MECHANICAL COMPARISON BETWEEN ROUNDHOUSE KICK TO THE CHEST AND TO THE HEAD IN FUNCTION OF EXECUTION DISTANCE IN TAEKWONDO

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The purpose of this research was to examine and compare maximum impact force (MIF) and execution time (ET) in two different Taekwondo techniques, roundhouse kick to the chest (Bandal Chagui) and roundhouse kick to the head (Dolio Chagui) in terms of the execution distance and to analyse the relationship between maximum impact force and weight for two different groups and kicks. To measure the mechanical parameters, a model explained in Falco et al. (2009) was used. In this study, the 23 male taekwondo players participating were divided into two groups: medallists (n = 12) and non-medallists (n = 11). For the medallists' group no differences had been found in MIF or ET from either distance between roundhouse kick to the chest and to the head. However, significant differences were found in MIF in the non-medallists' group from all execution distances between roundhouse kick to the chest and to the head. For the non-medallists' group, weight significantly predicts MIF, but not in the medallists' group. In conclusion, medallist taekwondo players should perform roundhouse kick to the head instead to the chest, because it produces a better score in the same time.

KEY WORDS: Distance, impact force, execution time, kick, Taekwondo.

INTRODUCTION: Taekwondo is a combat sport with hits, in which leg techniques are the most commonly used in competition (Olivé, 2005). Among the leg techniques, there is roundhouse kick to the chest (Bandal Chagui), being the action with 27% of the total points are obtained in the combat and 10% of the KO, and there is also roundhouse kick to the head (Dolio Chagui) with which 11% of the points are obtained being the second technique to score KO (Olivé, 2005). One difference between Bandal and Dolio Chagui is the height of the target: to the chest and the face, respectively (O'Sullivan et al., 2008). In 2009, competition rules were changed: a kick to the head (i.e. Dolio Chagui) is worth three points while a kick to the chest is worth one point (i.e. Bandal Chagui) (WTF, 2009).

According to Kim et al. (2008), athletes choose techniques that score points, using less force and more efficiency. Roundhouse kicks are the actions which are easily adapted to execution distance (ED) (Kim et al., 2008). In addition to the ED (Hristovski et al., 2006), among the factors that condition the success of the kick, there are mechanical variables such as the maximum impact force (MIF) and the execution time (ET) that are relevant to score when kicking the opponent (Falco et al., 2009).

Among the studies analysing the differences in terms of the kind of roundhouse kick, Lee and Huang (2006) and Pedzich et al. (2006) point out that athletes carried out the more difficult kicks with a smaller MIF than the easier ones, influencing the kind of roundhouse kick in the MIF. This statement was confirmed by the research of O'Sullivan et al. (2008) who studied Bandal and Dolio Chagui and found higher impact force on the kicks whose objective was to hit to a smaller height (p < .05). On the other hand, Hong et al. (2000) found higher ET in the kicks directed at a greater height. In the study of Pedzich et al. (2006) the trajectory of the kick affecting the mechanical results of same was observed; in this line, Nien et al. (2006) found that in similar techniques there were differences in execution technique such as in the coordination of the lower limb segments what would be based on the principle of kinetic chain when each limb could be thought of as a chain consisting of rigid overlapping segments connected by a series of joints.

Estevan et al. (2009) and Falco et al. (2009) suggest that higher level athletes would base their execution on the principle of the kinetic chain, which supposes a better technical execution. Lee et al. (2005) point out that keeping the principle of the kinetic chain is essential to the effectiveness of the roundhouse kick. However, according to Pearson (1997) and Pedzich et al. (2006) athletes use their weight to increase MIF, these authors found a positive relationship between weight and MIF. In studies carried out using the same procedure as in the present one (three ED), Estevan et al. (2009) and Falco et al. (2009) found a positive correlation between weight and MIF in a lower level athletes' group, but not in a higher level athletes' group.

The overall purpose of this study was twofold: firstly, to examine the MIF and the ET in the Bandal Chagui and the Dolio Chagui from three EDs, in two different level groups. And secondly, to examine the relation between the MIF and the weight in terms of the kind of roundhouse kick and the athletes level, in three EDs.

METHOD: Participants: A convenience sample of 23 male taekwondo athletes gave informed consent to participate in the study; their average age was 26.78 years ($SD = 2.27$), weight of 73.80 kg ($SD = 12.60$) and height of 1.78 m ($SD = 0.07$). They were divided into two groups: the medallists' group ($n = 12$) and the non-medallists' group ($n = 11$) in terms of whether they could be medal winners in official national and international events or not. All the athletes had at least 4 years of competitive experience and trained for at least 3 hours per week. They accepted to participate anonymously and voluntarily in the research.

Procedure: In order to carry out the present study, a model explained in Falco et al. (2009), developing the same protocol (two trials for each of the three different EDs considering the length of the subjects' leg), was used to measure relevant parameters to kick performance and relating to the mechanical variables: MIF and ET.

RESULTS: The preliminary analysis (Kolmogorov – Smirnov) showed a normal distribution of all the considered variables. The Bonferrini correction was applied to reduce error accumulated in the 6 t tests carried out to assess potential differences in mechanical variables from three EDs between the Bandal and Dolio Chagui ($p < .01$), in the two different level groups. Statistical description (mean and standard deviation, minimum and maximum) are shown in Table 1.

For the medallists' group, no differences were found in the MIF and the ET between Bandal and Dolio Chagui. For the non-medallists' group, differences were found from ED_1 ($t = 3.00$; $p < .01$) and ED_2 ($t = 3.32$; $p < .01$), in the MIF of Bandal and Dolio Chagui, respectively.

In order to determine the relationship between the weight and the MIF, Pearson's correlation was calculated within both groups. For the medallists' group, there was no correlation in Bandal and Dolio Chagui. However, for the non-medallists' group, a significant positive correlation ($p < .05$) was found between weight and MIF from ED_3 ($r = .73$) in Bandal Chagui, and significant positive correlation was found from ED_1 ($r = .74$; $p < .01$), ED_2 ($r = .62$; $p < .05$) and ED_3 ($r = .64$; $p < .05$) in Dolio Chagui. So as to analyse the predictive power of weight on MIF, a regression analysis was made for the non-medallists' group, which showed that in ED_3 ($\beta = .73$) weight predicts 53.4% of the variation in MIF of Bandal Chagui ($p < .01$). Therefore, in ED_1 ($\beta = .74$; $p < .01$) weight predicts 54.7% of the variation in MIF of Dolio Chagui, in ED_2 ($\beta = .62$; $p < .05$) 38.9% of the variation in MIF of Dolio Chagui, and in ED_3 ($\beta = .64$; $p < .05$) 41.3% of the variation in MIF of Dolio Chagui.

Table 1. Comparative analysis between Bandal and Dolio Chagui in Maximum Impact Force and Execution Time in function of Execution Distance.

| | ED | Bandal chagui | | | | Dolio Chagui | | | | |
		M	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*	*t*
					Medallist (*n* = 12)					
MIF	ED_1	1959.83	632.50	1258.50	3284.50	1934.13	573.82	1225.00	2660.50	.12
(N)	ED_2	2018.46	335.70	1491.50	2614.00	1889.00	401.23	1247.00	1405.00	.86
	ED_3	1852.29	381.09	1250.50	1431.50	1775.21	402.41	1278.00	2433.50	.49
ET	ED_1	.225	.038	.179	.312	.241	.030	.190	.285	-2.14
(s)	ED_2	.241	.020	.202	.267	.286	.100	.210	.580	-1.76
	ED_3	.329	.091	.236	.589	.313	.045	.227	.398	.63
					Non-Medallist (*n* = 11)					
MIF	ED_1	1910.82	677.18	664.00	2745.00	1457.10	537.71	665.00	2149.50	3.00*
(N)	ED_2	2040.68	307.45	1542.00	2436.50	1597.50	392.00	903.00	2390.50	3.32*
	ED_3	1871.64	370.61	1302.50	2391.00	1398.77	630.94	290.50	2580.00	2.74
ET	ED_1	.257	.095	.187	.472	.276	.015	.245	.290	-0.80
(s)	ED_2	.273	.043	.226	.378	.316	.072	.270	.520	-1.76
	ED_3	.344	.074	.218	.462	.370	.051	.292	.449	-1.18

Note. ED = Execution Distance (ED_1: short; ED_2: medium; ED_3: large); MIF = maximum impact force in Newtons (N); ET = execution time in seconds (s). * $p < .01$

DISCUSSION AND CONCLUSION: The main purpose of the present study was to examine whether the kind of roundhouse kick determines the impact force (MIF) and the execution time (ET). For the non-medallists' group, the influence of the kind of roundhouse kick on MIF on some the execution distances (ED) has been observed, that coincides with Lee and Huang (2006) and O'Sullivan et al. (2008) statements. Nevertheless, for the medallists' group, in any ED the kind of roundhouse kick does not condition the MIF. As for the ET, we observe that in any ED there are no differences between Bandal and Dolio Chagui for any group (medallists and non-medallists). In this way, for the medallists' group, the kind of roundhouse kick does not condition effectiveness of execution (same MIF and same ET), taking into consideration that Dolio Chagui is worth three points (two more than Bandal Chagui), we could guide the athletes to carry out more actions of Dolio Chagui in taekwondo combats to get more points.

Pearson (1997), Estevan et al. (2009) and Falco et al. (2009) analysed the relationship between the weight and the MIF in Taekwondo, they found a positive correlation between the weight and the impact force. In our research we have obtained results in the line of Estevan et al. (2009) and Falco et al. (2009) who found a relationship between the weight and the MIF, only for the non-medallists' group, that is, in the lower level athletes.

Estevan et al. (2009) point out that Dolio Chagui is a more complex kick than Bandal Chagui, which could explain for the non-medallists' group, the relationship between weight and MIF in Dolio Chagui in all EDs, instead Bandal Chagui that is only related in ED_3, explaining in Dolio Chagui higher percentage of impact force than in Bandal Chagui. On the other hand, the medallists' group would not use their weight to generate their MIF regardless of the roundhouse technique. Estevan et al. (2009) suggest that higher level athletes could achieve greater impact forces due to a better technical execution based on the principle of the kinetic chain.

MIF and ET in each ED was analysed in our study; to improve scientific bases of the efficiency of Taekwondo kicks future research should examine other mechanical parameters such as impact time or maximum impact force according to body mass, which may explain the differences depending on level. Furthermore, studies should analyse how reaction time influences each ED in mechanical parameters. Finally, it could be suggested that Dolio

Chagui is a more complex kick than Bandal Chagui, but for the medallists' group, the kick efficiency (with same force and same execution time) is not influenced by the kind of roundhouse kick. Therefore, coaches could guide the high level athletes to carry out more actions of Dolio Chagui in taekwondo combats to get a better score in the same time.

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