

REACTION AND PERFORMANCE TIME OF TAEKWONDO TOP-ATHLETES DEMONSTRATING THE BALDUNG-CHAGI

Gerhard Hermann, Markus Scholz, Manfred Vieten, and Markus Kohloeffel*

University of Konstanz, Konstanz, Germany

***German Taekwondo Union, Friedrichshafen, Germany**

The purpose of this study was to investigate two factors for success in taekwondo competition, the simple reaction time (RT) - beginning with an external signal and ending with a shoulder, hip or ankle movement – and the performance time (PT) – starting of the Baldung-chagi till hitting the target. Subjects were the top 9 athletes (6 ♂, 3 ♀) from the German National Team. Movements were recorded by 3 infrared cameras of LUKOtronic active marker Motion Capturing System. Seven markers were used, five on the subject (ankle, heel, hip, shoulder, wrist of the kicking side), one trigger marker at the floor, one at the hand-mitt. The average value for the ankle RT is 0.34 sec., 0.26 sec. for hip RT, 0.23 sec. for shoulder RT and 0.31 sec. for PT. A high ankle RT variation, in the range of 0.26 to 0.54 sec, indicates that reducing this variation though training arrangements could improve the probability for success.

KEY WORDS: Taekwondo, reaction time, kicking time, Baldung-chagi, Motion analysis

INTRODUCTION: Taekwondo is a combat sport that is one of the Olympic disciplines since the year 2000 Olympic Games in Sydney. It has become a global sport that has gained an international reputation with 188 nations organized within the International Taekwondo Federation and millions of participants worldwide. This study is one of a series, which aims to identify the factors for success in taekwondo competitions. Simple reaction time – the time beginning at the instant of an external signal and ending with the start of the shoulder, hip and ankle movement – was identified as one factor for success (Fontani, et al., 2006, Vieten, et al., 2007). The performance time – time from the first goal-oriented action till hitting the target – logically seems to be one other critical factor, which makes the difference between winning and losing. The goal of our study was to measure the reaction time (RT) and the performance times (PT) of top performing athletes in order to be able to compare their percentage on the entire action and herewith judge the influence on the success in competitions.

METHODS: We recruited the 9 best athletes (6 male, 3 female) of the German National Taekwondo Team, those eligible to start at the qualifying tournaments for the Olympic Games. Four of them – two females and two males – later did qualify for the Olympics. We recorded the Baldung-chagi (Roundhouse kick to the waist), as it is known to be the most often used kicking technique in competition. In association with the Dollyo-chagi (Roundhouse kick to the head) it is responsible for the majority of the points in competitions. The data acquisition was done with LUKOtronic's active three camera Motion Capturing System at 150 Hz. Seven markers were used. Five of them connected to the athlete at the body side of the kicking leg (ankle, heel, hip, shoulder and wrist). One trigger marker at the floor was synchronized with an LED (light emitting diode), which provided the initial visual stimulus to start the kick and which allowed us to identify a precise starting time. The seventh marker was placed at the target, the wrist of the person holding the hand-mitt (Figure 2). A kicking action was initiated by switching on the LED on the chest of the mitt holding person. This also started our clock measuring the reaction time (RT). A movement of at least one centimeter of the shoulder, hip or ankle marker determined the reaction measurements. Where RT-S denotes shoulder reaction, RT-H stands for hip reaction, and RT-A represents ankle reaction. The end of the reaction time of the ankle RT-A marked the start of the performance, which ended while the foot hitting the mitt. The precise ending of the performance time (PT) was defined by the mitt marker being shifted by at least one centimeter.

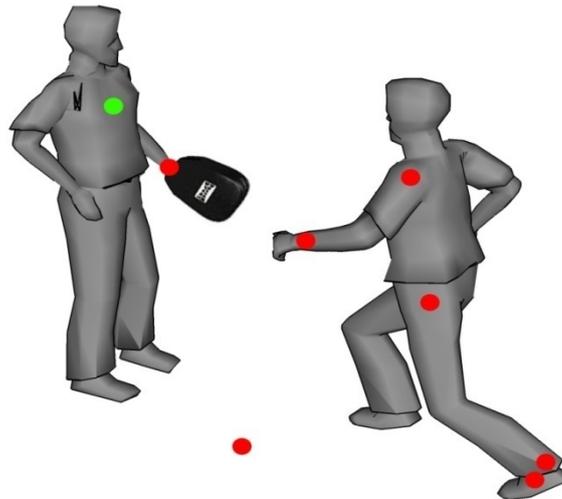


Figure 2: Experimental setup with markers in red and the LED in green (on the helper's chest)

To compare our results with those of the literature the impact time (IT) was defined as the reaction time of the ankle (RT-A) plus the performance time (PT). All measurements were made at the training center of the *BSV Friedrichshafen Taekwondo* in Friedrichshafen, Germany during a workshop of the German National Team in summer 2007. Subjects did a warm-up similar as at the beginning of a competition to be alert and ready for contest but not being exhausted. The technique was repeated ten times for each leg.

RESULTS: The average reaction time (RT-A) for men was shorter than those of the women (Table 1) while RT-S showed the opposite relation. However, these differences are not statistically significant. Also the performance time (PT) of men and women were not significantly different. For later comparison with literature results we also calculated the sum of RT-A and PT, which is called impact time (IT).

Table 1: Reaction time (RT, A=ankle, H=hip, S=shoulder), performance time (PT), impact time (IT) of male and female athletes (\pm = standard deviation).

	RT-A [s]	RT-H[s]	RT-S[s]	PT [s]	IT[s]
Men	0.329±0.042	0.249±0.039	0.233±0.028	0.294±0.023	0.623±0.041
Women	0.353±0.047	0.277±0.033	0.226±0.018	0.328±0.015	0.681±0.036
Overall	0.337±0.043	0.258±0.039	0.231±0.025	0.305±0.026	0.642±0.047
Non-dominant Leg					
Men	0.312±0.035	0.240±0.042	0.226±0.028	0.308±0.009	0.620±0.039
Women	0.369±0.063	0.307±0.025	0.241±0.016	0.320±0.006	0.689±0.057
Overall	0.326±0.063	0.256±0.048	0.230±0.026	0.311±0.006	0.637±0.057
Dominant Leg					
Men	0.350±0.043	0.259±0.037	0.240±0.028	0.278±0.025	0.628±0.047
Women	0.343±0.045	0.258±0.021	0.215±0.011	0.334±0.017	0.677±0.030
Overall	0.347±0.041	0.259±0.031	0.232±0.026	0.299±0.036	0.646±0.047

If we look at the performance of the individual athletes (Figure 3), we still find the above mentioned (statistically non-significant) relations. For 7 out of the 9 subjects and 67% of all trials the relation $RT-A > PT$ holds true, 8 out of 9 subjects and 99% of all trials it holds $RT-H < PT$, for all subjects and 99% of all trials is $RT-S < PT$. The standard deviation for RT-A is significantly bigger than for PT (non-dominant leg: $p = 7.04E-6$; dominant leg: $p = 0.003$), but the standard deviations of RT-S and RT-H are not significant different to PT at both sides (RT-S: $p = 0.143$ and $p = 0.451$; RT-H: $p = 0.131$ and $p = 0.285$). That shows a much bigger variation in the reaction time of the foot movement than in the performance of the movement itself (Figure 2).

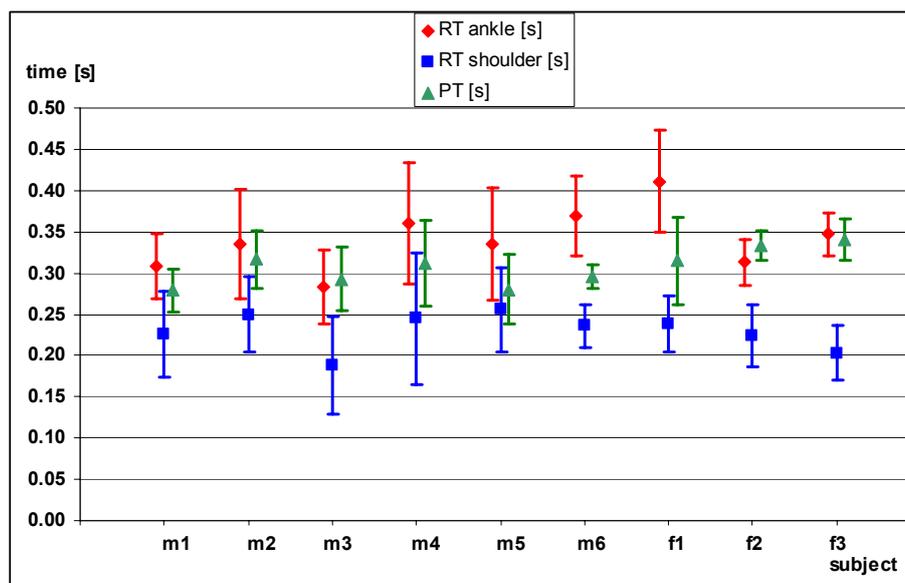


Figure 3: Mean of RT-A, RT-S and PT for all subjects (mean of both legs). RT-H suppressed to keep the figure readable and because of the close relationship to RT-S.

DISCUSSION: In the literature we sparsely find data for RT and IT. Table 2 shows some data for the roundhouse (Baldung-chagi, Dollyo-chagi). The results for the roundhouse kick (Joon, 1987) are in agreement with the data of this study. Hong et al. (2000) reports significant longer impact times (IT) but describes turning roundhouse kicks which are more complicated. The roundhouse kick is regarded as the most successful kick in competition. Own unpublished studies identify this kick to be the fastest in taekwondo. Still further studies are necessary to systematically see the differences in RT and IT for the various taekwondo kicks.

Table 2: Comparison of the results to other studies

	RT-A [s]	IT [s]	Comments	Author(s)
Male	0.329 ± 0.040	0.623 ± 0.041		This study
Female	0.353 ± 0.050	0.681 ± 0.036		
Male	0.31 ± 0.05			Vieten et al. (2007)
Female	0.35 ± 0.03			
Roundhouse kick		0.645	“the fastest performance time of the techniques”	Joon (1987)
Back leg, Turning kick		0.800 ± 0.087	“The front turning kick to the waist level with standing preparation form was significantly faster [...] than the other styles of kicking.”	Hong et al. (2000)
Front leg, Turning kick		0.720 ± 0.099		

The small variation in performance time (PT) of top athletes indicates the high quality of the kicking movement within drill exercise or under laboratory conditions, but further studies are needed to prove the situation in combat. However, if similar results should be confirmed in competition, which the authors expect to see, reaction time will be the principal factor for success.

CONCLUSION: Those athletes are successful who can execute their attack within a short impact time (IT). Consequently, they need a fast and excellent kicking technique (PT) and a short reaction time (RT). In their paper Mori et al. (2002) suggest that simple reaction time

cannot be improved by training. However, the reaction time in real combat is anything but simple. Of course, there must be a stimulus that initiates a kicking action. This can be the opponent's attack or an advantage situation. Recognizing the right moment to act depends on the athlete's experience, which can be enhanced by appropriate training methods. Such can be running specific drills of combat situations, video aided learning, or the trainer assisted video analysis. The athletes will in this way learn to anticipate a situation and be able to start an action earlier within a combat sequence. Our research put forward a second possibility for improvement. As was pointed out, the reaction time (RT) displays a significant bigger variance than the performance time (PT). We presume that this variance is mainly influenced by the athlete's state of concentration. If this proves right, specific work out routines might enable the athlete to keep focused for a prolonged period resulting in faster actions throughout the entire combat.

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