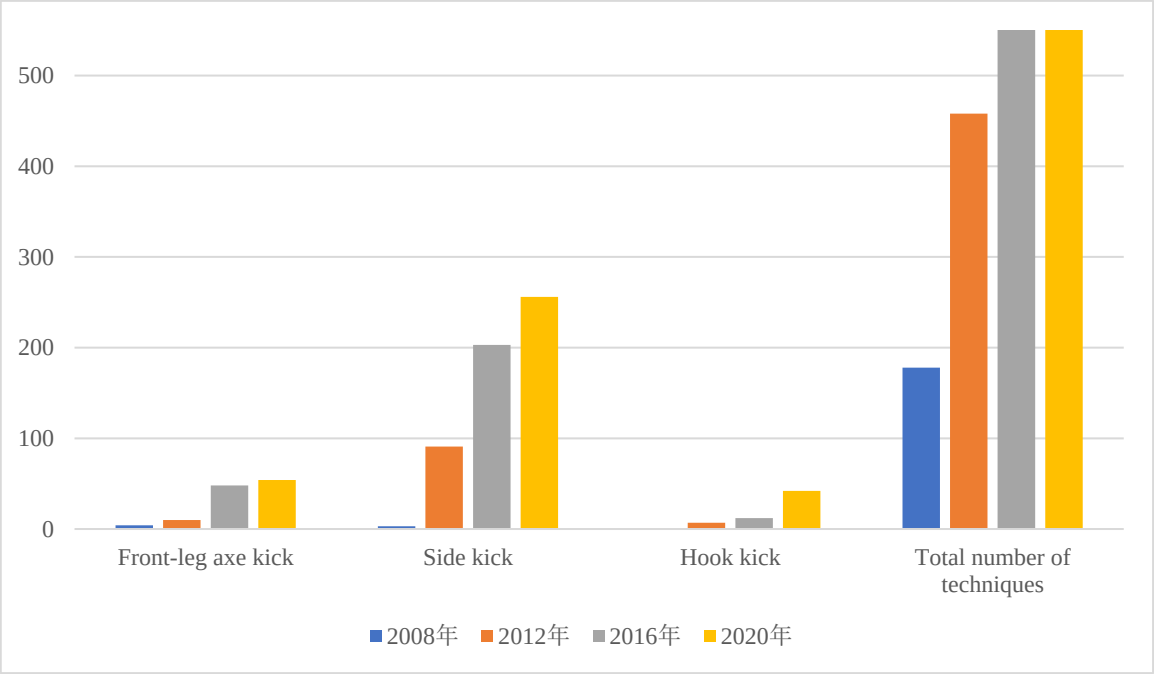

Figure 1 Leg technique statistics of male taekwondo athletes from 2008 to 2020

By analyzing the number of times men's taekwondo athletes' leg techniques were used from 2008 to 2020, it can be found that after the introduction of electronic protective gear in the 2012 London Olympic Games, the total number of athletes' leg techniques such as front leg axe kicks, side kicks, hook kicks and techniques increased year by year, and no obvious change trend was found for other techniques.

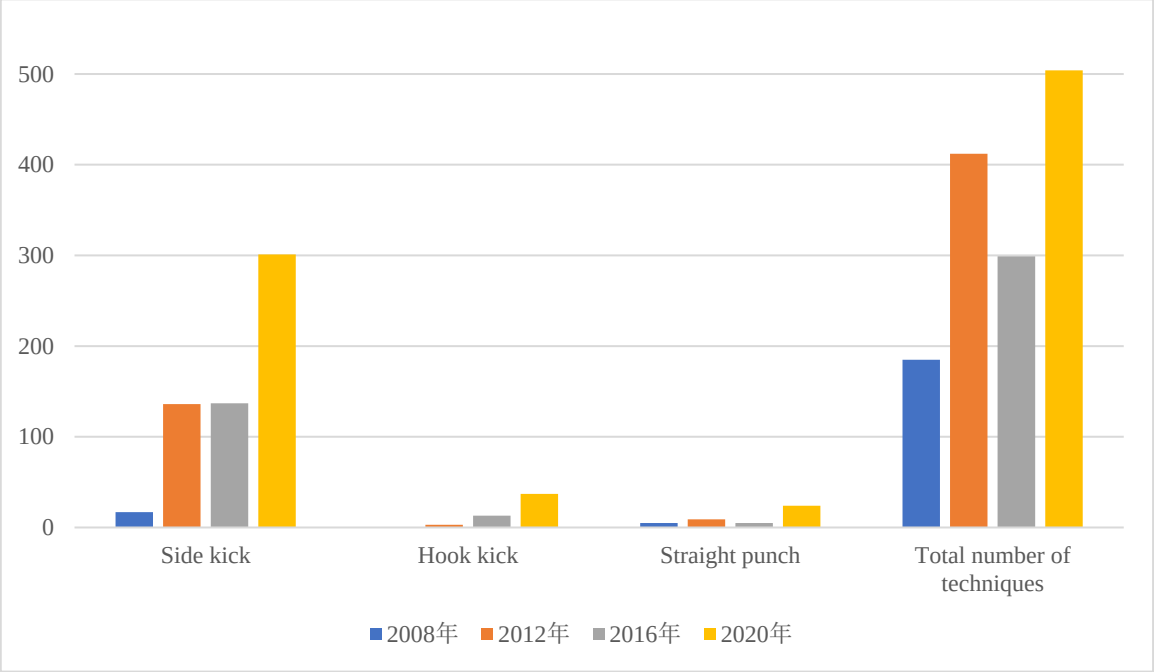

Figure 2 Leg technique statistics of female taekwondo athletes from 2012 to 2020

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By analyzing the number of times female taekwondo athletes used leg techniques from 2008 to 2020, it can be found that after the introduction of electronic protective gear in the 2012 London Olympic Games, the total number of athletes' leg techniques such as side kicks, hook kicks, straight punches and techniques increased year by year, and no obvious change trend was found for other techniques.

Discussion

Summary of results

Taekwondo differs from other traditional combat sports because it was a young combat sport that was constantly refining its rules. The introduction of electronic protective gear has also brought about new changes. This study analyzes videos from 32 Taekwondo semifinals. This process involves scientifically analyzing and utilizing data and applying it to practice. Currently, most training methods rely on empirical experience or the subjective analysis of coaches and coaching teams. By using video analysis, the design of training programs becomes more objective and rational. It can be found from the above research that after the introduction of electronic protective gear in the 2012 London Olympics, the total number of leg techniques used by taekwondo athletes showed an upward trend. Specifically, the use of side kicks and hook kicks by male and female athletes increased significantly, and the number of front leg axe kicks used by male athletes increased significantly, while the number of straight punch kicks used by female athletes increased.

Discuss the results

Regarding electronic protective gear, a study has proposed a disruptive perspective on electronic protective equipment, suggesting that the use of electronic sensors to determine striking areas and force can reduce subjective judgment and make matches more objective. However, the study also points out that the sensors of the Protective Scoring System (PSS) used in electronic protective gear may interfere with athletes' technical and tactical abilities. Therefore, electronic protective gear cannot completely resolve unfairness among referees, and disputes cannot be entirely resolved by electronic protective gear (Márquez, J.J., 2022). It emphasizes that although it provides more objective data, attention still needs to be paid to the fairness of referees (Zhao, 2008). However, other studies have questioned the use of electronic protective equipment, pointing out that the current WTF Taekwondo competition system, which revolves around the Protective Scoring System (PSS), has led to various significant negative trends. These include an excessive emphasis on weak front-leg kicks, stationary kicking techniques, favoring taller and thinner opponents with weaker athletic abilities, and the emergence of various non-traditional, and sometimes even bizarre, scoring techniques. One study believes that these characteristics were interrelated and largely due to the hasty and uncontrolled introduction of the PSS, transforming Taekwondo from a full-contact combat sport into a partially light-contact scoring game (Moenig, U.2017).

Similarly, the use of electronic protective gear effectively improves the objectivity and fairness of matches. However, they also point out that the application of electronic sensor devices significantly affects the strategies and tactics used in matches, making them more intense, exciting, and unpredictable. This viewpoint highlights the impact of electronic protective gear on the dynamics and tactics of matches, introducing more variables and challenges to the outcome of matches (Fan, et al, 2010). Therefore, analyzing these changes helps coaches and athletes better utilize electronic protective gear in training.

In this study, video analysis suggests prioritizing frequent use of front-leg roundhouse kicks, back-leg roundhouse kicks, and sidekicks in taekwondo training to increase scoring rates, reduce fouls, and provoke opponent fouls. Some studies have also analyzed the techniques of taekwondo athletes based on video analysis. For example, Apollaro et al, (2023). analyzed the relationship between the time-motion structure of high-level taekwondo matches during the 2020 Tokyo Olympics and factors such as gender, match outcomes, weight categories, and match rounds. By analyzing 134 matches (67 rounds, 24 matches: 4 rounds, 16 matches, 8 quarterfinals, 8 semifinals, and 4 finals) in the flyweight (≤58kg for men, ≤49kg for women) and heavyweight (≥80kg for men, ≥67kg for

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women) categories, the study found that rule changes and the implementation of electronic scoring systems had a significant impact on the time-motion structure of the fights. There was a much higher ratio of attack time/skipping time compared to the past, and the structure of the fights was influenced by both weight categories and match stages. The study suggests that coaches can engage in high-intensity interval training for specific movements based on the time-motion indicators identified in this research. Tornello et al, 2013. analyzed adolescent athletes, aiming to analyze the time-motion structure of fighting phases (fighting: F, non-fighting: NF, and stoppage time: ST) in the semifinals and finals of the 2010 Italian Taekwondo Championships for young athletes (13-14 years old) based on video analysis. The study also examined the relationship between the time-motion structure and gender (adolescent boys and girls) and categorized the athletes by weight divisions (light, medium, and heavy). The results showed differences in the frequency and average duration of fighting phases regardless of gender, weight division, rounds, and tournament stages. The ratio of fighting to non-fighting was found to be 1:2. During the fighting phases, there were 5±1 tactical actions and 4±1 technical attacks, lasting 0.6±0.1 seconds and 0.7±0.1 seconds, respectively. These findings reflect the intermittent nature of youth fights, characterized by frequent tactical actions and technical exchanges during the fighting phases. These research results effectively analyze the technical and time-motion characteristics of taekwondo matches.

Through observing the matches of the men's taekwondo 65kg and 80kg weight categories and above at the 29th Olympic Games, Fan Xiaojun conducted a corresponding analysis on the technical application of athletes from China and South Korea. It was found that Chinese athletes mainly adopt a defensive counterattacking style, while South Korean athletes primarily employ an aggressive attacking style. Chinese athletes tend to have relatively limited variety in their technical movements, whereas South Korean athletes exhibit more diverse techniques. These findings require our athletes to incorporate their unique styles in future training. Encouragement should be given to the adoption of high-difficulty headshot scoring techniques, strengthening psychological training for key rounds and key scoring situations, and improving the development of coaching teams. Similarly, in Zhao Ping's (1998) comparative analysis of leg technique application in domestic and foreign taekwondo competitions, it was revealed that the overall level of leg techniques among Chinese athletes was relatively low, and the utilization and innovation of high-difficulty technical movements were not as proficient as those of outstanding foreign athletes (Bian, 2001). This also contributes to the direction of future development for Chinese athletes. Both of these articles focus on the chapter comparing the technical abilities of domestic and foreign taekwondo athletes, highlighting numerous issues in the development of taekwondo techniques in China that need to be gradually addressed.

However, compared to previous research, this study also identified some new trends and changes. For example, in the 2016 Rio Olympics, the usage rate of sidekicks increased, possibly due to rule changes that categorized Category 5 fouls as warnings. However, the success rate and scoring rate of sidekicks decreased significantly. On the other hand, the scoring rate of straight punches improved after 2016, possibly due to further clarification of the requirements and standards for effective punches under the revised rules, leading to an increased scoring rate. The changes in rules have influenced the utilization of taekwondo techniques, and some of the rule changes in recent years have been driven by the introduction of electronic protective gear. Research has shown that the introduction of electronic protective gear in taekwondo significantly alters the techniques employed by athletes in training and competition (Hamar & Zemková, 2009). The incorporation of electronic scoring systems within the protective gear requires athletes to adopt new tactics to register scores accurately. This has led to the development of unique techniques such as hook kicks and cutting kicks, which were tapping actions rather than the traditional thrusting motions (Lee & Kim, 2018). These changes in techniques have resulted in a shift in athletes' approach to movement, altering their training programs and styles (Falcó et al., 2014). The protective gear redirects athletes' target areas toward scoring on the trunk and head (Lee & Kim, 2018). Our study demonstrates an increase in the frequency and scoring rates of hook kicks after 2020, which may also be attributed to the use of taekwondo protective gear. Additionally, psychological changes have led athletes to adopt a more aggressive style

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of play after encountering the electronic gear, as it allows them to score higher points according to Bandura's (1977) theory, which may contribute to the variation in techniques like side kicks and hook kicks. The introduction of electronic protective gear also increases performance pressure, intensifies anxiety, and changes the way athletes form and execute competitive strategies.

Maltais et al. (2017) emphasize that while electronic protective gear standardizes the scoring system, it also promotes changes in athletes' competition styles. Kim et al. (2017) report similar findings, highlighting the differences in the scoring system that tend to favor offensive and high-risk actions rather than defensive moves. They point out that modern scoring systems may guide coaches to train athletes specifically for electronic sensor scoring, as opposed to traditional techniques.

Suggestions

The emergence of electronic protective gear dramatically challenged traditional taekwondo competition scoring, making it essential for athletes to improve their skills according to the characteristics of this gear, understand the scoring rules better, and enhance their adaptability to electronic protective gear during training.

Recommendation

Suggestions for applying research results

1. Electronic gear has transformed taekwondo competitions, leading to a focus on skill-oriented matches where athletes and coaches strategically choose effective techniques and tactics for scoring.

2. Multiple revisions to the rules between 2008 and 2020 have resulted in fluctuations in the application of certain kicking techniques.

Suggestions for future research

1. The training model should not disregard previous training systems but instead incorporate them into a scientifically reasonable approach tailored to individual athletes.

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