Karate Kumite: How to optimize Performance

Chapter: Physiological Characteristics of Karate Athletes and Karate-Specific Tasks

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Abstract

Establishing the main physiological attributes of karate kumite is of high practical relevance for coaches, strength and conditioning specialists as well as sport scientists to better structure karate kumite training. The available scientific literature is unanimous regarding the importance of both aerobic and ATP-PCr energy systems for optimizing karate kumite high-level performance. The aerobic energy system guarantees the good recovery process during periods of low-intensity movements and/or rest, whereas ATP-PCr system is responsible for providing the required energy during periods of very short high-intensity actions (i.e., explosive movement during attacks). In addition, official as simulated karate kumite combats result in high cardiovascular stress with a reduced blood lactate responses during simulated matches in comparison to official ones. Future researches that extensively detail the physiological responses of karate practitioners during an ecological valid environment (i.e., official kumite) are needed to boost the present findings.

Keywords: Combat Sport; Exercise; Physiology

Introduction

Karate kumite is considered as a highly demanding physiological task [1,2]. To be successful in this task and from a biological point of view, karatekas need to develop several physical and physiological characteristics[3,4]. However, although these components are relevant for competitive performance, other characteristics especially technical-tactical-related aspects are also very important for this sport, especially because the performance is determined by the metabolic power divided by the economy [5]. The metabolic power is determined by the activation of the different energy systems (ATP-PCr, glycolysis and oxidative pathways), which are activated according to the intensity
and duration of a given effort, as well as by the metabolic adaptations generated by the athlete’s genetic characteristics and by the training stimulus exposure [5]. The economy is determined by the efficiency with which the movement is executed, i.e., athletes with better technical execution are able to perform the same movement with less energy expenditure [6].

To assess the metabolic power during karate kumite, some authors [1,2] estimated the energy system contributions during match simulations. Moreover, recent reviews [3,7] presented the main physical and physiological characteristics of karate athletes and the physiological responses to karate-specific tasks, including different types of training session, official and simulated matches conducted by athletes from different competitive levels.

Concerning the physiological characteristics of karate athletes, the present chapter will focus on those that were observed to be discriminant between winners and defeated athletes or between elite and non-elite athletes, as a recent review can be used to assess other information [3]. In addition, this chapter will focus, on the metabolic and hormonal demands during simulated matches and on physiological responses (e.g., blood lactate and heart rate) during official contests.

Physiological Profile – Aerobic and Anaerobic Profile

Aerobic power and capacity are important variables to allow athletes to maintain the intensity during the match, as well as to contribute to a faster recovery between successive combats [3,4]. The range of $VO_{2\text{max}}$ values of national and international male karate practitioners vary from 47.8±4.4 to 61.4±2.6 mL/kg/min, and from 32.75±4.1 to 42.9±1.6 mL/kg/min for females [3]. However, studies comparing higher and lower level karate athletes did not identify any significant difference between groups concerning aerobic power [8,9]. It is important to consider that the evaluation process used in these studies applied treadmill or cycle-ergometer tests, which are not karate-specific exercise modes. Thus, futures studies comparing karate athletes using specific tests, such as the karate specific aerobic test (KSAT) [10,11] (or the Karate Specific Test (KST) [12], should be conducted to confirm the similarity in aerobic fitness in karate athletes from different competitive levels. For instance, Chaabène et al. [11] reported that KSAT can effectively distinguish between karate practitioners from different competitive levels (national level vs regional level), but this finding need to be further considered. Additionally, little is known concerning the effects of aerobic power and capacity improvement and performance during official karate matches.

The anaerobic power is important in the technique execution within high-intensity attack and/or defensive actions responsible in the scores during the match, while anaerobic capacity is considered less relevant for karate athletes as the high-intensity action duration is very short and interspersed by long rest intervals [1,7]. As there is no karate-specific anaerobic tests, most investigations used the Wingate test or the force-velocity test to compare karate athletes [3]. One of these studies [13] evidenced that French national-level karate athletes presented lower maximal power (10.9 ± 1.5 W/kg) in the force-velocity test compared to international-level karate athletes (12.5 ± 1.3 W/kg). Conversely, when the same investigators [9] compared national- and international-level karate athletes concerning their anaerobic capacity, assessed via the maximal accumulated deficit (MAOD), no difference was observed between them (national = 64.5 ± 6.4 mL/kg; international = 67.8 ± 8.0 mL/kg). Overall, karate’s performance seems to be dependent on anaerobic-based power more so than anaerobic capacity itself.

Physiological Responses During Karate-Specific Tasks

Energy Cost And Energy Systems Contributions During Karate Kumite

Only two studies [1,2] reported the total energy cost of karate kumite using methods
estimating the phosphagens (ATP-PCr), glycolytic and oxidative contributions. Figure 1 presents the total energy expenditure in four successive simulated kumite matches.

![Figure 1: Energy cost of simulated karate kumite (Adapted from Beneke et al.[1]; values are mean and standard deviation).](image1)

In these 3-min simulated kumite matches, the energy cost can be considered high as it varied from 25.5 kcal/min to 27.7 kcal/min [1]. Additionally, Doria et al., [2] reported that males presented higher energy cost during kumite (18.2 kcal/min) compared to females (14.7 kcal/min).

Beneke et al., [1] detected a predominance of the oxidative system, followed by the ATP-PCr, with a very small participation of the glycolytic system (Figure 2). Additionally, they identified that the glycolytic system decreased its absolute contribution in the fourth match when compared to the second one.

![Figure 2: Energy system contributions during four successive simulated kumite matches (Adapted from Beneke et al., [1]; values are mean and standard deviation).](image2)

** different from match two for the glycolytic system
Doria et al., [2] compared male and female high-level athletes during 4-min and 3-min simulated matches, respectively, and found only a higher oxidative total energy expenditure for males compared to females due to the longer duration of the match for the first group (Figure 3).

![Figure 3: Energy systems absolute contribution to simulated kumite (Adapted from Doria et al.[2] ; values are mean and standard deviation).](image)

Thus, the aforementioned studies, indicated a predominance of the oxidative metabolism, although the high-intensity actions are probably sustained by the ATP-PCr pathway, while the glycolytic contribution to the total energy expenditure during kumite is low. Moreover, no significant differences were found between males and females for the ATP-PCr and glycolytic pathways, but the longer duration of males’match resulted in higher total oxidative participation.

**Cardiovascular Responses To Karate Kumite**

The oxygen uptake is considered an important marker of cardiovascular and respiratory integration, although its measurement was conducted only in two studies [1,2] using simulated combats. These authors observed values ranged between $34.9 \pm 3.0 \text{ ml.kg}^{-1}.\text{min}^{-1}$ (72% of $\text{VO}_{2\text{max}}$) [2] to $41.3 \pm 13.1 \text{ ml.kg}^{-1}.\text{min}^{-1}$ [1] confirming the high aerobic participation in this combat sport.

As oxygen uptake measurement involves sophisticated and expensive equipments, this variable is not usually measured during karate training programs or evaluation processes. Thus, to infer the cardiovacular responses to karate, some authors measured heart rate responses to typical karate kumite protocols[2,14–18].

Chaabène et al. [14] revealed that during official karate kumite, mean cardiovascular responses achieved $91\% \pm 5\%$ of heart rate peak (HRpeak) $(177 \pm 14 \text{ bpm})$ and that elite level karatekas spent 65% of the time exercising at HR >90% of the individual HRpeak. Moreover, Tabben et al., [16] established that during international karate kumite, peak heart rate response was around $182 \pm 9 \text{ bpm}$ [91\%3\% of maximal heart rate (HRmax)] with no significant difference recorded during the three successive matches. In another research [17], the same authors revealed that women’s heart rate displayed higher values compared to their male counterpart ($74.7 \pm 1.7\% \text{ HRmax}$ vs $73.1 \pm 4.3\% \text{ HRmax}$, respectively).

Iide et al., [18] reported that during 2-min match simulations, heart rate achieved $160 \pm 13 \text{ bpm}$ (85 \% HRmax), which was lower than observed in 3-min match simulations (170 \pm 9 bpm; 93 \% HRmax). Thus, increasing match duration results in higher cardiovascular stress. Confirming this assumption, Doria et al., [2] reported slightly higher values (175 \pm 5 bpm) in 4-min match simulations.
Certainly, one important aspect to be considered is how much combat simulations result in similar cardiovascular responses compared to official matches. To answer this, Chaabène et al., [15] compared the heart rate responses to both simulated and official competition in 10 national-level karate athletes. They reported no significant difference between the two combats modalities for mean and peak heart rate (Figure 4), with values around 92% HRmax.

Thus, simulated matches are appropriate to generate similar heart heart responses as those verified during official matches. Altogether, karate kumite event imposed high cardiovascular stress on karate practitioners regardless of gender and type of match (official vs simulated).

**Blood Lactate Responses**

Recently, Chaabène et al., [7] presented an extensive review concerning blood lactate responses to karate kumite. The studies included in their review are presented in the Table 1.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Match duration (s)</th>
<th>Lactate (mmol/L)</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simulated matches</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male athletes, elite level (n = 10)</td>
<td>267 ± 61a</td>
<td>7.7 ± 1.9</td>
<td>Beneke et al. [1]</td>
</tr>
<tr>
<td>Italian male, elite level (n = 3)</td>
<td>240</td>
<td>7.5 ± 2.4</td>
<td>Doria et al. [2]</td>
</tr>
<tr>
<td>Italian female, elite level (n = 3)</td>
<td></td>
<td>10.6 ± 4.8</td>
<td></td>
</tr>
<tr>
<td>Japanese male, black belt (n = 13)</td>
<td>120</td>
<td>3.1 ± 1.0</td>
<td>Iide et al. [18]</td>
</tr>
<tr>
<td></td>
<td>180</td>
<td>3.4 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>Brazilian male, elite level (n = 14)</td>
<td>180</td>
<td>Pre = 2.3 ± 0.4</td>
<td>Roschel et al. [19]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post = 5.1 ± 1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre = 1.8 ± 0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post = 5.2 ± 2.2</td>
<td></td>
</tr>
<tr>
<td><strong>Official matches</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elite level during World Championship (n = 20)</td>
<td>Not reported</td>
<td>11.1 (range 7.7 to 12.7)</td>
<td>Arriaza [20]</td>
</tr>
<tr>
<td>Tunisian male, elite level (n = 14)</td>
<td>180</td>
<td>Pre = 1.73 ± 0.54</td>
<td>Chaabène et al. [14]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post = 11.18 ± 2.21</td>
<td></td>
</tr>
</tbody>
</table>

Pre = before the match; post = after the match; a = taking into account the referee’s break. All other studies considered the registered time.

**Table 1**: Blood lactate responses to karate kumite (Adapted from Chaabène et al., 2015; values are mean and standard deviation or mean and range).

As can be noted from the data presented on Table 1, a high variability is found in blood lactate in response to kumite showing therefore a different anaerobic glycolysis contribution.
through these studies, with mean values around 7 mmol/L in simulated combat and around 11 mmol/L in official matches. In fact, the only study [15] that compared official and simulated matches identified a significantly higher blood lactate after official compared to simulated ones (Figure 5), indicating that the glycolytic participation is more elevated during the official matches. Thus, the training process should consider this important aspect and other studies are recommended to confirm this result.

* significant difference between official and simulated matches.

Figure 5: Blood lactate responses before and after simulated and official matches (Adapted from Chaabène et al., [15]; values are mean and standard deviation).

Another important aspect is to compare male and female athletes as many times they train together and some adjustments should be made when relevant differences are detected in physiological responses. Tabben et al., [16] compared male and female athletes concerning blood lactate responses during international level karate competition (Figure 6). The authors did not detect any difference between genders during these matches, suggesting that a similar glycolytic demand is imposed on the athletes independently of their gender.

Figure 6: Blood lactate responses to official international karate matches in male and female athletes (Adapted from Tabben et al. [16]; values are mean and standard deviation).
Hormonal Responses

A recent published investigation by Chaabène et al.,[4] (Figure 7) was conducted during successive simulated karate contests and aimed to detail the physiological stress in term of hormonal responses [i.e., Salivary Cortisol (sC), Salivary Testosterone (sT), and salivary testosterone/cortisol ratio (sR)]. Results from this study showed that sC post-combat 2 was more than two fold the values recorded at pre-combat 1. Compared to sT, the percentage of sC modification post-combat 1 and 2 was clearly higher. This observation was confirmed by the clear decrease in the sR post-combat 1 and especially post-combat 2. Altogether, these results show the clear domination of the catabolic hormonal aspect during simulated karate kumite. Another relevant point have to be stressed, which is the significant positive correlation between blood lacate responses and sC and negative one with both sT and sR. This constatation highlights the validity of blood lactate measure as an indicator of karate kumite’s physiological stress. The results of Chaabene et al., [4] were reinforced by a previous study of Parmigiani et al., [21] who reported a significant increase in cortisol level between pre and post karate match (108.36±9.41 ng/ml vs 162.80±11.09 ng/ml; p<0.001, respectively). Further investigations during official karate kumite are highly recommended.

Figure 7: Salivary ratio T/C during karate competition simulation and recovery phase. (Adapted from the study of Chaabene et al., [4], values are mean and standard deviation)

Conclusions and Future Directions

In summary, the intermittent nature of the karate kumite effort makes the oxydative system and the ATP-PCr systems the two main energy systems that dominate the energy release to sustain the activities performed during the match. Karate kumite creates a high level of cardiovascular, metabolic, and hormonal stress to the karate practitioners. Thus, considering these findings, coaches, fitness trainers, and sport scientists should strictly consider the development of these two energy systems during their training program intervention. However, in view of the elevated contribution of the anaerobic glycosysis during official contests compared to simulated ones [15], this energy system deserve a particular interest. In term of fitness level, the use of specific exercises that associate both physiological stresses and technical aspects (e.g., repeated techniques, sparring partner sessions etc...) is of great importance for karate kumite athletes in order to ensure not only a well developed metabolic power but also a better economy. Finally, despite the importance of data from simulated contests, and as official karate kumite conditions remain the reference for both coaches and athletes, further researches are needed to reinforce the available findings.
References