KINETIC AND KINEMATIC ANALYSIS OF THE DOMINANT AND NON-DOMINANT KICKING LEG IN THE TAEKWONDO ROUNDHOUSE KICK

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The purpose of this study was to examine kinematic variables relevant to kick performance with the dominant and non-dominant leg, in a roundhouse kick measured from three execution distances. Forty-three taekwondo athletes that had competitive taekwondo experience participated in the study. A dependent *t*-test indicated that there were no differences between extremities at any distance ($p > .01$). Based on these results, competitive taekwondo players do not seem to reveal differences in limb kinematics. The results also showed the influence of the distance from which the dominant leg explains a larger percentage of variance in reaction time (24%), execution time (20%) and total response time (60%) of the non-dominant leg from a short distance, whereas regarding impact force (22%), this higher percentage is explained from a long distance.

KEY WORDS: combat sport, impact force, reaction time, total response time, symmetry.

INTRODUCTION: In Taekwondo, like other sports, competitive athlete training starts with analysing the activity. In a kicking sport where techniques with the preferred and non-preferred leg alternate, the roundhouse kick with the back leg is widely used. According to Tang et al. (2007) symmetric skills are important to be among the elite in taekwondo. In general, athletes have preference for one particular foot to kick the target during training (Tang et al., 2007), and to date, it is unknown if this preference makes this sport as asymmetric. Pedzich et al. (2006) found statistically significantly higher stroke force values on the right side when the right limb was dominant in a yop and dwit chagi, respectively. Furthermore, the impulse stroke of the side kick (yop chagi) was found to be slightly higher (9%) for the left limb than for the right one. On the contrary, during dwit-chagi the impulse stroke was higher (9%) for the right limb than for the left one. In the same line, Peng (2006) found that in a roundhouse kick, the dominant leg was faster than the non-dominant one ($p < .05$). In contrast, Tang et al. (2007) found no significant differences between the preferred and non-preferred leg in movement time ($p > .05$) in this same type of kicking.
To date, there is still a lack of research on symmetries in taekwondo. With these investigations in mind, the purpose of this study was to examine if the dominant leg (D) produced better results than the non-dominant one (ND) in maximum impact force (MIF), reaction time (RT), execution time (ET) and total response time (TT) in a taekwondo roundhouse kick measured from 3 different execution distances (ED_1, ED_2, ED_3).

METHODS: In order to carry out the present study, a model based on the work of Falco et al. (2009), using a mannequin, contact platform, force platform, and adding a LED (see figure 1) to measure the reaction time and developing the same protocol; that is two trials for each of the three different distances considering the subjects' leg length (ED_2 or medium distance), 1/3 above (ED_3 or long distance) and 1/3 below (ED_1 or short distance), was used to measure parameters relevant to kick performance and related to mechanical variables: maximum impact force (MIF), reaction time (RT is initiated by switching on the LED on the chest of the mannequin until the athlete raises the kicking foot from the contact platform), execution time (ET starts when the athlete raises the foot of the kicking leg from the contact platform and stops when the athlete's foot impacts on the force platform reaching the maximum impact

force) and total response time (TT is defined as reaction time plus execution time).

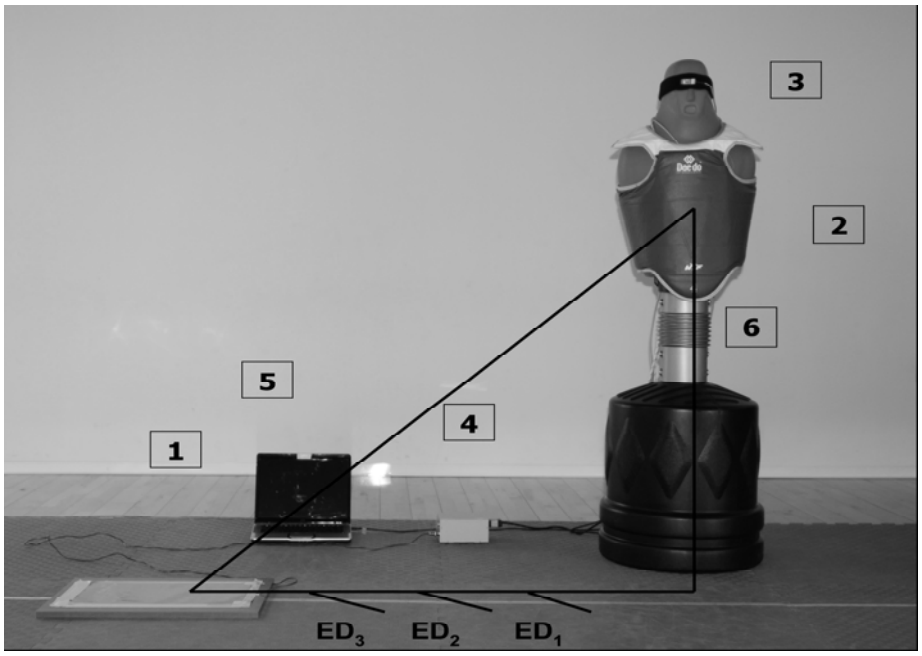

Figure 1. System set up with the three distances: short (ED_1), medium (ED_2) and long (ED_3). 1: contact platform, 2: force platform, 3: signal light, 4: microcontroller, 5: Pc, 6: mannequin

A sample of 43 taekwondo players (31 men and 12 women) aged from 13 to 38 years (*M* = 24.49; *SD* = 5.94), weighing from 46 to 101 kg (*M* = 70.91; *SD* = 12.91) and with a height ranging from 1.53 to 1.93 m (*M* = 1.73; *SD* = 0.15), kicking from distances between 0.69 (ED_1) and 1.37 (ED_3) metres (*M* = 1.03; *SD* = 0.07) (ED_2) were selected to participate in the study. All of them had been doing taekwondo for at least 4 years and had competitive taekwondo experience (including athletes that had won a medal in a national or international championship). Informed consent was given.

2-tailed, paired *t* tests were performed to assess the variation of the kinematical measures (MIF, RT, ET & TT) over execution distances (ED_1, ED_2, ED_3) through the dominant (D) and non-dominant (ND) leg. The Bonferroni correction was applied to reduce the accumulated error in the 12 *t* tests performed to assess potential differences in mechanical variables from three EDs between the dominant and non-dominant leg ($p < .01$). A Pearson product moment correlation was also performed to evaluate the relationship among paired variables between dominant and non-dominant leg. Moreover, a regression analysis was done to analyse the predictive power of the dominant leg on the non-dominant leg in the variables under study (MIF, RT, ET & TT) at each distance (ED_1, ED_2, ED_3). The criterion level set as $p < .01$ was considered significant for all analyses.

RESULTS: The preliminary analysis (Kolmogorov –Smirnov) showed a normal distribution in all the considered variables. Descriptive statistics (mean and standard deviation) and *t* coefficients are presented in Table 1. The results indicated that there were no differences between the dominant and non-dominant leg from any distance ($p > .01$).

Table 1. Descriptive statistics and *t* coefficients for dominant and non-dominant legs (N = 43)

		Dominant		*Non-Dominant*		
		M	*SD*	*M*	*SD*	*t*
MIF (N)	ED_1	1317.64	727.91	1024.11	519.73	2.52
	ED_2	1032.62	630.34	966.40	473.72	.65
	ED_3	960.71	515.01	866.97	494.74	1.18
RT (s)	ED_1	.50	.09	.50	.07	-.54
	ED_2	.52	.11	.53	.09	-.67
	ED_3	.61	.11	.62	.13	-.31
ET(s)	ED_1	.27	.07	.27	.07	-.33
	ED_2	.32	.10	.32	.11	-.23
	ED_3	.36	.10	.38	.13	-.72
TT (s)	ED_1	.76	.08	.78	.09	-1.68
	ED_2	.83	.12	.85	.11	-1.14
	ED_3	.96	.10	1.00	14	-1.73

Note. ED= Distance (1= short; 2= medium; 3= long); MIF = maximum impact force; RT = reaction time; ET = execution time; TT = total response time *p < .01

Significant positive correlations (p < .01) between the dominant and non-dominant leg were found in MIF from the ED_1 (r = .34), ED_2 (r = .31) and ED_3 (r = .47), in RT from the ED_1 (r = .49), in ET from ED_1 (r = .45) and ED_2 (r = .31) and in TT from the ED_1 (r = .78), from the ED_2 (r = .36) and from the ED_3 (r = .40). Also, the regression analysis results to predict the power of the dominant leg over the other leg into variables under study are showed in Table 2.

Table 2. Regression Analysis for all variables in the dominant over non-dominant leg (N = 43)

Variable	*B*	SE *B*	β	*t*	R^2
IF_DED_1- $IF_{ND}ED_1$	.24	.11	.34	2.25	.12
IF_DED_2- $IF_{ND}ED_2$	.23	.11	.30	2.05	.09
IF_DED_3- $IF_{ND}ED_3$	.45	.13	.47	3.42	.22
RT_DED_1- $RT_{ND}ED_1$	.35	.10	.49	3.48	.24
ET_DED_1- $ET_{ND}ED_1$	.42	.13	.45	3.11	.20
ET_DED_2- $ET_{ND}ED_2$	.33	.16	.31	2.05	.09
TT_DED_1- $TT_{ND}ED_1$	.81	.11	.78	7.56	.60
TT_DED_2- $TT_{ND}ED_2$	.13	.32	.13	2.41	.13
TT_DED_3- $TT_{ND}ED_3$	.57	.21	.40	2.73	.15

Note. ED= Distance (1= short; 2= medium; 3= long); D= dominant leg; ND = non-dominant leg; MIF = maximum impact force (N); RT = reaction time (s); ET = execution time (s); TT = total response time (s) *p < .05

DISCUSSION: The purpose of this study was to examine the mechanical variables maximum impact force, reaction time, execution time and total response time between the dominant and non-dominant leg, in a sample of 43 taekwondo athletes. In line with previous studies (Tang et al., 2007), results revealed that taekwondo athletes achieved a symmetrical sport style while performing a roundhouse kick. In contrast with other studies (Pedzich et al., 2006; Peng, 2006), the absence of differences exhibited in our study might be due to the technique under study if we take into account that yop and dwit chagi are considered more difficult to perform (Pedzich et al., 2006) while the roundhouse kick is the most useful technique. Perhaps as athletes´ experience and practice increase, the differences between limbs decrease. Thus, differences founded by Peng (2006) could have been due to the fact that the taekwondo athletes who performed roundhouse kicks were teenagers. As pointed out Tang et al. (2007) symmetrical kicking skills are important at the elite level of taekwondo.

In our study, in line with Falco et al. (2009), regression analysis also showed the influence of the distance in a roundhouse kick. This influence is witness to the major variance explained from the short distance from the dominant on non-dominant leg in reaction time, execution time and total response time, while in impact force this variance is better explained from the long one. Finally, a limitation of the study is the potency of this. In this way, future studies should examine the inter-relations between kinematical variables within different distances and into different level and age groups and be performed with a greater number of participants.

CONCLUSION: This study could suggest the absence of asymmetry during a roundhouse kick in a sample of taekwondo competitive athletes. Based on these results, we suggest that taekwondo players did not seem to show mechanical differences between the dominant and non-dominant leg. Perhaps symmetries in taekwondo kicks are important in order to reach excellence in this sport, but more studies are needed to confirm this comparing the variables by level and gender as well as using other techniques within the same groups. In addition, the results showed the influence of the distance to determine/predict impact force, reaction time, execution time and total response time. The measurements from the non-dominant leg can be better explained by the short distance except for impact force, which is better explained in the long one.

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