A CASE STUDY OF THE KICKING FOOT AND STANCE IN ROUNDHOUSE KICK: CONTROL AND COMBAT SITUATIONS

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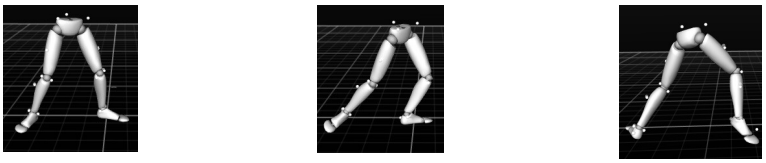
Once this work is part of a long term study, the aim was to show the preliminary results of the comparison of the kicking foot and stance in the roundhouse kick according to the onset condition (control vs. combat situation). One black belt athlete participated on this study. A motion capture system of 18 cameras (Optitrack© 360Hz) was used for the kinematic data acquisition. In order to obtain the maximum height and speed, execution and movement time of the kicking foot we used one marker. In order to represent the stance positions we used five markers. The preliminary analyses suggest that there are differences between control and combat situations: 1.the maximum height was smaller in combat situation since the athlete prefers to kick in the trunk of the opponent and 2.the stance positions highlight the influence of the movements of the opponent in combat.

KEYWORDS: Taekwondo, 3D Kinematics, Kick techniques.

INTRODUCTION: Taekwondo is a Korean Martial Art and an official Olympic sport since the Games of Sydney 2000, where kicks are the most use techniques to score (Vieten, Scholz, Kilani & Kohloeffel, 2007). Despite the massive number of kick techniques, the Roundhouse Kick is, by far, the most used in officials and amateurs competitions. Pieter and Pieter (1995) reported that this kick is the fastest and most effective, and Kim, Kwon, Yenuga and Kwon (2010) stated that it is the easiest to adapt for long or short distances. In control situations, it is hard to simulate the opponent moves, which turns hard to understand how the athlete is going to respond in the combat. Many studies try to analyze the reaction time (Estevan & Falco 2013; Falco, Estevan & Vieten, 2011; Vieten et al., 2007) kick speed (Lara, Silva, Misuta, Silvatti, Mercadante & Barros 2011; Li, Yan, Zeng & Wang 2005; Nien, Chang & Tang 2007; Pieter & Pieter 1995; Tang, Chang & Nien 2007), execution time and effect of the distance of the target (Estevan & Falco 2013, Falco et al., 2011). However, is important to analyze these variables in the combat situation. Nevertheless, in the literature is uncommon to find studies that report the comportment of the athlete during a combat situation. This fact highlight how difficult is to analyze this kind of situation. Thus, the purpose of this work was to show the first results of the comparison of the kicking foot and stance in the roundhouse kick according to the onset condition (control vs. combat situation).

METHODS: Is important to enhance that this work are going to show just the preliminary results of a long term study in which we are going to analyze athletes of an training center (Centro de Treinamento Esportivo - EEFFTO-UFMG) that competes at national level. The mainly question that we are going to study is related to the understanding of the combat and control situations that could help coaches to create and to improve the training, and the athletes to understand their movements in both situations.
We used 18 cameras around the athlete to acquire the kinematic data (OpitTrack system, Prime 17W, 70º FOV, 1.7 MP and 360 Hz). An acquisition volume of 6x4x3 m^3 was used (X axis latero-lateral, Y axis vertical and Z axis anterior-posterior). In order to model and to allow us to calculate other important variables in future studies (linear and angular), the lower body model (Helen Hayes), composed by 19 retro-reflexive markers was used. However, in this study we used just six of these markers.
In order to represent the pelvis center we used the 3D coordinates of three markers fixed on the right and left anterior superior iliac spine and a middle point between the posterior

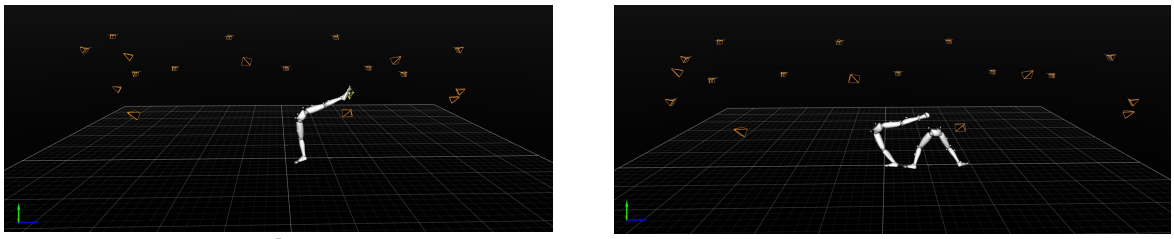
superior iliac spines. The pelvis center and two markers fixed on the left and right lateral malleolus were used to define the stance position. This analyze could be interesting to help the understanding of the balance before and after the kick. So, we analyzed the stance position in three instants: initial stance, consisting of the moment that precedes the beginning of the kick movement (P1), the toe-off moment, defined by the last instant that the athlete has both foots on the ground (P2) and the moment of the first contact of the foot to the ground (P3).



P1 P2 P3

Figure 1. The stance in three different instants: Initial stance (P1), toe-off moment (P2) and first contact to the ground with the kicking foot (P3).

In order to obtain the kinematics variables of the kicking foot, we used the marker fixed on the fifth metatarsus of the kicking foot and we calculated the maximum height, maximum speed, the execution time (time between the toe-off until the impact) and movement time (time between the toe-off and the first contact of the toe to the ground).
Since this is a first study just one black belt (1º dan) male taekwondo athlete with 8 years of practice who competes at national level participated in this study (18 years, 1.74m, 65 Kg).
We performed the analysis of the kinematics variables of the kicking foot and of the three instants of the stance according to the onset condition. The control situation (Fig. 2-A) consisted of the execution of four Roundhouse Kicks, with the right leg, to the target (paddle) positioned at the head height. Two of them were performed with the leg in back position and two with the leg in the front position. In the combat situation (Fig.2-B), the athlete should fight freely against an opponent, and could use any kick at any height. However, in order to perform the comparison with the control situation only the Roundhouse kicks with the right leg were computed (one with the leg in back position and one with the leg in front position).



A B

Figure 2. The Control Situation (A) and the Combat Situation (B).

RESULTS AND DISCUSSION: The values of the maximum height (Table 1) were smaller in the combat situation for both positions of the leg (front and back). These findings suggest that in the combat situation, the athlete prefers to perform kicks in the trunk of the opponent and this could be related with the actions and movements of the opponent during the combat. However, for a better understanding of this point would be interesting to do an analysis of both athletes in combat.
Our results of the maximum speed in control and combat situations agree with the values reported in the literature for expert athletes that range from 10 m/s to 18 m/s (Lara et al., 2011; Li et al., 2005; Nien et al., 2007; Pieter & Pieter, 1995; Tang et al., 2007). As expected, because the longest trajectory until the target, the kicking leg in the back position presented high values of maximum speed than the kicking leg in front position and Li et al. (2005) and Lara et al. (2011) reported same results.
The values of the execution and the movement time in both conditions were in accordance with the values reported by Estevan and Falco (2013) and Tang et al. (2007), however, the execution time found in this work were smaller than the values reported by Falco et al.

(2011). These results highlight the training level of this athlete that could maintain the execution time in different positions of the kicking leg and in the control and combat situations. No statistical analysis was performed since we have just one subject and few kicks.

Table 1. Kinematic variables of the kicking foot in control and combat situations.

Kicking Leg	Situation	Kick	Height [m]	Maximum Speed [m/s]	Execution Time[s]	Movement Time [s]
Front Position	Control	1	1.67	15.43	0.23	0.61
		2	1.65	13.31	0.25	0.66
	Combat	1	1.18	14.24	0.25	0.54
Back Position	Control	1	1.64	17.36	0.30	0.75
		2	1.66	15.84	0.34	0.74
	Combat	1	1.26	12.37	0.29	0.77

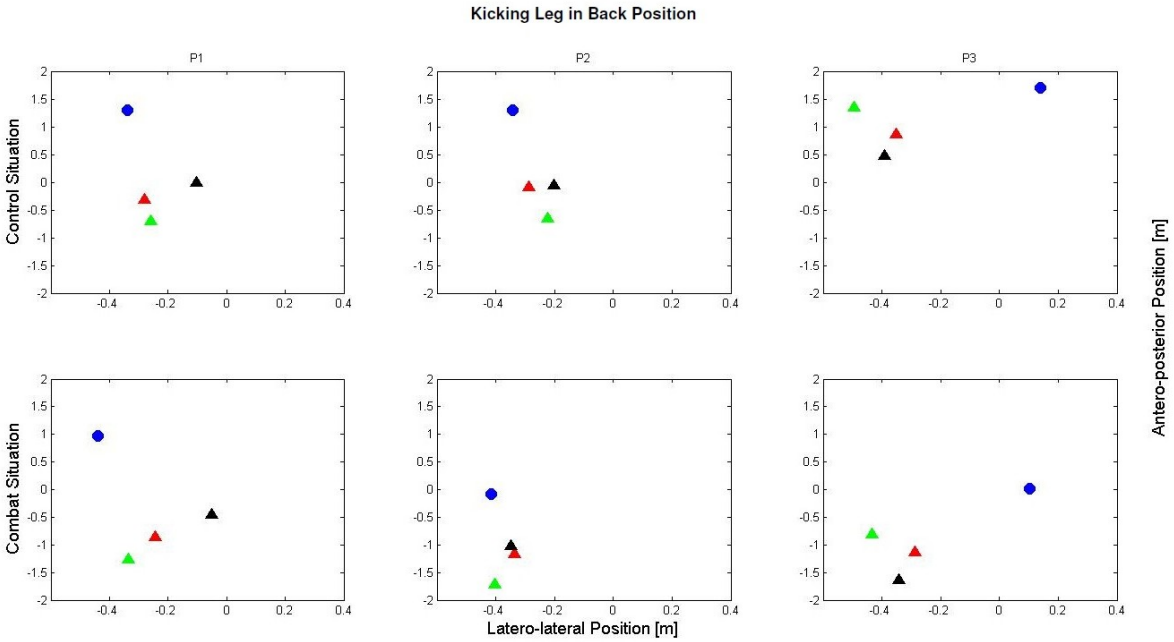


Figure 3. The figure 1 shows the stance in control and combat situations with the kicking leg in back position in three different instants: (P1) the initial stance, (P2) the toe-off and, (P3) the moment that the kick foot retakes the contact with the ground. The green triangles represent the right foot (kicking leg). The red triangles represent the pelvis center. The black triangles represent the left foot. The blue circles represent the target.

The stance moments present similarities in control and in combat situations (Fig. 3), mainly in the P3. This finding highlights a similar pattern in both conditions to stability himself after the impact. Based on the stance reported in the literature (Estevan, Falco & Jandacka, 2011), the initial stance (P1), in both situations, presented a diagonal direction, however in combat situations it is wider than the control situation. For the P2 stance, in combat situation the pelvis center approximated to the left foot in a forward position while in a control situation the pelvis centre moves to the lateral (Fig. 3). The preliminary analyses suggest that these differences could be influenced by the movements of the opponent in combat situation.

Furthermore, the athlete has to protect himself in combat situation, while in control situation he does not have this concern.
In future works, we plan to analyze 1.both athletes during combat, 2.different athletes in more combats situations using different variables. These analyses could help to understand the differences between the athlete who is attacking and the one who is defending and their relationship. Therefore, this work enhances the importance to study the combat situations to improve the understanding of their specificity by the coaches that could apply this information in the training sessions.

CONCLUSION: The preliminary analyses of the roundhouse kick in control and combat situations suggest that there are differences. The first one was related to the maximum height that in the combat situation the athlete prefers to perform kicks in the trunk of the opponent. The second one was related to the stance positions that highlight the influence of the movements of the opponent in combat situation.

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