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Changes in blood lactate concentrations during taekwondo combat simulation

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The aim of this study was to analyze blood lactate response before, during and after simulated taekwondo fight in young male athletes. The experiment was composed of simulated official taekwondo fight. During the experiment a total of 7 blood samples (25 μL) were collected that following: at rest, after 1st, 2nd, and 3rd rounds, and 3, 5, and 10 min after the end of combat. The results showed that blood lactate concentrations $[Lac]_B$ increased significantly after 1st, 2nd, and 3rd rounds of the combat compared to the rested values. The $[Lac]_B$ after 3rd round was higher when compared to 3, 5, and 10 min of recovery. After 10 min of passive recovery, the $[Lac]_B$ was significantly lesser than 3 and 5 min of recovery, and 2nd round. These data showed that taekwondo requires high activation of anaerobic lactic metabolism, and improves the ability to rapidly remove the lactate from blood.

Keywords: Lactate kinetics, Recovery, Athletes, Metabolism

INTRODUCTION

Taekwondo (TKD) is an ancient Korean martial art, very popular and practiced in 140 countries around the world by people of all ages (Bouhlel et al., 2006; Lin and Ryder, 2006). TKD showed up first at media sources during the Korean Olympic Games in 1988, as a demonstrative sport (Lin and Ryder, 2006). Later in year 2000 it was accepted as an Olympic official sport (Campos et al., 2012; Franchini et al., 2003).

Even though TKD has great popularity, few researches about physiological response during combat simulation were made. It is important to improve training and performance for TKD practitioners (Bridge et al., 2014; Kim et al., 2015). Previous research has reported that during TKD combat simulation the aerobic metabolism is predominant, and anaerobic lactic has less contribution (Bridge et al., 2014). But some other researchers have demonstrated high blood lactate concentration during real combat (Campos et al., 2012; Santos et al., 2014a). The difference could be explained by the intensity applied during these situations.

A single day of TKD competition involves several rounds of combat, thus an efficient recovery capacity is important for the athlete to improve performance (Butios and Tasika, 2007; Campos et al., 2012). Removal capacity of blood lactate reflects the recovery ability on an athlete, being optimal at faster rates (Franchini et al., 2003). Therefore, the aim of this study was to compare lactate concentrations ($[Lac]_B$) before, during and after a simulated TKD competition in juvenile athletes.

MATERIALS AND METHODS

Participants

Seven young male amateur athletes (15±1.3 years; 60±8.1 kg; 169.1±10.1 cm) participated in a simulated official TKD competition following international rules, in accordance with the 2009

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World Taekwondo Federation's, consisting of 3 rounds of 2 min spaced with 1-min rest periods. All participants were provided personal protective equipment consisting of uniform (Dobock), thorax, foreleg, forearm and head shields. All volunteers had participated in regular training for TKD events for more than 2 yr, 3 times per week, 2 h per training section totaling 6 h per week.

All participants gave written informed consent prior for their inclusion in the study. The investigation was approved by the medical research ethics committee of The *Federal University of São Carlos* (protocol n° 116/2008), which is in accordance with the norms of the Brazilian National Health Council, under resolution n° 196, promulgated on 10 October 1996, referring to scientific research on human subjects.

Blood samples and lactate analysis

In this experiment, seven blood samples were collected: at rest, immediately after the 1st, 2nd, and 3rd rounds, and 3, 5, and 10 min after the simulated competition (recovery). Auricular blood samples were collected following aseptic protocols using dischargeable lancets and heparinized capillaries (25 µL).

Samples were transferred to Eppendorf tubes containing sodium fluoride (1%) and frozen at -14°C for posterior analysis. Measurements were performed using an electro-enzymatic model (YSI 1500 Sports, Yellow Springs Instruments, Ohio, OH, USA). Lactate concentrations are expressed as mmol/L^{-1}.

Statistical analysis

Initially, a descriptive analysis of the data was performed. To compare the variables along the time, analysis of variance for repeated measures was used. Mauchly's sphericity test was applied, and when it was violated, technical corrections were performed using the Greenhouse-Geisser test. When the F test was significant, complementary analysis was performed using Bonferroni's test for multiple comparisons. A statistical significance of 5% was adopted ($P \leq 0.05$).

RESULTS

Lactate concentrations collected at seven moments during the simulated competition are presented in Table 1. Our results showed a significant increase in lactate after each of the three rounds in comparison to rest (1st round $P = 0.001$; 2nd round $P = 0.007$; 3rd round $P = 0.029$) (Table 1).

At the end of the 3rd round, immediately after the combat, lactate concentration was higher than observed in the measurements at recovery (3, 5, and 10 min after the simulated competition). Significance values of the lactate concentration during the period of passive rest were: 3 min $P = 0.036$; 5 min $P = 0.012$, and 10 min $P = 0.013$.

No significant differences during the passive rest (3, 5, and 10 min after the combat) were observed in comparison to rest period before the rounds (P-values for 3, 5, and 10 min were $P = 0.150$; $P = 0.070$; $P = 0.119$ respectively). At the end of the 10 min of recovery, lactate concentration decreased in comparison to the end of the 2nd round and at the 3 and 5 min of recovery (Table 2).

Table 1. Blood lactate concentration in different times during simulated combat

	Mean ± SD	95% Confidence Interval	
		Lower Bound	Upper Bound
Rest	1.05 ± 0.35	0.72	1.37
1st round	5.18 ± 0.90	4.34	6.01
2nd round	7.05 ± 2.17	5.04	9.06
3rd round	7.36 ± 2.97	4.60	10.11
3 min R	6.26 ± 2.79	3.67	8.85
5 min R	5.58 ± 2.57	3.20	7.95
10 min R	4.48 ± 2.20	2.44	6.53

Values are expressed as mmol/L^{-1} (Mean ± SD). R, Recovery.

Table 2. Differences in values of lactate concentration obtained during simulated combat

	1st round	2nd round	3rd round	3 min R	5 min R	10 min R
Rest	0.001*	0.007*	0.029*	0.053	0.070	0.119
1st round		0.483	0.972	1.0	1.0	1.0
2nd round			1	1.0	0.147	0.020*
3rd round				0.036*	0.012*	0.013*
3 min R					0.150	0.041*
5 min R						0.031*

*Statically significant ($P < 0.05$). R, Recovery.

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DISCUSSION

The main finding in this study was the elevated blood lactate concentration after a simulated TKD combat, which reflects the contribution of anaerobic metabolism to re-synthesize Mg-ATP, which is the characteristic of intermittent sports. $[Lac]_B$ at the tenth minute of passive recovery did not differ from rest concentrations, showing the high athletes' recovery ability in blood lactate elimination (Gladden, 2004; 2008a; 2008b).

After simulated combat a high $[Lac]_B$ is expected (Bridge et al., 2014), because of the nature of this sport modality. In fact, our findings demonstrated intense glycolytic anaerobic system demand to re-synthesize Mg-ATP, similar to boxing (Ghosh et al., 1995) and TKD (Santos et al., 2014a), to maintain the intensity of the fight.

However, another study (Butios and Tasika, 2007) found low $[Lac]_B$ after simulated combat in adult athletes. The differences between protocols were the number of combats and athletes age. We used only one combat, while Butios and Tasika (2007) used three, spaced with one and a half hour interval between them. The difference in $[Lac]_B$ may be due to fighting style between adults and juvenile athletes. Adult competitors use a different fight strategy, which implies in lower energetic demand rather than juvenile bohks. Another fact is the expertise of adult bohk, who shows an improved technique leading to spend low energy (Bouhlel et al., 2006). Thus, a lower glycolytic amount of Mg-ATP should be re-synthesized. The combats sequence could lead the athletes to be more conservative in their fight strategy, spending less energy, and consequently lower $[Lac]_B$, in accordance with governor central theory (Noakes et al., 2004).

Fight movements with no opponents implies in diminished muscle power demand (Lee et al., 1999). During a real combat, evasive and attack maneuvers are needed, requiring rapid energy replenishment. This stress during real combat must be considered in an increased blood catecholamine's concentration that potentiates glycolytic system pathways and lactate production (Urhausen et al., 1994). The different between a simulated combat with no opponent or physical contact, using a pre-determined movement sequence, and simulated real combat, must be taken into consideration to understand the metabolic demand and $[Lac]_B$ observed in each study.

The lactate kinetics analysis during combat showed an increased $[Lac]_B$ as rounds were played, peaking at the 3rd round, as well as the other study (Santos et al., 2014a). This response could be explained by the higher number of attacks during last round than first (Santos et al., 2014a) Therefore, the energy provision during TKD match implies in high glycolytic anaerobic system activation to maintain of the effort during combat, with or without caffeine supplementation (Santos et al., 2014b). This metabolic response implies in the fight strategy, because $[Lac]_B$ is associated with fatigue and lower performance (Franchini et al., 2003).

Comparing our results with those obtained by Butios and Tasika (2007) lactate mean values are divergent after each combat round. After 1st round in our study it was 5.18 mmol/L^{-1} vs 2.15 mmol/L^{-1} from Butio's study; after the 2nd round it was 7.05 mmol/L^{-1} vs 2.98 mmol/L^{-1}, and after the 3rd, 7.36 mmol/L^{-1} vs 2.90 mmol/L^{-1}. At the end of a 5-minute rest period it was 5.58 mmol/L^{-1} vs 2.53 mmol/L^{-1}. This important difference between ours and Butio's results could be explained by a different volunteer's training level which is known to enhance athletes' blood lactate removal or less lactate production (Casolino et al., 2012) by increasing oxidative metabolism enzymatic machinery (Armstrong and Welsman, 1994).

In comparison with adults, teenagers show lower $[Lac]_B$ after sub maximum and maximum exercise (Armstrong and Welsman, 1994). This difference is due to low enzyme content of glycolytic anaerobic system, such as phosphofructokinase (PFK) (Fournier et al., 1982). On the other hand teenagers show higher aerobic enzymatic machinery content such as succinate dehydrogenase (SDH) (Eriksson et al., 1973) and isocitrate dehydrogenase (ICDH) (Markovic et al., 2005; Melhim, 2001). Systematic physical training lead to alter aerobic and anaerobic enzymes content and activity. This adaptation is dependent of the type of physical training (i.e. power, velocity or endurance sports) (Armstrong and Welsman, 1994). Considering this, TKD bohk presents an increased glycolitic anaerobic system as an adaptation to the energy requirements for this modality (Butios and Tasika, 2007; Campos et al., 2011). This metabolic characteristic is due to high intensity of fights (Melhim, 2001), a particular aspect of TKD (Markovic et al., 2005).

Analyzing lactate kinetic after combat we could observe higher lactate removal ability. This capacity may be due to a good aerobic system that is improved in response to a systematic TKD training (Haddad et al., 2011; Kim et al., 2015), and it is important to speed recovery between rounds and fights (Bridge et al., 2014). Our data corroborate with the other ones (Kim et al., 2014).

We conclude that TKD combat induces high glycolytic anaerobic system to re-synthesize Mg-ATP, as shown by elevation of lactate after first, second and third rounds. Subjects presented a faster lactate removal response, indicating faster recovery ability. Our study is one of the few regarding lactate kinetics and TKD combat. This information is important to improve athletes training and performance.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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