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KINEMATIC DIFFERENCES IN THE ROUNDHOUSE KICK AMONG UNIVERSITY TAEKWONDO PLAYERS: BRIEF REPORT

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Abstract This study aimed to investigate the bilateral kinematic differences in temporal variables between the dominant and non-dominant legs in the roundhouse kick of college-level women practicing Taekwondo. Four male athletes with black belts volunteered to participate in the study. Participants were instructed to perform five kicks with each leg after visual stimuli at maximal velocity allowing 30-s passive recovery time between each kick. Reaction time, movement time, and attack time in the roundhouse kick were assessed using video cameras and force platforms for both the dominant and non-dominant legs.

The analysis revealed no significant differences in reaction times (0.15 ±0.03 and 0.15 ±0.04 s, n = 20), movement times (0.62 ±0.06 and 0.64 ±0.04 s, n = 20), or attack times (0.77 ±0.09 and 0.79 ±0.06 s, n = 20) for the dominant and non-dominant legs ($p > 0.05$). However, a bilateral dominance was observed, consistent with the sporting level of the participants. These results support an equally oriented training regimen focusing on both the left and right kicking legs to enhance overall performance in Taekwondo.

Key words: sports biomechanics, medium roundhouse kick, college athletes, taekwondo, kinematics

Introduction

Taekwondo (TKD) is a Korean-origin martial art that has been considered an Olympic sport since 2000 (De Prado et al., 2011). What distinguishes TKD from other combat sports is that even though its name can be translated as the art of punching and kicking, it presents a predominant use of the legs over the arms (Park et al., 2009; Rufino Añorbe, 2017), whereas the medium roundhouse kick is not only one of the most widely implemented movements in the discipline but also one of those that can generate greater strength and speed (Falco et al., 2013; Pieter & Pieter, 1995).

Due TKD it is a combat sport, numerous studies focus on recognizing the factors that intervene or influence sports technique, where biomechanics has made interesting contributions to improve sports performance (De la Fuente & Gómez-Landero Rodríguez, 2019; Falco et al., 2013). Comparisons by sporting levels have made it possible to recognize the kinematic and neuromuscular variables that describes the elite TKD athletes from non-elite ones, the latter presenting a longer time to initiate the movement, although both groups are the same regarding the EMG of the knee extensors (Ervilha et al., 2020).

Other reports on TKD compare athletes of different competitive levels in physical and physiological profiles (Moreira et al., 2016) focusing mainly on the effect of impact (Estevan & Falco, 2013; Quinzi et al., 2013; Thibordee & Prasartwuth, 2014). In this sense, the use of the dominant (D) and non-dominant (ND) leg is a controversial issue in sports medicine (Falco et al., 2013), in the practice of TKD the use of a particular leg is usual during training, however, reaching the elite level requires symmetrical skills on both legs (Tang et al., 2007) as well as quick reaction time for greater success in competitions (Junior et al., 2020; Vieten et al., 2007).

These demands have been analyzed in a wide variety of studies (Yilmaz, 2023). In terms of reaction speed in TKD, comparisons between medalists vs. non-medalists are targeted, specifically addressing motor differences in TKD cadet athletes according to a competitive level and competitors vs. non-competitors (Falco, et al., 2009; Vieten et al., 2007) reporting that a lower reaction speed is characteristic of competitors of a higher sporting level.

The Roundhouse Kick (RHK) is a motor gesture that has been studied considering bilateral comparisons in elite black belt athletes. Competitive athletes have reported no differences in impact force and temporal reaction variables between their D and ND legs, regardless of the target distance (Falco, et al., 2009; Tang et al., 2007). Likewise, medalists athletes showed greater impact force and shorter execution time than non-medalists (Estevan et al., 2013).

When the participants are induced to fatigue reaction time increases as well as kick impact decreases (Sant'Ana et al., 2017). To the best of our knowledge, research has primarily concentrated on investigating performance variables in elite athletes, with limited attention paid to undergraduate performance. Furthermore,

much of the available data has been collected in developed countries such as Korea, Japan, the USA, or the UK. However, there is a significant gap in information regarding this topic in Latin America. Therefore, the present study is designed to address this gap and aims to assess bilateral kinematic variations in temporal variables during the execution of the mean roundhouse kick in college-level women practicing Taekwondo in Mexico.

Material and Methods

Participants

Four female Black Belt taekwondo athletes (age: 23.5 ±2.9 years, weight: 63.0 ±12.9 kg, height: 161.0 ±5.5 cm, experience: 10.8 ±3.2 years) voluntarily participated in the study and provided informed consent in accordance with the Helsinki Declaration. Their training regimen included at least three two-hour sessions per week, with two of them being non-competitive at the time of the study. The study was approved by the by committee scientific board of the Autonomous University of Chihuahua with registration code 210923-064.

Table 1. General characteristics of the participants

Subject	Age (Years)	Weight (kg)	Height (cm)	Experience (Years)
1	27	80	164	8
2	23	57	155	14
3	24	50	158	13
4	20	65	167	8
Mean	23.5	63.0	161.0	10.8
±SD	2.9	12.9	5.5	3.2

The circular roundhouse kick test was executed by the participant and captured using a setup comprising 12 active cameras (Vicon®), operating at a sampling frequency of 100 Hz and included 39 reflective passive markers with a diameter of 12 mm were placed on bone anatomical landmarks of the body proposed by Vicon®.

An additional video camera (Basler model a2A1920-51gmBAS) with a sampling frequency of 50 Hz was used to synchronize the visual stimulus and calculate the reaction time. This camera was employed to ascertain the duration during which the light source was active. Following this interval, the activation of movement time was initiated and consistently identified until alterations were discerned by the force platform. The participant was questioned as to their preferred leg to discriminate their dominant and non-dominant leg.

The test involved executing five repeated medium roundhouse kicks using both the dominant and non-dominant kicking legs, with a 30-second rest between each kick. Participants were instructed to execute the kick as quickly as possible after observing the visual stimulus (a light) and aiming to hit the palchagui target and return to the starting position (as shown in Figure 1).

The study recorded changes in Ground Reaction Force (GRF) using two force platforms (AMTI) connected analogically at a sampling frequency of 1000 Hz. The data were processed using Nexus 2.5 software. Prior to the test, the subjects underwent anthropometric measurements necessary for data analysis, including body mass and height measured using a digital scale and stadiometer (Tanita WB 3000). The visual stimulus was determined using a red LED light, and the target was to hit a palchagui.

The trochanter-ankle length allows the height of the hitting palchagui and is then adjusted by the subject.

Experimental procedure

Each subject underwent a joint warm-up and a period of kicking the palchagui, accumulating a total of 10 minutes. Once the warm-up was complete, the legs were placed on the force platforms, with the palchagui and visual stimulation located in front at a comfortable distance for the subject.

The test consisted of executing five repeated medium roundhouse kick with the left and right legs; a 30-second rest was given between each kick. After observing the visual stimulus getting on, the kick should be executed as quickly as possible, aiming to hit the palchagui and return to the starting position (Figure 1).

Figure 1. The sequence of the roundhouse kick

The variables recorded in this study were:

i) Reaction time (RT): This refers to the time that elapses once the light of the visual stimulus is turned on and the moment in which the force plate registers contact changes in the attacking leg.
ii) Movement time (MT): This is the time immediately after the RT until the attacking leg contacts the palchagui. This was measured trough motion analysis.
iii) Attack time (AT): This is the sum of RT and MT, representing the total time taken to execute the kick from the moment the visual stimulus is presented.

Statistical analysis

Statistical analysis involved Wilcoxon test to compare between the two legs (D and ND). For intra-subject comparisons, an ANOVA of one factor with post hoc and Bonferroni corrections was used, with a significance level of 0.05. The outcomes of the statistical analysis were employed to identify significant differences among the measured variables, including reaction time, movement time, and attack time, utilizing the Statistical Package for the Social Sciences version 15.0.

Results

Figure 2 shows no significant differences found between the dominant (D) and non-dominant (ND) leg in terms of mean times for each phase of RT (0.15 ±0.03 and 0.15 ±0.4 s, n = 20), MT (0.62 ±0.06 and 0.64 ±0.04 s, n = 20) and AT (0.77 ±0.09 and 0.79 ±0.06 s, n = 20) respectively for D and ND leg.

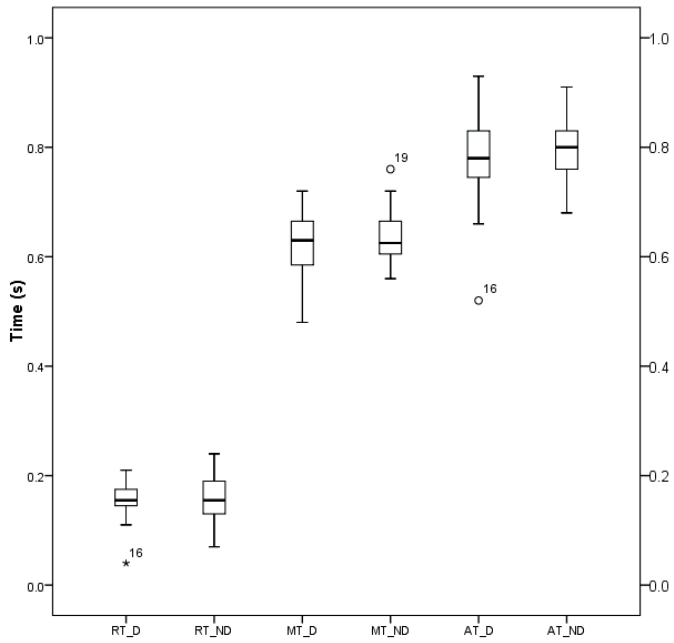

Figure 2. Mean values for times in the dominant (D) and non-dominant (ND) leg in reaction (RT), movement (MT) and attack (AT)

Table 2 shows mean and SD for reaction time (RT), movement time (MT) and attack time (AT) for both kicking legs. Intrasubject comparison confirms that participant 4 has the lower time for most of kicking variables within bilateral components.

Table 2. Within-subject comparisons for the variables reaction time (RT), movement time (MT), and attack time (AT) between the dominant leg (D) and the non-dominant leg (ND)

Variable	Leg	Subject	Number of attempts	Mean (s)	Standard deviation
RT	Dominant	1.00	5	0.17	0.02
		2.00	5	0.14	0.02
		3.00	5	0.18	0.03
		4.00	5	0.14	0.06
		Total	20	0.16	0.04
MT	Dominant	1.00	5	0.64	0.03
		2.00	5	0.64	0.02
		3.00	5	0.68	0.04
		4.00	5	0.52*	0.03
		Total	20	0.62	0.07
AT	Dominant	1.00	5	0.81	0.05
		2.00	5	0.78	0.01
		3.00	5	0.85	0.06
		4.00	5	0.66*	0.08
		Total	20	0.78	0.09
RT	Non-Dominant	1.00	5	0.18	0.03
		2.00	5	0.18	0.04
		3.00	5	0.16	0.04
		4.00	5	0.10†	0.03
		Total	20	0.15	0.05
MT	Non-Dominant	1.00	5	0.60	0.02
		2.00	5	0.64	0.02
		3.00	5	0.69	0.03
		4.00	5	0.63	0.08
		Total	20	0.64	0.05
AT	Non-Dominant	1.00	5	0.78	0.03
		2.00	5	0.82	0.05
		3.00	5	0.85	0.04
		4.00	5	0.73ⱪ	0.06
		Total	20	0.79	0.06

*Differences compared to the rest of the participants: † differences with participant 1 and 2; ⱪ differences with participants 2 and 3. Where: RT = reaction time; MT = movement time; AT = attack time.

Discussion

As expected for representative athletes at the university level and with a black belt category in TKD, they manage to maintain the same reaction times regardless of the dominant or non-dominant legs, which seems to be a common denominator in studies with subjects of that sports level. Developing the ability to hit in combat with both legs offers a perspective of symmetry. The same was reported by Kim and Kim (2010) mentioning that the reaction

times were similar for both legs, but they also evaluated other types of kicks such as front, side, back, thrashing, and turning-back kicks, with the same results in subjects with 10 years of experience in that sport.

On the other hand, Wąsik et al. (2018) and Andrzejewski and Elbaum (2005) found that the dominant leg had higher speed values, however their sample was made up of subjects with around five years of experience and the execution included targets of different sizes, as well as using the front kick. What it suggests is that by suggesting a test protocol with small objects (table tennis ball) subjects tend to focus their efforts on contacting the ball by stimulating specific areas of the brain involved in a manual response to peripheral visual stimulation that results in better times with the dominant leg. Another study also points out similarities in the dominant extremity and ND in kick speed, concluding that the participants present an inter-segmental coordination movement according to their elite sports level (Harun & Xiong, 2010).

The investigation into the bilateral symmetry of kicks has been explored by Yilmaz et al. (2021), their research delves into the examination of the preferred leg versus the non-preferred leg among TKD players. Remarkably, the study reveals an absence of discernible bilateral or ipsilateral strength ratios across various angular velocities. Nonetheless, the findings of the study also highlight significant inter-limb strength variations within individual legs, thereby adding nuance to our understanding of the intricate biomechanical aspects involved in executing kicks within the Taekwondo discipline.

Bilateral asymmetry, characterized by discernible differences between the dominant and non-dominant limbs, bears implications for combat sports as it may give rise to imbalances during engagements. While not inherently indicative of overall sports performance, it has been acknowledged as a contributing factor to the susceptibility of athletes to sports-related injuries (Lee et al., 2023). Recently (Harbili et al., 2022), noteworthy findings emerged, revealing an absence of significant strength distinctions between the dominant and non-dominant legs among TKD participants. The disparities in bilateral performance domain may be attributed to multifaceted factors, encompassing sample-specific characteristics, nuances in measurement methodologies, the distinct demands of task-specific movements, and the potential influence of varied training interventions. This underscores the intricacies involved in comprehending the role of bilateral asymmetry in the context of Taekwondo, prompting a holistic consideration of diverse variables in research and practice.

On the other hand, it must also be considered that auditory stimuli may not represent the best scenario of ecological validity since it is not a task that is commonly used in training or competition, in these cases, the visual part is the greatest trigger to initiate the motor gesture of the kick as we used in this study (Ervilha et al., 2020).

In relation to movement time, which is the interval immediately following the RT until the leg contacts the target, no changes were detected due to laterality. A consistent bilateral performance was observed with both left and right kicking leg. In this parameter, there are few references or similar studies, one of them was performed in the Frontal kick, the authors report 50% less time in this variable than our study subjects since the action requires less commitment and displacement of body segments than the roundhouse kick used in this study (Tsai et al., 2005).

Whether the movement time of the roundhouse kick can vary depending on the distance of the kicking leg and the target. In this regard, Kong et al. (2000) conclude that the trailing leg will take significantly longer to reach the target, however, it produces greater velocity due to the rotational components of the hip and trunk, thus generating greater momentum. Although it has also been reported that the greatest impact force is found at short distances, the author attributes that it is due to the visual stimulus as a trigger for the start of the movement, which requires a longer response time over long distances (Falco et al., 2013).

Intrasubject comparisons reveal that subject 4 exhibited significantly better performance than their peers. This can be attributed to their impressive sports record, which has earned them national-level awards and even a prestigious Teporaca award at the state level for their exceptional athletic achievements. The findings of this study provide valuable information about the potential connection between their performance in this study and their remarkable accomplishments in the field of sports.

Applications

The findings of this study have practical applications as a guide for dosing training in Taekwondo (TKD). The study reinforces the proposal that bilateral symmetry in leg strength is indicative of high-level athletes. Furthermore, it has been associated with a decrease in sports-related injuries due to balanced utilization of both the dominant and non-dominant legs. Therefore, these results can be utilized to optimize training programs in TKD, ensuring a balanced development of leg strength and reducing the risk of injuries.

Limitation of the study

Firstly, the relatively small sample size (n=4) may constrain the generalizability of our results. Larger sample sizes would enhance the robustness and external validity of the study. Secondly, our study specifically evaluated the roundhouse kick, while this allowed for a detailed examination of a specific technique, it limits the extrapolation of our findings to the broader spectrum of Taekwondo movements. The diversity of techniques within Taekwondo warrants consideration for a comprehensive understanding of bilateral comparisons. Moreover, the controlled environment in which the assessments took place may introduce a level of artificiality. Real-world combat scenarios involve additional stressors such as competitive pressure and heightened stress levels, which could impact performance differently. Therefore, the ecological validity of our study in mirroring actual combat situations may be a point of consideration.

Conclusion

Similar values of Reaction Time (RT), Movement Time (MT), and Action Time (AT) were found regardless of the leg used, suggesting that it is attributable to training time and skill level observed in individuals with Black Belt rank. This also allows for a bilateral training guide where both stances are trained to enhance success in this sport. By emphasizing the training using left and right legs, athletes can improve their overall performance in Taekwondo.

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