Study of the correlation between the velocity of motor reaction and blood lactate in different times of combat in judo

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ABSTRACT

The velocity of motor reaction in humans or reaction time is an important physical capacity to judo competitors. During a high intensity fight, there is a considerable increase in serum lactate (SL), which is closely related to muscle fatigue. This fact may interfere in the capacity of the athlete in reacting to stressful situations during the combat. The main objective of this work is to study the role of serum lactate increases after a 1'30", 3' and 5' combat situations (Randori) in the velocity of motor reaction in high level judo competitors. **Methods:** For this purpose 11 healthy male competitors, 23.4 ± 2 years old, were evaluated. To record the simple reaction time, initially, immediately after combat and at the three minutes to rest, the *Cybex Reactor* System was employed. Serum lactate concentrations were measured by a portable lactate analyzer (*Accusport*). Variance analysis (Kruskal-Wallis) showed significant differences between serum lactate before, immediately after combat and at the three minutes to rest ($p < 0.05$) and in the velocity of motor reaction (*Cybex Reactor*), between the number of errors to execute the tests before and after combats ($p < 0.05$). A high correlation between the number of errors to execute the tests at *Cybex Reactor* and the lactate concentration ($r = 0.9341$) was observed. However, no significant differences between the motor reaction time before and after combats ($p > 0.05$) were found. The results demonstrate that the high serum lactate concentration does not affect the motor reaction time in high level judo competitors, indeed it suggests that there is a decrease in the reaction efficiency. This fact was demonstrated by the high correlation found between the lactate concentrations and the number of errors in the reaction tests, probably due to decreases in concentration in judo competitors to stressful situations.

Key words: Muscle fatigue. Lactate. Reaction time. Judo.

INTRODUCTION

Judo combats are developed at high effort intensity in intermittent periods of activity and rest[1], where a high development of the lactic anaerobic capacity is required. This may be observed in some studies that verified high blood lactate concentrations after the development of combats[2-4].

The reaction capacity to external stimuli, also known as velocity of motor reaction or time of reaction (TR), is the time interval between the moment of the external signal presentation and the beginning of the proper muscular response[5], being essential for judo competitors. As the judo competitor defines combat strategies during a combat, he should be aware of the opponent's actions, reacting appropriately to his strokes in order to respond with a counterstroke or just to avoid his strokes, what depends on a high degree of attention[6] and on the velocity of his response after the signal is presented.

The accumulation of high lactate concentrations in blood during combat may interfere on the judo competitor performance, especially if his capacity to eliminate it is slow, once in next combat the judo competitor will have a higher chance of success the faster is the lactate removal. Once yielding is jeopardized, the TR may be one of the physical capacities that will be negatively affected in this stage. If the athlete decreases the capacity to react quickly and his lactic anaerobic capacity is insufficient to maintain his performance, his chances to avoid a stroke or to perform a counterstroke are likely decreased.

Chmura *et al.*[7] verified the TR behavior in different effort loads and lactate concentrations. The results showed an initial reduction on TR up to values of 6 mM/l of blood lactate with an exponential increase from these values. Johnson *et al.*[8] related the TR complex to the progressive increase on the cardiac frequency (FC) between 80, 115, 145 and 175 beats per minute (bpm). They verified the lowest TR in FC of 115 bpm and the highest in FC of 175 bpm. When the individual performs light exercise loads, a heat effect is generated and hence it increases the central temperature[6,9]. In these conditions, the CNS is activated causing alert and attention state and performance improvement[6]. This also results in increase on the dissociation of the oxygen from hemoglobin, higher blood flow in muscles, decline on the muscular viscosity and increase on the conduction velocity of the action potentials[6,9]. These factors must have been the responsible for the TR initial improvement.

With the objective of observing the TR behavior of the judo competitor under progressive effort conditions generated by different times of combat in judo, an experimental protocol was developed where the increase on the blood lactate concentration was induced, what may lead to the decrease on performance due to the acidosis caused by the accumulation of H^+ dissociated from the lactic acid[10].

METHODOLOGY

The work was developed in the Biodynamic Laboratory of the Health and Sciences School at the Vale do Paraíba University – São José dos Campos. For this purpose we evaluated 11 healthy male competitors who compete for at least 10 years, regularly attending to university trainings, 23.4 ± 2 years old. The athletes were informed about the work and signed the consent form for their participation. The entire experimental protocol was submitted and approved by the Research Ethics Committee of the Vale do Paraíba University (Protocol # A011/2003/CEP).

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The entire experiment was performed in a single day divided into 3 stages with 4 hours between them. In each stage, the athletes performed the TR task in the *Cybex Reactor* device, which is able to measure the TR by means of the detection of the floor pressure alteration[11,12]. For the TR recording, the athlete was oriented to remain standing and stable on two platforms in front of the monitor waiting for the signal presentation that, one time to the left side and the other to the right side, where the visual signal must be responded the fastest as possible. The task may be observed in figures 1 and 2. Besides the TR, blood samples were collected from the fingertip in order to verify the blood lactate in a portable lactate analyzer (*Accusport*). The collection of these variables was performed in rest and after a 10-minutes warm-up exercise; the athletes were submitted to a judo combat stimulus. Shortly after combat, the athletes performed a TR task. Three minutes after the end of combats, the lactate concentration was verified and the TR measured once again. The collection stages presented different time of combat: 1'30", 3' and 5' at 8, 12 and 16 hours, respectively, developed in high intensity. For each situation performed, each subject executed three repetitions for left and right sides of the platforms, performing 18 repetitions. The attempts with results below 0.130 seconds and the results that could not be recorded by the equipment were considered as errors, once they indicate probable anticipation due to the lack of stability during the stimulus presentation.

The data recorded were exported to a spreadsheet. The average among the lowest values of TR between left and right side outlets was considered for the TR in rest, once these values are not significantly different ($p = 0.64$). For TR immediately after combats and three minutes after the end of combat, the lowest values between outlets for left and right sides were considered. The lactate recordings were also organized in a spreadsheet for further analysis.

The Kruskal-Wallis analysis of variance method was used and the level of significance applied was of $p < 0.05$ for all tests, where differences in TR pre- and post-combat were verified with outlets for the left and right sides of the platform and the sum of the number of attempt errors was analyzed in the execution of TR task in rest, immediately after combats and 3 minutes after the end of the combat. Differences on the blood lactate concentrations in rest and after fights were also verified. The numbers of TR collect errors with the lactate concentration in rest and after 3 minutes from the end of the combat were correlated through the Pearson correlation coefficient.

Fig. 1 – *Individual stabled on the* Cybex Reactor *platform waiting for luminous signal*

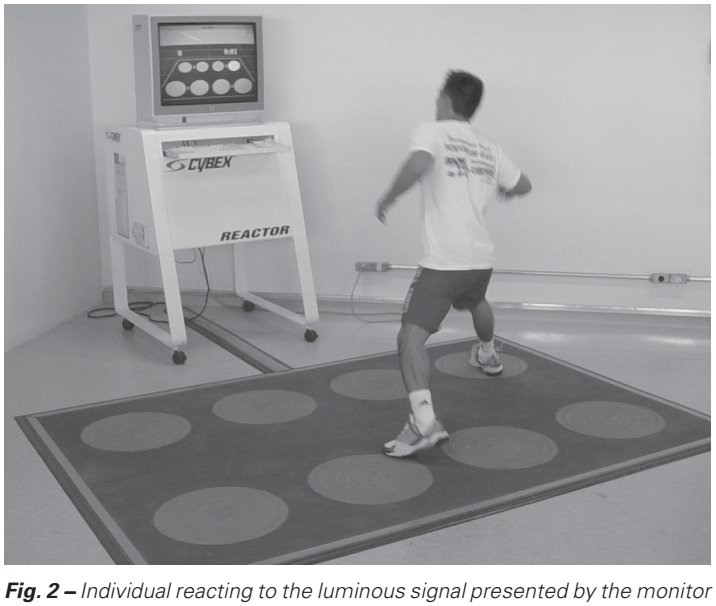
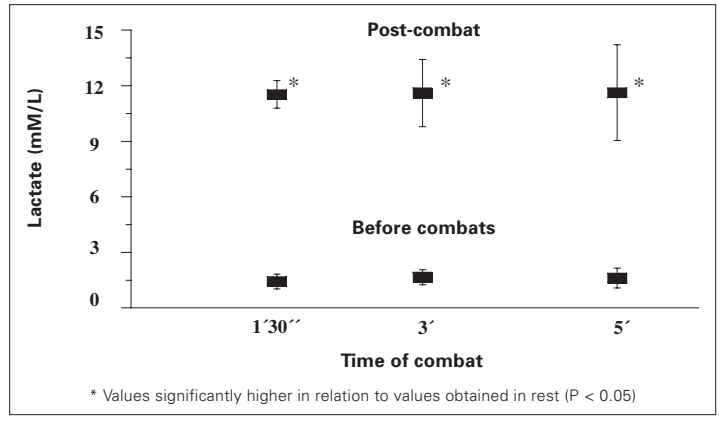


Fig. 2 – *Individual reacting to the luminous signal presented by the monitor*

RESULTS

Graph 1 shows the blood lactate values in rest and after combats of 1'30", 3' and 5'. These results demonstrate that the post-combat blood lactate concentration increased significantly when compared to the blood lactate concentration in rest ($p = 0.00$). No significant difference between blood lactate concentrations in rest ($p = 0.41$) and post-combat conditions ($p = 0.97$) was found between 1'30", 3' and 5'combat situations.

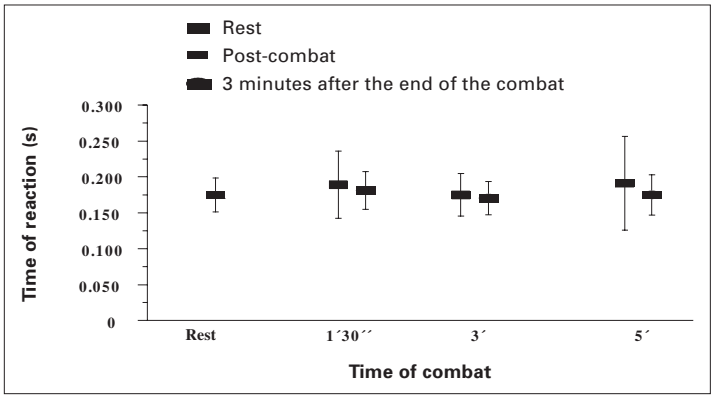


Graph 1 – *Average and standard deviation of the group for blood lactate concentration (before combats) and after the three combat stages*

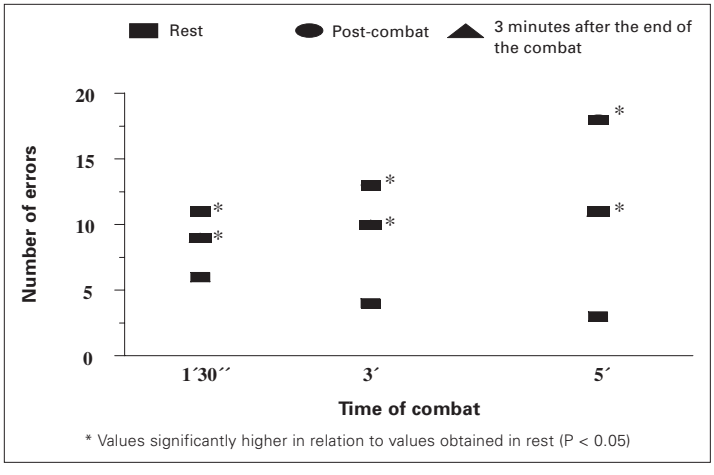
Graph 2 presents the lowest values of TR recordings collected in rest, immediately after combats and at 3 minutes from the end of combats. Generally, all athletes achieved performing the task proposed, although TR values relatively different were found (average deviation of the group ± 0.05 s).

In order to verify the effects of each time of combat on the TR, the TR in rest and the TR immediately after 1'30", 3' and 5' combat situations ($p = 0.91$) and the TR in rest with the TR after three minutes from the end of combats ($p = 0.77$) were compared and no significant difference was found (graph 2).

Even though the TR task was performed satisfactorily, an increase on the number of errors during its execution after combats in relation to rest recordings was observed. The number of errors on the task execution may be observed in graph 3.



Graph 2 – *Average and standard deviation of the group for TR in rest, immediately post-combat and 3 minutes after the end of 1'30", 3' and 5' combat situations*



Graph 3 – *Total number of errors of the group obtained during TR test in rest, shortly after combats and 3 minutes after the end of combats*

These values demonstrated that a significant variation (p = 0.03) of the total amount of errors in function of effort time generated by combats occurred, both immediately at the end of the combat and 3 minutes after, if compared to the number of errors in rest.

In order to verify the influence of the lactate concentration after combats in the execution of tasks, the variables were analyzed altogether in correlation tests. As result, a significant correlation between the blood lactate concentration and the number of TR recording errors was observed in rest and after 3 minutes from the end of the combats (p = 0.006; r = 0.9341).

DISCUSSION

In this work, the TR in rest and in conditions of high blood lactate concentrations induced by different times of combat in judo was verified. The blood lactate concentration was analyzed before the beginning of each combat stage, firstly, to verify the rest values and at the following stages, to confirm the return to the lactate initial values, essential for the athlete to begin the subsequent combat in low lactate concentrations condition, once the collections were performed at a single day. No significant difference between rest values was found, demonstrating that the interval of 4 hours between each combat was sufficient for individuals to present lactate concentrations back to initial values[13].

A significant increase on the blood lactate concentration was verified after 1'30", 3' and 5' combat situations in relation to the lactate concentration in rest. These results demonstrate that the effort caused by combats was sufficient to elevate lactate significantly to high concentrations as expected and observed in other studies[2-4]. According to Linnamo *et al.*[14], significant lactate increases, above 10 mmol/l indicate large utilization percentile of fast fibers during effort, being a good indicative of anaerobic power[15], making the development of this capacity for the better performance of the judo competitor relevant.

The different times of combat induced no progressive increase or with significant difference on the blood lactate concentration. Chmura *et al.*[7] controlled the effort load in cycle-ergometer and obtained progressive increase of lactate concentration. These differences are probably due to a possible knowledge acquired by the athlete through previous experiences of how to manage the effort intensity during combats. Apparently, these athletes performed a more intense effort in the shortest combats and a less intense effort in the longest combats, once they had been previously informed about the duration of the combats in order to compensate the volume through the effort intensity, thus obtaining similar values of blood lactate.

No significant difference on TR in high lactate concentrations was found, unlike results obtained by Chmura *et al.*[7], who demonstrated that the intense increase on the blood lactate (6 mmol/l or more) leads to higher TR. Besides, the performance on TR was not dependent on the side of the limb that will perform the task (right or left), unlike results found by Mori *et al.*[16], who observed significant difference between sides, observation that corroborate Coronel *et al.*[17], who demonstrated that there might be influences of the cerebral hemisphere specialization on TR tasks. Generally, it is understood that the spatial position of the stimulus[18], the type of response requested (unilateral or bilateral) and the subject's position may influence the time of reaction. In the protocol applied by Mori *et al.*[16], the subjects remained sitting and reacted to the visual signal with upper limbs by pressing the key that recorded the TR, one time with the left hand and the other time with the right hand, thus obtaining no influence from one of the sides, when the other had to respond providing a distinct TR for each task execution side. In this protocol, the subjects performed the TR test standing and reacted to the signal with lower limbs concurrently, however, they were informed the stimuli would be presented at the left side or at the right side of the monitor. Thus, after the presentation of the signal, the time of reaction was obtained after a change of pressure on the ground for the feet to move the fastest as possible towards the platform presented in the monitor, regardless the side the stimulus was presented. Therefore, this was the probable reason why no significant differences on the results of the analysis between the outlet sides were found.

On the observation of TR recordings, an increase on the number of execution errors of post-combat TR tasks was verified in relation to rest, despite the maintenance of the TR values. A probable concentration difficulty of the post-combat subjects caused the outlets to be anticipated or that the athletes do not stabilize on the platforms. However, it was observed that the number of errors was even higher immediately after combats when compared to values obtained three minutes after the end of the combat.

With the objective of verifying the behavior between the blood lactate concentration and the number of TR errors recorded, a correlation analysis of these variables in two moments was performed: in rest and three minutes from the end of the combat, obtaining significant result. This demonstrates that the increase on the blood lactate concentration in judo combats may influence the performance during the maintenance of the correct response in the reaction capacity.

Several factors may be related to the number of errors in each test stage. The moment of the blood collection three minutes after the end of combats does not necessarily represent the stage of highest lactate concentration in the muscle or of highest muscular acidosis, but rather the dynamics between the production of muscular lactic acid, its dissociation into lactate and ions H^{++} and

its removal[19], while, immediately after combats, the metabolic condition may vary as result of its duration and intensity. These results demonstrate that, in order to maintain a given task in optimum performance level, the maintenance of the lactate concentration after and during high-intensity efforts is required, being related to the capacity of supporting the exercise acute effects on the muscular apparatus. Apparently, as the athletes maintained the TR levels significantly unchanged during all blood collection stages and the TR performance was reduced indirectly due to the inability to maintain the capacity of performing the task, the metabolic effects observed may produce different adaptive responses of the organism in order to preserve the motor capacity despite the specific abilities required in each task.

Besides the lactate concentration, it is known that many other factors may contribute for the decrease on the muscle contraction capacity and these factors may also influence the results obtained in motor tasks.

Firstly, we understand that a muscular acidosis may have occurred in function of the H^+ accumulation[20-22] dissociated into lactate from lactic acid. The reduction on the energy levels and CP for the ATP resynthesis related to the increase on the Pi levels in the sarcoplasm may have limited the muscle contraction capacity[23]. A complex formed by Pi and Ca^{++} may cause the precipitation of such complex inside the sarcoplasmic reticulum, thus reducing the amount of free Ca^{++} available in the sarcoplasm resulting in lower affinity with the troponin bonding sites[24-27] with reduction on the bonding power of crossed bridges between actin and myosin at the end of the muscular contraction stage. Another important factor is that an inhibitory response may be unchained by the muscle exhausting condition that sends an afferent signal to the supraspinal region and later to the motor neuron[28], or by direct inhibition of the own motor neuron towards the muscular fiber[23], thus reducing the number of signals to the muscular fiber as a type of stimuli economy in order for the muscle to lengthen the work even if the contraction power is decreased[28]. This condition of muscle fatigue may provide a signal to the central command known as afferent inhibitory feedback[20]. Besides, a failure on the transmission mechanisms of the motor neuron electric impulse to the muscular fiber may occur due to the excessive and frequent stimuli in the neuromuscular joint, resulting in limitation on the release of acetylcolin by the termination[29,30].

These factors associated may have influenced the performance of the individuals, leading them to make more mistakes when performing the task, what would influence their motivation, being also related to the perception and processing of information in the CNS[31].

Based on the results obtained, we have concluded that there is a difference between the time of reaction and the capacity to react correctly, factors that may be decisive in judo combats. It was observed that the lactate concentration trends to be elevated after high intensity efforts, regardless the combat duration, leading to the athlete's fatigue, influencing negatively in his skill capacity when reacting to a given stimulus.

This work showed that even with high lactate concentrations after combats, the athlete's reaction capacity was maintained, but the frequency that this performance occurred was decreased, resulting in wrong and random responses. This incapacity of maintaining the performance in all reaction stages during an intense combat is a factor that should be considered during training. Generally, the development of the anaerobic lactic capacity is vital for the judo competitor to support the high blood lactate concentration during combat and to present the capacity of reabsorbing the lactate accumulated during intervals in order to start subsequent combats able to react against the opponent's strokes with a higher skill frequency.

Although this work evidences some important aspects for the good performance of judo competitors, it does not verify all factors involved in the analysis of the time of reaction with accuracy. It is known that the fractioning of the time of reaction in stimulus perception, information processing and signal propagation up to the muscular contraction characterizing the beginning of the response may explain in which levels of the motor system the deficiencies occur. We have also observed that the explicit determination of the combats duration may have influenced on the way athletes manage the effort intensity, once similar phenomenon does not occur in competitions. Thus, we suggest that further studies be conducted with the objective of better analyzing the relations between neuromuscular fatigue and the time of reaction.

All the authors declared there is not any potential conflict of interests regarding this article.

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