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ORIGINAL ARTICLE

Striking with precision: The mechanics of the flying front snap kick and side punch for an elite female taekwondoin

Stephanie Kew Yen Nee . *Exercise and Sports Science. School of Health Sciences. University Sains Malaysia. Kubang Kerian, Kelantan, Malaysia.*
Sport Calgary. Father David Bauer Olympic Arena. Calgary, Alberta, Canada.

ABSTRACT

Taekwondo is a combat sport popular for its high-flying kicks and hard-hitting punches. Intrigued by the underlying techniques, this research aims to analyze and understand the intricate mechanics of flying front snap kicks, valued for their agility, and side punches, scrutinized for their effectiveness in close-quarters combat. Despite their distinctive potential efficacy, there is a lack of existing literature that delves into the details of these techniques, unlike roundhouse kicks and straight punches. In this study, a taekwondoin, Stephanie Kew Yen Nee, who achieved the remarkable feat of holding a black tip rank within a year, performed the kicks and punches. Every execution was captured in the form of three-dimensional (3D) data and examined through frame-by-frame analysis. The key findings demonstrated that the flying front snap kick necessitates well-coordinated body movements, including the lifting through contractions of the hip and leg muscles, which are vital for generating momentum. The side punch, on the other hand, predominantly depends on the right thoracic rotation and activation of the core muscles to exert force. Therefore, analyzing these mechanics can facilitate the tactical integration of these techniques into different facets of Taekwondo, including sparring and self-defense.

Keywords: Performance analysis, Taekwondo, Biomechanics, Elite athlete, Flying front snap kick, Side punch, Martial arts performance.

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Corresponding author. *Exercise and Sports Science, School of Health Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.*
E-mail: stephanieyenneekew77@gmail.com
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INTRODUCTION

Within the combat sports community, Taekwondo, also defined as Tae (foot) Kwon (fist) Do (the art), is a discipline characterized by high-intensity short activity (Santos et al., 2020). Taekwondo has its origins in the historical practices of Korea, and it generally began to form during the mid-20th century. Typically, century-old customs and modern athletic components coexist in Taekwondo. In the domain of physical prowess, the core skills of Taekwondo revolve around the impeccable method of delivering precise attacks and the effective ability to perform forceful strikes. Practitioners of Taekwondo, referred to as "*taekwondoin*," undergo intense training to become proficient in various kicks. Equally important to kick, punching techniques form a well-rounded repertoire for practitioners since they complement the kicking techniques, which is crucial to bring about a balanced skill set for both defensive and offensive manoeuvres. Undoubtedly, the International Taekwon-Do Federation (ITF) is known for its flying kicks and powerful punches. Comparatively to other Taekwondo academies, it is more traditional-oriented, and highly regarded for its patterns with a heavier emphasis on self-defence. The wide variety of kicking and punching techniques not only establishes ITF as a formidable combat sport but also presents a great opportunity to discover the fascinating human movement and the underlying mechanics behind all these techniques.

In Taekwondo, the flying front snap kick could be regarded as an elite weapon in sparring. While numerous kinds of kicks are staples in combat sports, the flying front snap kick adds a unique element that encapsulates a fusion of agility and precision. This kick is hugely characterized by its aerial nature, where it entails propelling the body into the air to generate a rapid and precise frontal strike. Principally, the power for this kick is mainly generated from both the hip and leg muscles engagement that create momentum, which is responsible for propelling the body in the direction of the target. However, to ensure that the maximum force is applied, it is essential to maintain a straight and tense kicking leg at impact. Moreover, for this kick to be executed effectively with stability upon landing, the key elements of balance and control have to be taken into account. In essence, such a kick not only empowers practitioners with the ability to traverse considerable large distances but also surprises opponents by catching them off guard with unexpected strikes. Despite its potential effectiveness, according to the existing works of literature, unlike the roundhouse kick (Falco et al., 2013; Thibordee & Prasartwuth, 2014; Sant'Ana et al., 2016), the flying front snap kick remains relatively unexplored.

Side punch known as lateral punch is a versatile striking technique. The mechanics of a side punch involve a stable stance to ensure a solid base, rapid rotation of the torso, and proper body alignment for power generation and good balance. As opposed to straight punches which were studied in some literary works (Wasik et al., 2013; Wasik & Nowak, 2015; Wasik et al., 2017), a side punch involves lateral motion in which the practitioner strikes with force from unconventional angles. Comparatively, although straight punch is commonly employed, when facing close-quarters combat, side punch can potentially surpass its advantages. A finding by Wąsik et al. (2017) discussed that factors such as distance can likely have an impact on striking efficiency. In this context, by executing a side punch, practitioners can effectively strike from confined spaces where a straight punch might be less feasible thereby, facilitating adaptability. Hence, understanding the mechanics behind side punch is crucial for enhanced practicality, particularly when strategically integrating this punching method into sparring and self-defence scenarios.

The Environmental Success Factors (ESF) model

The framework utilized for analysing various factors that lead to success within a specific field is generally called the ESF model. According to Henriksen and Stambulova (2023) the ESF model can be described as a working model that represents the success of the athletic talent development environment (ATDE) based

on the holistic ecological approach (HEA) introduced by Henriksen et al. (2010). It is an interplay between various components, that encompasses individual development (athletic skills, resilience, and rank), preconditions, and processes alongside the organizational culture. Similarly to a great deal of other sports be it individual or team sports (Larsen et al., 2013), the ESF model can also be applied to ITF Taekwondo to assess the vital elements influencing practitioner success and the efficacy of training regimens. Through the ESF model, the methods in which preconditions and processes, in addition to contextual inputs, interact to yield outputs from the combat sports environment to the ultimate success can all be elucidated. With an awareness of these elements, practitioners can maximize overall performance and accomplish the set objectives.

ITF taekwondo training environment

An important aspect that can significantly influence the development of ITF practitioners is the training environment itself. In general, this aspect takes into account the physical amenities, training techniques, coaching personnel, and last but not least, the overall ambiance of the training facility. To ensure effective training, facilities are designed such that they can accommodate a range of training requirements, from form practice that requires a clear, unobstructed area to sparring with suitable flooring that minimizes impact forces and reduces the risk of serious injury. In terms of training approaches, a blend of conventional and modern sports techniques is adopted. For example, one of the traditional methods is flexibility training to improve the range of motion in critical muscles and joints, often equipped with straps and blocks to aid the practitioner in stretching. On the other hand, plyometric exercises, such as side leg splitting and Cossack squats which are classified under modern sports methods can be included during practice to enhance explosive power for rapid and forceful kicks. Not to mention, coaches do play an essential role in the development and success of athletes by providing proper technical instruction, training programs, and necessary support, and instilling values like perseverance in them. Moreover, athletes would often feel more motivated to challenge themselves and reach their greatest potential when the training atmosphere is encouraging and positive.

ITF participant

In this finding, it focuses mainly on discovering the performance and skills of a single ITF Taekwondo practitioner. In this research, the target Taekwondo athlete, the first author herself, is the focal point of this research, defined by her journey and many achievements. Her success is majorly justified by both the elements of uniqueness and the rarity of achieving the black tip rank within a short timeframe. This achievement is not only phenomenal but also offers an unparalleled opportunity to discover more about the mechanics, practices, and strategies that have empowered her to successfully reach this degree of Taekwondo competence. Additionally, one of her innovative practices involves the extraordinary style of blindfolded kicks and punches, which showcases her exceptional control, preciseness, and sensory awareness. This inventive form of training certainly upgrades the challenge by relying heavily on muscle memory and proprioception rather than visual cues, thereby improving overall proficiency and competence. To build the ITF Taekwondo ESF empirical model, the first author has applied an inductive approach (Braun & Clarke, 2012; Clarke & Braun, 2013) that aligns with the HEA approach. This model highlights three key elements, namely preconditions, processes, and finally, organizational culture and outcomes.

ESF empirical model: Preconditions

Preconditions are identified by the ESF empirical model as one of the significant variables influencing Taekwondo's success. In essence, preconditions usually refer to 1) the external factors that affect the subjective norms including the influence of the coach (Seonwoo & Jeong, 2021), 2) material factors, such as specialized equipment and training facilities, 3) internal factors that involve the distinctive qualities of the practitioner like mental toughness, physical fitness, and prior expertise in combat sport. These prerequisites

may have an impact on the ability of a practitioner to succeed in ITF Taekwondo, hence it is crucial to consider them when developing training programs. The ITF Taekwondo facility is spacious enough to conduct sparring and other drills. To help practitioners hone their skills and prepare for testing, they are well-supplied with the necessary equipment, including sparring gears (hand wraps, gloves, and foot protector), training weapons (knives and breaking boards), and other required gear (target pads and kicking pads). Having these props and equipment can benefit practitioners in developing resilience to work through challenges and improve overall strength.

ESF empirical model: Processes

In the ESF empirical model, processes particularly direct to the variety of techniques and specific procedures that are implemented during the training sessions used to raise fitness and improve skill levels. This includes 1) drills (pattern (tul) practice, blocking, and countering drills), 2) workouts (warm-up exercises and strength training), and 3) sparring strategies (point sparring in ITF style, free sparring or Kyorugi, semi-free sparring, scenario-based sparring, tag team sparring, and continuous sparring). Usually, the effectiveness and productivity of these processes may vary from practitioner to practitioner, thus they are implemented in an individualized manner to meet the exact needs and goals of every athlete. Athletes are provided more training time and regular practices that progressively grow in frequency. The competitive training frequency may increase from 2 to 3 times per week or even more depending on the practitioner's level of dedication, commitment, and goals in ITF Taekwondo. While there are scheduled time slots for training and practices at ITF Taekwondo, the scheduling is generally flexible. Extra training sessions are often extended to athletes who exhibit an excellent work ethic.

ESF empirical model: Organizational culture and outcomes

The set of espoused values, cultural artifacts, and basic assumptions that play a vital role in shaping the training environment are collectively referred to as organizational culture. The aspect of espoused values typically indicates the social ideals, standards, and goals that are passed along to the larger Taekwondo community. The values that are incorporated involve offering "*the enjoyable spirit*" in training sessions, manifesting "*human energy*", emanating from a small, confined training area, and an open practice environment. During Taekwondo practice, "*the enjoyable spirit*" is achieved by means of engaging in competitive games and interactive drills, such as obstacle course (the action of dodging, jumping, and weaving through created obstacles, vital for improved speed and agility), tag-style warm-ups (main target is to avoid being tagged by skilfully moving around the designated area to enhance reflexes), call-and-response patterns (played by calling out a pattern and having others follow it for increased memory), or relay races (required to complete a series of prepared tasks in a relay-style for enhanced cardiovascular fitness). The focus on "*human energy*" manifestation underlines the need for positive energy throughout the practice by nurturing a can-do mentality and fostering ingenuity in adjusting to the training environment, despite area constraints. In an open training environment, the values of individual expression and creativity are always welcome so that continuous learning is developed.

During each Taekwondo practice session, cultural artifacts can be observed to have a variety of effects on training and practitioner from story-telling of former legends, iconic events in Taekwondo history, or even certain training tools or methods that are appreciated for their efficacy. For example, to motivate practitioners, the coach may narrate tales of the past great Taekwondo artists or play videos featuring noteworthy matches. Some of the deeply rooted histories that represent the iconic symbol of the ITF Taekwondo's ethos and tradition would also be occasionally told to remind the values of discipline and respect that underpin the basis of Taekwondo ideology. Another instance is the sharing of the historical tradition, philosophical idea, and practice of Poomsae known in simpler terms as patterns. In general, Poomsae consists of a sequence of

predefined steps executed against imaginary opponents, and it is taught to practitioners during every training, particularly about the cultural values of focus and perseverance. With respect to all the aforementioned, an essential component of athletic growth is having knowledgeable coaches and a fulfilling coaching environment (Larkin et al., 2022). Not to mention, these cultural relics can undeniably aid in the development of an engaging and rich training atmosphere that improves the experience that practitioners have with ITF Taekwondo.

The basic assumption of "*determination and independence in training hard*" and "*steady athlete development*" is the emphasis in ITF Taekwondo. A practitioner is encouraged to apply the assumption of "*determination and independence in training hard*" by self-motivating and depending on their inner drive to achieve the objectives. This principle is crucial throughout the process, as practitioners can build resilience in overcoming different setbacks, in addition to cultivating a strong work ethic. As a matter of fact, a practitioner should have a strong sense of personal responsibility and ownership to stay committed to their progress and outcomes, even when faced with challenges. Meanwhile, the assumption of "*steady athlete development*" typically means the need for consistent efforts and continuous improvement while enjoying the journey of practicing. In special cases, practitioners who leverage this concept may advance swiftly due to dedication and continual skill development. By establishing definitive goals and diligently pursuing them, it is feasible to attain a high ranking in a fairly short time, as demonstrated by the first author herself. Without reprise from the coach, athletes are given the initiative to take control over the training intensity according to their ability and potential. All in all, persistence is the key element in the application of this approach.

Undoubtedly, better outcomes can only be achieved when a positive organizational culture, along with specific preconditions and processes, are working hand in hand, thereby facilitating individual athlete development and environmental effectiveness. By instilling problem-solving skills and decision-making during the training process, athletes can gain traction and increase their autonomy. Based on the principle of sports talent environment (STE), Taekwondo practitioners are empowered to voice their preferences, ensuring that a more personalized and productive training experience is adopted. Elite coach-athlete teams also contribute to the growth and achievement of the athlete, in which both sides actively support and work together (Ge et al., 2016). In brief, a Taekwondoin's performance and experiences on and off the mat can be greatly influenced by the overall effects of organizational culture in ITF Taekwondo.

Therefore, by exploring the first author's performance, technique, and training, the present study aims to fill in the research gap and uncover the mechanics that define the successful execution of the flying front snap kick and side punch. This research can indeed provide Taekwondo practitioners with a more profound insight into the physical principles and mechanics at play. The choice to concentrate on sole practitioner was undertaken by the desire to perform a thorough analysis and gain a deeper understanding of the mechanics' theory behind the techniques. From the sports perspective, this study is essentially to demonstrate the successes and abilities of women in a historically male-dominated field, making it a source of inspiration.

METHODOLOGY

The flying front snap kick, alongside the inclusion of the side punch, was the main subject of this study.

Participant selection

A skilled young female Taekwondo practitioner, holding a black tip rank achievement from the International Taekwon-do Federation (ITF) academy, was chosen. Within an impressively short timeframe of only one year, she accomplished the grand feat of achieving her black tip level, proving a high level of dedication,

rigorous training, and skills in this combat sport. On top of that, her substantial sparring experience has exposed her to diverse combat scenarios, making her a more versatile practitioner. She also had a Body Mass Index (BMI) value of 18.56, which is within the healthy range of 18.5 to 24.9. BMI is considered an important criterion when selecting a practitioner because it serves as a general indicator of physical fitness, particularly in athletic endeavours like Taekwondo. The practitioner was signed up for this research project voluntarily, as approved by the Taekwondo Association Committee, and performed accordingly with the principles.

Data collection

Before data collection, the practitioner underwent a series of warm-up exercises (Figure 1), including side leg splitting, sidekicks, Cossack squats, and light punches, essential to reduce the risk of injury and achieve optimal performance. For data collection, the practitioner is required to perform flying front snap kicks and side punches, recorded using cutting-edge technology such as high-speed cameras. To ensure an accurate and detailed capture, the cameras were set to a resolution of at least 1000 frames per second. Different angles: front, left and right angles of capturing were all included for a thorough analysis. All data gathered were in three-dimensional (3D) encompassing joint angles and body positions. To gain a better comprehension of force transmission throughout motion, the ground reaction forces and moments were recorded as well.

Figure 1. Warm-up exercises (a) sidekick, (b) light punches, (c) Cossack squats, and (d) side leg splitting.

In-depth analysis

Focusing on precision and power, each execution of flying front snap kicks and side punches was performed with multiple iterations. The high-speed video footage was then thoroughly analysed frame-by-frame to reveal the key elements, including body positioning and trajectory. Following this, images were synthesized from the motion capture data for further analysis, with a resolution of 108 megapixels (MP) provided by the high-speed cameras.

RESULTS

The results of this study offer valuable insights into the dynamic and potent Taekwondo moves of flying front snap kicks and side punches, as shown in Figure 2 and Figure 3, respectively.

Flying front snap kick

The findings, as illustrated in Figure 2, demonstrate the flying front snap kick from different angles of execution, typically left, front, and right views, for better visualization. From the right view, it is observed that the practitioner propels her body into the air, lifting her left knee before deliberately thrusting her right leg forward in a way that the motion is sharp, controlled, and precise. When viewed from the front, the kick is positioned in a symmetrical form in which the practitioner holds a central posture, keeping her torso upright, yet ensuring the kicking leg is extended to the desired target point. In the left-angle view, the movement appeared to be reversed of the right-viewed image, in which the left leg's initial knee lift is seen before the right leg extending swiftly in a snapping motion.

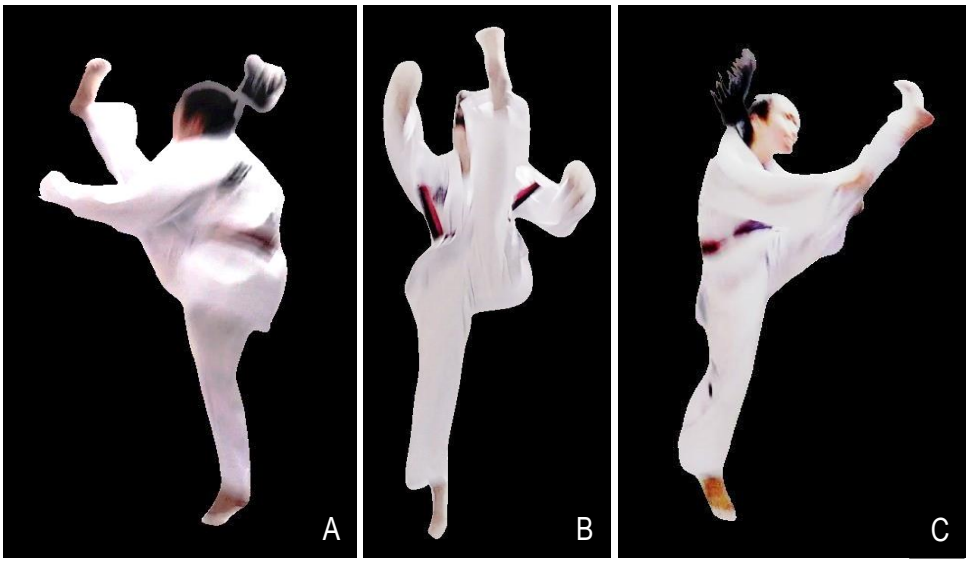

Figure 2. Flying front snap kick (a) right view, (b) front view, and (c) left view. Images were displayed in self-mirrored form.

Side punches

Similar to the flying front snap kick, the execution of side punches was observed from all three angles: left, right, and front. From the front view, the practitioner is standing with both feet firmly on the ground, giving the impression of stability and balance. In the right view, the practitioner's body is rotated slightly to the side, with the right arm straightening out from the shoulder and the fist directed towards the target. Conversely, from the left view, it may appear that the punch is executed with the opposite arm.

Figure 3. Side punches, (a) right view, (b) front view, and (c) left view. Images were displayed in self-mirrored form.

DISCUSSION

Taekwondo is recognized for its kicking skills and free-style combat using merely bare feet and hands (Ishac and Eager, 2021). Commonly, Taekwondo places a strong emphasis on its kicking techniques, which are discovered to be more prominent compared to punching. However, various punching skills still play an imperative part in Taekwondo, ensuring a well-rounded and competent regimen is practiced. In this study, both the flying front snap kick and side punch skills highlighted demonstrate shared fundamental mechanic principles, for instance initiating movement from the core, engaging specific muscle groups, and coordinating body movements for the generation of maximal power and speed during execution. In a flying front snap kick, the engagement of the hip and leg muscles, along with the coordination of the whole-body motion, is responsible for propelling the body in an upward and forward manner, thereby generating power while executing the kick. Similarly, inside punch, power is generated by the involvement of torso rotation and core muscles, such as rectus abdominis, obliques, and transverse abdominis.

Flying front snap kick placed a significant emphasis on proximo-distal motion, where the movement starts at joints and segments closer to the centre of the body and gradually moves outward in the direction of the extremities (Vagner et al., 2023). When initiating the kick, the practitioner must raise the kicking leg's knee towards the chest. During this motion, there must be a strong contraction in both quadriceps muscles as well as the hip flexors. Subsequently, the leg would be rapidly extended forward in an attempt to strike the opponent using the ball of the foot. In this context, the hip extensor muscles, especially the glutes and hamstrings, are responsible for this extension. To enhance the momentum of the kick, enabling a greater extension of reach with a wider range of movement, the practitioner can rotate the hip of the kicking leg medially in tandem with leg extension. Meanwhile, maintaining control and balance is another vital aspect that must be taken into account throughout the airborne phase of the kick. This can simply be accomplished by keeping the torso upright with little inclination forward (Figure 2(a) and (c)). According to the observation (Figure 2), this kick certainly necessitates a powerful and rapid extension of the hip joint to be able to propel the leg swiftly in the direction of the target. In general, achieving a desired trajectory and effective kicking impact requires precise hip flexion and knee extension velocities, in addition to the fast motion of the centre

of mass (COM) towards the opponent (Gavagan and Sayers, 2017). It was also observed that the core muscles helped stabilize the body throughout the kick, contributing to the overall balance and control.

As its name suggests, the flying front snap kick delivers a snapping motion, striking either the head or the chest of the target. Attributed to its fast and forceful nature, this snapping action can typically increase the power and speed of the kick. In addition, the effectiveness of this kick lies in its capacity to cover great distances swiftly, which helps close the gap between the practitioners and opponents rapidly. The pace of the attack will not only take opponents off guard, but it may also make it tougher for them to mount a defence. Overall, in terms of basic mechanics, it is agreed that the flying front snap kick in ITF Taekwondo may share some similarities with forms from other Taekwondo academies; however, differences in the execution techniques and emphasis set them apart. In ITF Taekwondo, teaching styles and practices may largely focus on real-world self-defence and conventional patterns. One significant distinction is the attention placed on sine wave motion, entailing the body to move vertically throughout the execution. Such an approach is intended to make use of the natural body's gravitational force so that more power can be generated in the process of delivering a strike. Another apparent difference is seen during sparring, where precision and control are prioritized over sheer power and speed. This is to align with the emphasis on controlled execution techniques and technical proficiency.

The mechanics of the side punch, on the other hand, are majorly dependent on both the correct rotation of the torso and the activation of the core muscles for the generation of ample power. In the process of executing a side punch, the rotation of the torso is a key element for maximizing the rotational force because such rotational movement not only engages the core muscles but also adds momentum to the punch. The coordinated movement of the torso motion and contraction of the core muscles are the main contributors to the transfer of energy from the lower body and into the arm, thereby, creating a kinetic chain. The term "*kinetic chain*" refers to the complex synchronization of various segments to execute a certain technique that requires exact timing, speed, and positioning (Almansoof et al., 2023). Although a side punch attack may resemble a straight punch attack that involves arm extension in striking the target, there is a twist in the form of a variation. Unlike the straight punch, which utilizes a forward stance, the side punch is executed in a horse-riding stance or may be referred to as a straddle stance (Figure 3), with the practitioner initiating a turn while moving forward. Inside punch, the use of the "*turbo hand*" simply known as the opposite hand, instantaneously retracts which is crucial to enhance the hip speed and power. The seamless, flowing motion rather than a step-and-pause approach observed indicates proper execution of the side punch.

From the general principle, a side punch can be highly effective and efficient in close-up battles because of its direct trajectory, subtle movement, and potent strikes. Essentially, the wayside punch is taught and performed within the styles of ITF Taekwondo and is heavily influenced by its purpose and application. Often, the side punch is tactically employed in situations involving a sequence of self-defence moves or in conjunction with various other techniques. Moreover, the intended effect and strategies in tackling opponents may be viewed differently between ITF Taekwondo and some other Taekwondo styles. Instead of being utilized predominantly for direct offensive techniques aimed at targeting the head or body of the opponent, the side punch in ITF Taekwondo is mainly employed as a means to interrupt the opponent's attack or create distance when practitioners encounter close-quarter combat. While other Taekwondo styles may put more emphasis on elements such as force, strength, and speed, ITF Taekwondo focuses on precise timing and coordination, often synchronized with a pivot to generate power to its full potential. In a broader sense, the fundamental concepts of flying front snap kick and side punch may be consistent across all Taekwondo develops; nevertheless, each style embraces its subtleties.

CONCLUSION

This research is the first to present the mechanics of flying front snap kicks and side punches in Taekwondo, focusing on a female Taekwondoin with rigorous training and expertise. Not only does it offer practical implications for strategic incorporation into Taekwondo training, but it is also useful in sparring matches and self-defence. The results presented in this study reveal the fundamental principles of body coordination, muscle engagement, and power generation. Overall, the objectives of the finding were met, providing deeper insights into the theory underlying the mechanics of these techniques in Taekwondo. This understanding is helpful for improving efficiency and effectiveness in practice, leading to greater control, balance, and precision.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

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