ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

EFFECT OF FATIGUE IN ROUNDHOUSE KICK'S REACTION TIME, RESPONSE TIME AND IMPACT FORCE IN TAEKWONDO

[1]Jader Sant' Ana, [1]Vinicius Santos da Silva and [1]Fernando Diefenthaeler
[1] Biomechanics Laboratory, Federal University of Santa Catarina, Florianópolis-SC, Brazil;
email: jader_sancorpore@hotmail.com; web: http://biomec.paginas.ufsc.br/

SUMMARY
The aim of the present study was to verify the effect of fatigue on reaction time, response time, and impact force during the roundhouse kick in Taekwondo athletes. Six competitive male athletes performed a time to exhaustion test. Results show that a specific protocol to exhaustion reduce impact force but do not change reaction time and response time during the roundhouse kick in Taekwondo athletes.

INTRODUCTION
Taekwondo is a traditional martial art from Korea that consists predominantly of kicks. Among kicking techniques the most used during competitions is the roundhouse kick, unleashed in the trunk and head [1]. Motor retardation to a specific stimulus (i.e. visual) during a competitive combat can compromise athlete's performance [2]. Therefore, both reaction time (RT) and response time (T_{RESP}) can potentially affect the execution and outcome of a roundhouse kick. According to Schmidt and Wrisberg [3], RT is the interval of time between presentation of a stimulus not anticipated until initial response of the person. It also represents subject's time to make decisions and initiate actions. RT also can be used to measure the information processing speed, considerate one of the most important measures in human performance in many situations. Both electroencephalogram and electromyography (EMG) methods are considerate ideal to measure RT during sports [4]. T_{RESP} has been defined as the time elapsed between the beginning and the end of the RT [4]. In other words, is the movement time or the time required to perform a voluntary movement after a stimulus [4].
Late response of a motor action to a particular stimulus may be the result of a failure of any of the processes involved in muscle contraction during a certain period in a certain intensity of physical effort (i.e fatigue). These processes encompass several factors working simultaneously from the cardiovascular system, muscular skeletal, and central nervous system [3]. There is a lack of studies in the literature that sought to investigate RT, T_{RESP}, and impact force of roundhouse kick in taekwondo athletes submitted to a protocol-specific fatigue. Therefore, the aim of the present study was to verify the effect of fatigue on RT, T_{RESP}, and impact force during the roundhouse kick in Taekwondo athletes.

METHODS
Subjects: Six male competitive athletes were evaluated (24.50 ± 3.94 years; 8.82 ± 6.09 years of practice; height 176.4 ± 3.39 cm; body mass 73.67 ± 5.99 kg and fat body 11.66 ± 1.44%). The athletes were selected intentionally and were informed about the objectives and methods of research, and risks and benefits associated with testing protocols, and signed a consent form. This study was approved by the Ethics Committee on Human Research of the institution where this study was conducted.
Protocol: Tests were performed in two different days. In the first day, anthropometric measurements and the Progressive Specific Test for Taekwondo (TST) [5] were performed. In the second day athletes performed a specific protocol for determining RT, T_{RESP} and impact force of roundhouse kick. This protocol was conducted before and after a time to exhaustion test (T_{LIM}) at intensity corresponding to the maximal kick frequency (FK_{MAX}) obtained from TST. The athletes were instructed not to perform any other type of physical exertion 24 hours that precede the data collection. The protocol for determining RT, and T_{RESP}, and impact force consisted in executing the roundhouse kick on a punching bag with maximum speed in response to visual stimulation from a light signal. T_{LIM} protocol consisted of kicks unleashed on a punching bag at a pace corresponding to FK_{MAX}, determined by beep, until exhaustion. During the test athletes were verbally encouraged.
Data collection: To determine RT, each athlete performed three roundhouse kicks (two before and one immediately post) preceding T_{LIM} protocol. RT was defined as the time interval between the visual cue and muscle activation response. Muscle activation was assessed by means of surface electromyography (EMG) from rectus femoris of the preferred limb. Signals were amplified and recorded at a sampling rate of 2000 Hz with 14 bit resolution using Miotool system (Miotec Biomedical, Brazil). Pairs of Ag/AgCl electrodes (bipolar configuration) with a diameter of 22 mm (Kendall Meditrace, Canada) were positioned on the skin after careful shaving and cleaning of the area with an abrasive cleaner and alcohol swabs to reduce the skin impedance [6]. The T_{RESP} was defined as the time interval between the light signal and the peak impact identified from the kick executed with the leg in which the triaxial accelerometer (Brüel & Kjaer™, model 4321, Germany) was fixed on the ankle. The measurements obtained from

the accelerometer is given by amplifying the signals in which it was used a pre-amplifier to the axis (x-posterior-anterior) (Brüel & Kjaer™, model 2635, Germany). The signal was acquired through a module MCS1000 (Lynx®, Brazil) with a sampling rate of 1000 Hz and signal processed by AqDados software 7.02 (Lynx®, Brazil). To determine RT and T_{RESP} light signal, acquisition systems used to obtain the EMG signal, and the impact achieved by the accelerometer were synchronized.

Data analyses: The raw EMG signals were smoothed with a 4th order band pass Butterworth digital filter at 20-500 Hz. EMG baseline activity was assessed for 150 ms prior to each light signal used to ascertain execution roundhouse kick. An increase in the EMG equal to 5 times the standard deviation of this baseline value was used to determine the initiation of muscle response [7]. The accelerometer signals were normalized by the impacts 9.81 m/s^2 in units of gravitational acceleration (g).

Statistics procedures: For presentation of the data was used descriptive statistics (mean and SD) and the normality of the same, verified by the Shapiro-Wilk test. To check for differences between the mean values of RT Wilcoxon test was used for variables T_{RESP} and impact before and after T_{LIM} protocol a test t was used for dependent samples and Pearson linear correlation was used to relate the variables obtained. The level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION

The FK_{MAX} and T_{LIM} were 33.73 ± 8.47 kicks·min^{-1} and 227.5 ± 24.5 s, respectively. Table 1 show the results for RT, T_{RESP}, and impact force in both pre and post moments. No differences were observed for RT and T_{RESP}. However, impact decreased significantly from pre and post test ($p<0.01$).

Table 1 - Mean and standard deviation of reaction time (RT), response time (T_{RESP}), and impact force during pre and post test (n = 6).

	Pre Mean ± SD	**Post** Mean ± SD
RT (ms)	150.83 ± 52.17	232.50 ± 143.23
T_{RESP} (ms)	871.25 ± 147.34	779.92 ± 198.60
Impact force (g)	44.10 ± 32.55	12.60 ± 11.10*

SD=standard deviation; ms=milliseconds; g=acceleration of gravity; *=p<0.01.

A significant positive correlation ($p<0.05$; $r=0.881$) was observed between T_{RESP} and impact values at post test (n=6 kicks) and between T_{RESP} and impact values for 18 kicks assessments ($p<0.01$; $r=0.628$).

The main contribution of this study is that to our knowledge this is the first study that investigated the effect of fatigue in roundhouse kick's RT, T_{RESP}, and impact in Taekwondo athletes during a specific T_{LIM} protocol. Results for RT observed in this study are in agreement with literature reviewed where RT in response to visual stimulus is roughly 200 ms [3]. Even not being significantly different RT after T_{LIM} was higher than RT pre test. This result associated with the significant decline on impact force could suggest a reduction in force capacity of some muscles due to fatigue processes. T_{RESP} of the athletes evaluated in the present study were higher than the values (646 ms) observed for the German National team [8], but similar to the Spanish National Taekwondo team (740 ms) [9]. These differences could be explained by the level of the athletes evaluated in each study. Hermann et al. [8] evaluated Olympic-level athletes while in the present study and Falco et al. [9] athletes were regional and national level.

A significant positive correlation was observed between T_{RESP} and impact values when all 18 kicks executed were analyzed. It seems that greater was the impact of the kick longer was the time to reach the target. Our data suggest that it allows storing more elastic energy in muscle-tendon units leading to increased force output.

CONCLUSIONS

Results show that a specific protocol to exhaustion reduce impact force but do not change reaction time and response time during the roundhouse kick in Taekwondo athletes.

REFERENCES

1. Roh JO and Watkinson EJ, *The Journal of Sports Medicine and Physical Fitness.* **42**(3):348-353, 2002.
2. Cojocariu A, *Biology of Sports*. **28**:139-143, 2011.
3. Schmitd RJ and Wrisberg CA. 4ªed. Artmed, SP, Brazil, 2011.
4. Magill RA. Edgard Blucher, 5ed, SP, Brazil, 2000.
5. Sant' Ana J, et al., *Motriz*. **15**(3):611-620, 2009.
6. Merletti R, *Journal of Electromyography and Kinesiology*. **7**(2):1-11, 1997.
7. Hopper D, et al., *Clinical Orthopaedics and Related Research*. **350**:159–65, 1998.
8. Hermann G, et al., Proceedings of ISBS XXVI, Seoul, Korea, Proceeding, 2008.
9. Falco et al., Proceedings of ISBS XXIX, Porto, Portugal, 2011.