

Unveiling the Winning Formula: Limb Selection Patterns for High Scoring in Taekwondo

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Abstract Background: Taekwondo, a global Olympic sport, is known for its powerful kicks, punches, discipline, and respect; now, limb-based performance analysis is vital for improving tactics and scoring. **Aim:** To identify the most effective limbs for scoring, supporting evidence-based coaching, and improving elite athlete performance. **Methods:** This study analyzed 320 matches from the 2021–2023 World Taekwondo Championships, covering all genders and weight classes from 99 countries. Two national-level players independently reviewed each match frame-by-frame to record points by limb, resolving discrepancies jointly. **Statistical Analysis:** Descriptive statistics were used; due to assumption violations, Kruskal-Wallis with post-hoc ($p < .05$) was applied, showing high power ($1-\beta = 0.99$ total, 0.93 male/female) and a medium effect size ($\epsilon^2 = 0.06$). **Result:** Taekwondo athletes score mostly with legs (right 47%, left 43%) and minimally with hands (right 5%, left 4%). Males use legs equally (46%), while females favor the right leg (49%), and hands more (6%). Mean right leg score was 5.79 (SD 5.69), left hand 0.51 (SD 1.04). Kruskal-Wallis showed significant limb differences ($p = .000$); Dunn's test confirmed legs scored more than hands ($p = .000$), with no

significant difference between the right and left legs or between the right and left hands. **Conclusion:** Taekwondo players primarily score using their legs, especially kicks, with women relying more on the right leg, highlighting the importance of strong and well-practiced kicking techniques for success.

Keywords Sparring Tactics, Limb Dominance, Gender Differences, Scoring Efficiency

1. Introduction

Taekwondo is a Korean martial art and modern Olympic sport that emphasizes powerful kicking and striking techniques [1], [2]. The term taekwondo is translated as "the way of kicking and punching," reflecting both its physical execution and philosophical underpinnings [3]. Its origins can be traced to traditional Korean martial systems such as taekkyon, subak, and gwonbeop [4], [5]. During the 1940s and 1950s, taekwondo was formalized by martial artists who synthesized native practices with external

influences from Chinese and Japanese combat styles [6], [7].

In 1959, the Korea Taekwondo Association (KTA) was established to unify the diverse martial arts schools, or kwans, under a single national identity [8], [9]. Initially known as the Korea Tang Soo Do Association, the organization was largely shaped by General Choi Hong Hi, who promoted his Chan Hon-style taekwondo [10]. However, this centralized approach faced opposition from other kwan leaders, who favored a more collective style that reflected the shared traditions of all schools [11]. The conflict led to Choi's departure from the KTA in 1966 [8], after which two major branches of taekwondo emerged: the International Taekwondo Federation (ITF), led by Choi, and the World Taekwondo (WT) system, focused on sport-based development and Olympic recognition [12].

To formalize a unified and internationally recognized style, the Kukkiwon was established in 1972 by the KTA and South Korea's Ministry of Culture, Sports, and Tourism [13]. As the World Taekwondo Headquarters, Kukkiwon took responsibility for standardizing techniques, certification systems, and competitive rules [9], [14]. The following year, the World Taekwondo Federation (WTF) was formed to govern international competitions, and in 2017 it was renamed World Taekwondo (WT) to eliminate confusion with unrelated acronyms [2], [15].

Taekwondo debuted as a demonstration sport at the 1988 Seoul Olympics and was later recognized as an official medal sport following the 103rd International Olympic Committee session in 1994 [16]. It became a full medal event at the 2000 Sydney Olympic Games and was included in the Asian and Commonwealth Games respectively in 1986 and 2010 [17]. Today, WT oversees global governance of Olympic taekwondo and is a member of the Association of Summer Olympic International Federations (ASOIF).

Taekwondo evolved into a global sport known for explosive kicks, discipline, and respect [18]. Modernization, institutional support, and technology like electronic scoring boosted its Olympic legitimacy and performance assessment. As the sport continues to evolve, performance analysis plays an increasingly important role in optimizing athlete development and competitive success. Modern full-contact sparring demands not only physical conditioning but also rapid tactical decision-making involving technique selection, timing, and target identification [19]. Among these factors, limb selection is the choice of arm or leg used for offensive or defensive actions and has emerged as an important contributor to scoring efficiency [20], [21].

Despite its relevance, limited empirical research has investigated the role of limb selection in elite-level scoring outcomes. Understanding which limbs contribute most effectively to point accumulation can provide valuable insights into biomechanics, motor learning, and competition strategy. In light of this gap, the present study

seeks to explore limb usage patterns during high-scoring exchanges in international-level Taekwondo. Accordingly, the research addresses the following question: What are the limb selection patterns associated with high-scoring actions in international-level Taekwondo sparring? This research aims to identify and analyze the most effective limbs used during scoring actions, thereby contributing to evidence-based coaching practices and enhanced athlete performance at the elite level.

2. Materials and Methods

2.1. Participants

This study analyzed data collected from 320 sparring athletes representing 99 countries, selected based on the availability of match footage. The competitors participated in the following weight categories: Men's divisions included -54kg, -58kg, -63kg, -68kg, -74kg, -80kg, -87kg, and +87kg, while Women's divisions that comprised -46kg, -49kg, -53kg, -57kg, -62kg, -67kg, +67kg, and +73kg. 20 male and 20 female athletes from each weight category were selected for video analysis (Figure 1).

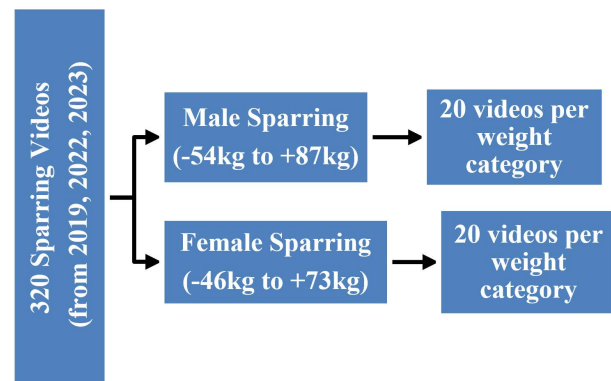


Figure 1. Distribution of 320 Sparring Videos across Male and Female Weight Categories from the 2019, 2022, and 2023 World Taekwondo Championships

2.2. Study Design

This descriptive observational study aimed to identify limb selection patterns that contribute to successful point scoring in elite-level taekwondo sparring. A total of 320 sparring videos were randomly selected based on online availability and clarity of visibility from the World Taekwondo Championships, which took place in Manchester, United Kingdom, in 2019, were canceled in 2020 and 2021 due to COVID-19, and resumed in Guadalajara, Mexico, in 2022 and Baku, Azerbaijan, in 2023. Videos were sourced from publicly accessible platforms such as World Taekwondo official channels and YouTube, and only clear, full-length matches featuring uninterrupted action and electronic scoring systems were

included. Each match was reviewed to identify which limb was used to score each point, specifically the right hand, left hand, right leg, or left leg. Two trained observers independently coded the videos, and any disagreements were resolved through discussion. To ensure consistency in the coding process, two independent observers analyzed the videos separately. They showed excellent agreement (Cohen's $\kappa = 0.98$), and any initial disagreements were settled through discussion to guarantee reliable scoring of the sparring videos. This step helped confirm that the observations were reliable and not based on individual bias or error. The total number of points scored by each athlete using each limb was recorded, and the data were analyzed to determine whether statistically significant differences existed in scoring effectiveness between the limbs.

2.3. Test Protocol

Two independent observers meticulously reviewed each match frame-by-frame, recording every scoring action according to the limb used—right hand, left hand, right leg, or left leg. Any discrepancies between observers were discussed and resolved to ensure data accuracy. Discrepancies between observers were discussed and resolved to ensure data accuracy. The compiled points scored by each limb for every athlete were then prepared for statistical analysis.

2.4. Data Collection Procedure

Both video analysts, who are national-level taekwondo players chosen for their strong knowledge of the rules and scoring system, independently reviewed the matches and recorded points scored by each limb. Afterward, their observations were compared. If the scores matched, the data were accepted. If there were any differences, the analysts reviewed the videos together to resolve the discrepancies. Once all differences were settled, the final data were entered into a spreadsheet for further statistical analysis.

2.5. Statistical Analysis

Data were analyzed by SPSS software using both descriptive and inferential statistical methods. Descriptive statistics, including percentage, mean, and standard deviation, were used to summarize the distribution of points scored by each limb. Tests for normality and homogeneity of variance indicated violations of assumptions for parametric analysis. Therefore, the non-parametric Kruskal-Wallis H test was applied to compare differences in scoring among limbs. When a significant result was found, pairwise post-hoc comparisons were conducted using Dunn's test with Bonferroni correction to identify specific group differences. Statistical significance was set at $p < .05$ (2-tailed). With a medium effect size ($\epsilon^2 = 0.06$) and significance ($\alpha = 0.05$), the Kruskal-Wallis test showed high power ($1-\beta = 0.99$ for the combined group ($N = 320$) and $(1-\beta) = 0.93$ for both male and female groups ($N = 160$ each).

3. Results

Figure 2 indicates that both male and female taekwondo athletes predominantly rely on their legs for scoring, with significantly less use of the hands. When combining male and female data, 47% of points were scored using the right leg and 43% with the left leg, while only 5% and 4% were scored using the right and left hands, respectively. Male athletes showed equal reliance on both legs, each contributing 46% of the total points, with only 5% and 3% scored by the right and left hands. In contrast, female athletes showed a stronger preference for the right leg, which accounted for 49% of their points, while the left leg contributed 39%. Notably, women used both the right and left hands slightly more than men, with 6% each. This pattern suggests a clear dominance of leg-based techniques in taekwondo, with some gender-based variation in limb preference.

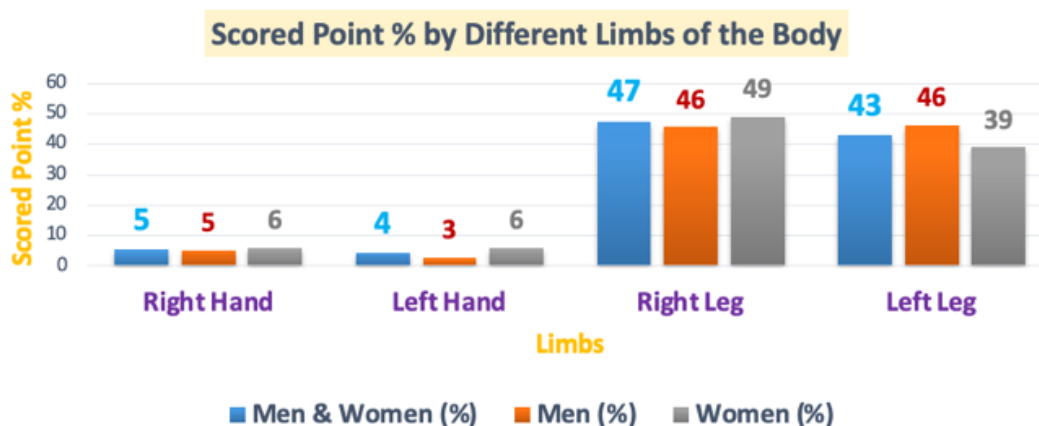


Figure 2. Percentage of Scored Points by Different Limbs

The descriptive statistics (Table 1) indicate a clear dominance of leg-based scoring in taekwondo among both male and female athletes. When analyzing the data for all participants combined, the right leg accounted for the highest mean score ($M = 5.79$, $SD = \pm 5.69$), followed by the left leg ($M = 5.24$, $SD = \pm 4.98$). In contrast, hand usage was considerably lower, with the right hand showing a mean score of 0.66 ($SD = \pm 1.22$) and the left hand at 0.51 ($SD = \pm 1.04$). Further, gender-specific analysis revealed subtle variations in limb usage. Male athletes demonstrated a strong preference for leg-based scoring, particularly with the left leg ($M = 6.06$, $SD = \pm 5.59$) and right leg ($M = 5.99$, $SD = \pm 6.00$). Hand usage remained minimal, with the right hand scoring ($M = 0.66$, $SD = \pm 1.26$) and the left hand scoring the lowest ($M = 0.38$, $SD = \pm 0.89$). In contrast, female athletes also relied more heavily on their legs, with the right leg ($M = 5.58$, $SD = \pm 5.37$) and left leg ($M = 4.41$, $SD = \pm 4.14$) contributing the most to overall points. Notably, females showed equal use of both hands, each with a mean score of 0.64, although the standard deviation for the left hand was higher ($SD = \pm 1.68$) compared to the right hand ($SD = \pm 1.19$), suggesting greater variability in

left-hand scoring. These findings' descriptive analysis confirms that leg techniques are the primary mode of scoring in taekwondo, with slight gender-based differences in limb preference and consistency.

The Kruskal-Wallis (Table 2) test revealed statistically significant differences in points scored across the four limb categories (right hand, left hand, right leg, left leg) for the combined group, with a chi-square (χ^2) value of 466.805 and degree of freedom (df) 3 ($p = .000$). Separate analyses also showed significant differences for males ($\chi^2 = 254.035$, $df = 3$, $p = .000$) and females ($\chi^2 = 215.362$, $df = 3$, $p = .000$). These results indicate that scoring distribution varies significantly among limbs across all groups. In both cases, the null hypothesis was rejected, confirming that the distribution of points varies across limb categories within each gender. These findings suggest that the limb used in taekwondo sparring significantly influences scoring patterns. A follow-up analysis using pairwise comparisons, such as Dunn's test with Bonferroni adjustment, is recommended to determine which specific limb pairs differ significantly in their scoring performance.

Table 1. Descriptive Statistics of Points Scored by Limbs

Points Scored	N	Limbs	Descriptive Statistic	
			Mean	Std. Deviation
Male & Female Together (point)	320	Right Hand	Mean	.66
			Std. Deviation	± 1.224
		Left Hand	Mean	.51
			Std. Deviation	± 1.044
		Right Leg	Mean	5.79
			Std. Deviation	± 5.687
		Left Leg	Mean	5.24
			Std. Deviation	± 4.978
Male (point)	160	Right Hand	Mean	.66
			Std. Deviation	± 1.261
		Left Hand	Mean	.38
			Std. Deviation	± 0.889
		Right Leg	Mean	5.99
			Std. Deviation	± 5.999
		Left Leg	Mean	6.06
			Std. Deviation	± 5.587
Female (point)	160	Right Hand	Mean	.64
			Std. Deviation	± 1.189
		Left Hand	Mean	.64
			Std. Deviation	± 1.68
		Right Leg	Mean	5.58
			Std. Deviation	± 5.368
		Left Leg	Mean	4.41
			Std. Deviation	± 4.140

Table 2. Hypothesis Test Summary among the Limbs

Group	Null Hypothesis	Test	Test Statistics ^{a,b}			Decision
			Chi-Square	df	Sig.	
Male & Female Together	The distribution of points is the same across categories of limb.	Independent – Samples Kruskal-Wallis Test	466.805	3	.000*	Reject the null hypothesis
Male	The distribution of points is the same across categories of limb.	Independent – Samples Kruskal-Wallis Test	254.035	3	.000*	Reject the null hypothesis
Female	The distribution of points is the same across categories of limb.	Independent – Samples Kruskal-Wallis Test	215.362	3	.000*	Reject the null hypothesis

a. Kruskal-Wallis Test; b. Grouping Variables: Limb; Significance level is $\alpha=.05$; *The mean difference is significant at the .05 level.

Table 3. Pairwise comparison among the Limbs

Group	N	Sample 1 VS Sample 2	Sig.	Remarks
Male Female Together	320	Left Hand VS Right Hand	.245	Not Significant
		Left Hand VS Left Leg	.000*	Significant
		Left Hand VS Right Leg	.000*	Significant
		Right Hand VS Left Leg	.000*	Significant
		Right Hand VS Right Leg	.000*	Significant
		Left Leg VS Right Leg	.916	Not Significant
Male	160	Left Hand VS Right Hand	.931	Not Significant
		Left Hand VS Left Leg	.000*	Significant
		Left Hand VS Right Leg	.000*	Significant
		Right Hand VS Left Leg	.000*	Significant
		Right Hand VS Right Leg	.000*	Significant
		Left Leg VS Right Leg	1.00	Not Significant
Female	160	Left Hand VS Right Hand	1.00	Not Significant
		Left Hand VS Left Leg	.000*	Significant
		Left Hand VS Right Leg	.000*	Significant
		Right Hand VS Left Leg	.000*	Significant
		Right Hand VS Right Leg	.000*	Significant
		Left Leg VS Right Leg	1.00	Not Significant

2-tailed tests; Significance level is $\alpha = .05$; *The mean difference is significant at the $p = .05$ level.

The post hoc analysis (Table 3) using Dunn's pairwise comparisons reveals that athletes score significantly more with their legs than with their hands. For the combined group of male and female athletes, significant differences were found between the left hand and both the left leg ($p = .000$) and right leg ($p = .000$), as well as between the right hand and both the left leg ($p = .000$) and right leg ($p = .000$). However, no significant difference was found between the left and right hands ($p = .245$) or between the two legs ($p = .916$), indicating similar scoring within each pair. This pattern is consistent within both male and female groups. Among males, significant differences were observed between both hands and both legs (all $p = .000$), while no significant difference was found between the left and right hands ($p = .931$) or between the two legs ($p = 1.00$).

Similarly, in the female group, leg techniques significantly outperformed hand techniques (all $p = .000$), with no difference between hands ($p = 1.00$) or between legs ($p = 1.00$). These results confirm that leg techniques, especially the right leg, arithmetically are the dominant method of scoring in taekwondo, with consistent trends across genders. The hands contribute minimally, and their scoring effectiveness is statistically similar, reinforcing the tactical importance of leg use in competitive sparring.

4. Discussion

Understanding which limbs contribute most to scoring in taekwondo is essential not only for optimizing athlete

training and strategy but also for informing coaching policies and resource allocation to improve competitive performance at all levels. The data show that both male and female taekwondo athletes primarily score with their legs. Combined data indicate 47% of points came from the right leg and 43% from the left leg, while the right and left hands contributed only 5% and 4%, respectively. Males used both legs equally (46% each) and scored 5% and 3% with the right and left hands. Females favored the right leg (49%) over the left leg (39%) and used both hands slightly more (6% each). This highlights leg dominance in scoring, with notable gender differences in limb use. Further, significant differences in points scored across limbs for the combined group ($\chi^2(3) = 466.81, p = .000$), males ($\chi^2(3) = 254.04, p = .000$), and females ($\chi^2(3) = 215.36, p = .000$), indicating varied scoring distribution among limbs. In addition, athletes scored significantly more with their legs than with hands ($p = .000$), with no difference between left and right hands or between legs. This pattern was consistent across genders, underscoring the dominance of leg-based techniques in taekwondo scoring.

In taekwondo, the legs can generate higher torque and, when combined with a jump, produce significantly greater force than a hand punch, making kicks more effective for scoring [22]. Leg length is longer than the hand [23]. The rule of Taekwondo permits to use the leg and hand for scoring and defending, which is also important [24], [25]. Therefore, using the leg is more advantageous to reach further. Mostly, the right side is the dominant side, and in both genders, right leg strength is greater than the left, but a notable difference exists in female leg strength [26]. Limb symmetry index is higher in males than in females, which leads to uneven strength development of legs more in females [27]. In the context of reaction time in both males and females, no statistically significant difference was found between the legs; however, the right leg was consistently faster arithmetically, with males showing slightly better reaction times overall [28]. Existing literature mostly supports the findings. Hence, Taekwondo players use their legs more than their hands because leg kicks generate greater reach, speed, and power, making them more effective for scoring points while keeping opponents at a distance.

4.1. Study Limitations

This study has a few limitations. Videos available on public platforms might have caused observer bias due to different camera angles and visibility, despite the fact that agreement between observers was high. Players' limb selection might have been affected by the changes in Taekwondo rules from 2021 to 2023, particularly in scoring. Since the study was observational and based on available footage, it may not accurately represent the performance of the entire population of competitors. Factors such as stance, opponent style, and match speed were also not considered, which could have influenced

limb use patterns.

5. Conclusions

In conclusion, taekwondo athletes mainly use their legs to score points, with kicks being far more effective than hand strikes. Both men and women show this trend, though women tend to rely a bit more on their right leg. Overall, the results highlight how important strong and well-practiced kicking techniques are for success in taekwondo. It is recommended for Taekwondo trainers and players to implement drills that balance limb use and develop strategies to optimize right-leg dominance.

5.1. Future Directions

Future research should include the current study's limitations by applying advanced statistical methods, such as Generalized Linear Mixed Model (GLMM) or regression, to account for weight class, stance, and year, providing an additional comprehensive understanding of sparring performance.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research paper.

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