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Features of Energy Supply for Competitive Activities in Kumite Karate

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Abstract

The article presents an analysis of the energy supply characteristics of competitive activity in kumite karate (WKF), taking into account the intermittent structure of the bout and the tournament format of competitions. Based on a narrative review of modern scientific research, data on the time organization of the bout, physiological markers of load, and the contribution of the main energy systems (phosphagen , anaerobic-glycolytic, and aerobic) to various phases of competitive activity are summarized. It is shown that decisive technical actions in kumite are primarily provided by the phosphagen and anaerobic-glycolytic systems, while aerobic metabolism plays a key role in maintaining overall performance, resynthesis, and the metabolism of energy. Phosphocreatine and recovery between bouts of activity and combat. A practical model of kumite energy supply is presented, and key implications for planning karate training are formulated.

Keywords: Karate, kumite, energy supply, aerobic metabolism, anaerobic metabolism, lactate, heart rate, phosphocreatine, interval performance.

Introduction

The scientific novelty of the article lies in the comprehensive and karate-specific generalization of data on the contribution of energy systems to competitive kumite activity, taking into account the time structure of the fight and the tournament format, as well as in the formation of a practical model of energy supply focused on the combination of the power of decisive actions and resistance to repeated high-intensity loads.

Kumite karate (WKF) is an intermittent competitive sport: a bout involves multiple, short-term episodes of high intensity (attack, counterattack, explosive advance/escape), separated by pauses for active observation, distance readjustment, and referee stops. This structure determines a mixed energy supply, where "decisive" actions require the fastest possible ATP resynthesis, and resilience to repeated episodes depends on the effectiveness of recovery between them [1].

The WKF regulations set time limits for the fight and rest, which directly affects the energy of the fight: time is kept according to the rules (“ time up "), and athletes are guaranteed a rest period between bouts equal to the standard duration of the match (with the exception of changing the

color of the equipment). Consequently, in the tournament format of kumite, the athlete is forced to repeatedly perform high-intensity work with limited recovery intervals, which increases the importance of both phosphagen power and aerobic "recovery" capacity [2].

Field studies of official and simulated bouts show that even with the relatively short overall duration of kumite, athletes demonstrate high cardiorespiratory and metabolic responses: high heart rates and significant lactate accumulation are recorded, confirming the significant contribution of anaerobic processes during high-intensity action. Furthermore, a comparison of "official" and "simulated" bouts reveals differences in physiological response, which is important to consider when modeling training loads [1].

From an energetics perspective, the key practical question is which system (ATP-CP, anaerobic-glycolytic, or aerobic) plays a leading role in different phases of combat. The phosphagen system ensures the most rapid resynthesis of ATP during short, explosive actions, anaerobic glycolysis increases during series of attacks and "exchanges" without sufficient pauses, and aerobic metabolism determines resistance to repeated efforts and the rate of recovery between episodes (including resynthesis). phosphocreatine). Karate-specific research and review materials emphasize that kumite requires the simultaneous development of aerobic and anaerobic capabilities, and that energy supply assessment should be based on a combination of time - motion data and physiological markers (heart rate, lactate, fatigue indicators) [3].

Thus, the relevance of studying the specifics of energy supply during competitive kumite is determined by: the intermittent structure of the bout and the high variability of the "density" of combat episodes; the WKF regulations and the repetition of bouts on tournament days; and the need to substantiate training models that simultaneously develop the power of decisive actions and resistance to repeated high-intensity efforts. The purpose of this article is to summarize current data on the temporal structure of kumite and physiological markers of load, determine the contribution of the main energy systems, and formulate practical implications for the training of karatekas.

The study was conducted as a narrative review of scientific literature devoted to the specifics of energy supply for competitive activity in kumite karate. The analysis included publications reflecting the time-motion structure of fights . analysis), physiological responses of athletes in official and simulated fights, as well as data from karate-specific tests used to assess energy capabilities.

Search sources was carried out V international scientific bases PubMed, Scopus and Web of Science data using key words And their Combinations of karate, kumite , energy systems, time-motion analysis, physiological responses, heart rate, lactate, aerobic, and anaerobic techniques were included in the review. Original studies, systematic and narrative reviews, and official WKF regulatory documents were included .

Competitive activity in kumite karate has a clearly defined intermittent structure, which determines the contribution and alternation of energy systems during a bout. According to WKF rules , a bout is conducted in "pure time" mode and consists of multiple episodes of high intensity, separated by both active pauses (movements, tactical anticipation) and stops at the referee's command. This organization of combat fundamentally distinguishes kumite from cyclical sports and requires an analysis of energy supply, taking into account the temporal structure of actions.

Time - motion analysis data from official bouts show that most offensive and defensive actions in kumite are very short in duration, typically less than 1–2 seconds, with the total time of active actions significantly shorter than the overall bout time. In the work " Physiological responses and time-motion analysis between official and simulated karate combat " has shown that high-intensity episodes make up only a small portion of the fight, while a significant portion of the time is spent on low- or moderate-intensity actions and pauses [4]. The work-to-rest ratio in kumite varies depending on the level of the athletes and the combat tactics, but for episodes of maximum intensity it can reach 1:8–1:12, which emphasizes the crucial role of rapid recovery mechanisms between attacks [5].

This combat structure determines the functional division of energy systems. Short-term explosive actions (attacks, counterattacks, sudden approaches, or withdrawals from the line of attack) require an immediate supply of ATP and rely primarily on the phosphagen system (ATP-CP). At the same time, series of actions and exchanges without sufficient pauses are accompanied by an increased role of the anaerobic-glycolytic pathway, as evidenced by a significant increase in blood lactate concentration after official bouts [6].

Despite the visually explosive nature of kumite , a number of studies highlight the key importance of aerobic metabolism in supporting overall competitive performance. High heart rates recorded throughout most of the bout indicate significant aerobic load, ensuring the maintenance of combat activity and, most importantly, regeneration. phosphocreatine between episodes of high intensity [4,7]. It is the aerobic system that largely determines the ability of a karateka to repeatedly repeat explosive actions without a significant decrease in power.

Thus, the structure of kumite creates a mixed energy supply model, in which the phosphagen and anaerobic-glycolytic systems support critical actions, while aerobic metabolism creates an energy "background" that supports resistance to repeated efforts and efficient recovery between them. Consideration of this structure provides a methodological basis for analyzing the physiological demands of kumite and for developing specialized training.

Competitive kumite activity is characterized by a mixed energy supply, in which the contribution of various energy systems varies depending on the duration, intensity, and tactical structure of the bout. Unlike cyclic sports, it is impossible to identify a single dominant system in kumite : the phosphagen , anaerobic-glycolytic, and aerobic systems function in concert, supporting both individual decisive actions and the athlete's resilience to repeated stress throughout a bout and tournament.

The phosphagen system (ATP-CP). The phosphagen system plays a key role in supporting short-term explosive actions, such as single attacks, counterattacks, sudden accelerations, and changes in direction. The duration of these episodes typically does not exceed 1–2 seconds, which corresponds to the temporary capabilities of the ATP-CP system. Review " Physiological responses to karate specific activities : a critical review » emphasizes that it is the phosphagen system that provides the maximum power of actions that determine the outcome of an episode in kumite [5].

At the same time, the effectiveness of this system in tournament conditions depends on the speed of resynthesis phosphocreatine , which is produced primarily through aerobic metabolism between episodes of activity.

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The anaerobic-glycolytic system. Naerobic glycolysis is more involved during series of attacks and intense metabolic exchanges, when rest intervals are shortened and phosphagen reserves do not have time to fully recover. Experimental studies of official bouts have recorded a significant increase in blood lactate concentrations after the bout, indicating a significant contribution of the glycolytic pathway during high-intensity competitive activity [4,7].

An increase in glycolytic input is accompanied by an increase in metabolic stress, which can reduce the precision of movements and reaction speed at the end of a fight, especially in high tactical combat situations.

Aerobic system. Despite the "explosive" nature of key actions, the aerobic system plays a leading role in the overall energy supply of kumite . High heart rate values, recorded throughout most of the fight, indicate a significant aerobic load [7]. Aerobic metabolism ensures: maintaining the overall intensity of the fight; accelerated resynthesis Phosphocreatine between attacks; recovery between fights in a busy competitive schedule.

Therefore, the level of aerobic fitness largely determines the karateka's ability to repeat high-power actions without a significant decrease in efficiency.

Table 1 - Contribution of energy systems to various elements of competitive activity in kumite

Energy system	Main function in kumite	Typical episodes of the duel	Physiological markers	Practical significance
Phosphagen (ATP–CP)	Delivering maximum power	Single attacks, counterattacks, explosive accelerations (≤2 s)	High power, minimal lactate	Determines the effectiveness of decisive actions
Anaerobic-glycolytic	Maintaining intensity during series of actions	Dense exchanges, repeated attacks with short pauses	Increased blood lactate	Affects resistance to fatigue at the end of a battle
Aerobic	Maintaining overall performance and recovery	Pauses between episodes, recovery between battles	High heart rate, VO_2	Provides repeated high-intensity activity

Thus, the energy supply for kumite is integrated: the phosphagen and anaerobic-glycolytic systems support the crucial episodes of competitive activity, while the aerobic system creates the physiological basis for their repeated reproduction and effective recovery. Considering this distribution is key when planning the training process and assessing the functional readiness of karatekas.

To assess the specific energy requirements of competitive kumite , objective physiological markers are used, allowing for indirect assessment of the contribution of various energy systems and the athlete's level of functional stress. The most informative and frequently used in scientific research are heart rate, blood lactate concentration, and karate-specific testing data .

Heart rate (HR) is considered an integral indicator of overall exercise intensity and aerobic metabolic activity . Studies of official and simulated bouts show that in kumite , athletes spend a significant portion of the bout at HR levels close to their maximum , indicating high cardiorespiratory demand and the significant role of the aerobic system in sustaining competitive performance.

lactate concentration is the primary marker of anaerobic-glycolytic system activity. Elevated post-competition lactate levels observed in karatekas after bouts reflect the significant contribution of glycolysis, especially during high-intensity attacks and bouts without adequate recovery. Lactate dynamics also allow one to assess the degree of metabolic fatigue and the effectiveness of recovery between bouts.

Additionally, karate-specific tests (such as simulated combat or SKPT) are used to comprehensively assess energy levels. These tests analyze heart rate, lactate , and recovery responses. These tests allow us to replicate the competitive structure of kumite and objectively assess an athlete's readiness for repeated high-intensity performance.

Taken together, the use of these physiological markers allows not only to describe the energy profile of kumite , but also to justify the direction of training interventions and recovery measures in karatekas.

A practical model of kumite energy supply should reflect the actual temporal and physiological structure of a bout and take into account the repetition of competitive loads under tournament conditions. From the perspective of applied physiology, kumite should be viewed as a sequence of short, explosive episodes fueled by the phosphagen system, against a background of high overall aerobic load, maintaining the athlete's readiness for repeated actions and recovery between them.

In this model, decisive technical actions (attacks, counterattacks, sudden accelerations) rely predominantly on the ATP-CP system, while the anaerobic-glycolytic pathway increases with the intensity of combat and the number of consecutive actions. The aerobic system plays a connecting role, ensuring resynthesis. phosphocreatine, maintaining overall intensity of the fight and recovery between episodes of activity and fights during the tournament.

This model emphasizes the need for combined training, in which the development of power and speed must be combined with the formation of aerobic stability, which allows maintaining the effectiveness of technical actions throughout the entire match and competition day.

Table 2 - Practical model of energy supply for competitive activity in kumite

Element of competitive activity	Nature of the load	Dominant energy system	Practical significance
Explosive attack / counterattack	Short-term (≤2 s), maximum intensity	Phosphagen (ATP–CP)	Determines the effectiveness of decisive actions
A series of attacks, a dense exchange	High intensity, short breaks	Anaerobic-glycolytic + ATP–CP	Increases metabolic stress and fatigue
Pauses between episodes	Variable, low-moderate intensity	Aerobic	Provides resynthesis of CF and reactivation
Recovery between battles	Minutes–hours	Aerobic + nutritional support	Maintains functionality in tournament format

Thus, the practical model of kumite energy supply assumes the integrated functioning of energy systems, where aerobic metabolism creates the physiological basis for the repeated production of high-power actions supported by the phosphagen and anaerobic-glycolytic systems. Taking this

model into account allows for more informed planning of training interventions and the preparation of karatekas for competition.

The specific energy requirements of competitive kumite necessitate a comprehensive approach to karate training. Training should be aimed at developing the power and speed of decisive actions, fueled by the phosphagen system, while simultaneously building a sufficient aerobic base to support repeated high-intensity activity and effective recovery between bouts.

Developing repeated speed-strength performance is essential, which requires the inclusion of intermittent exercises in the training process that simulate the time structure of kumite . Such loads allow both anaerobic and aerobic energy supply mechanisms to adapt to real competition conditions.

Additionally, preparation must take into account the tournament format, which involves multiple bouts throughout the day. This requires an emphasis on recovery, nutritional support, and monitoring of athletes' functional state. Taken together, these considerations help improve the sustainability of karatekas' competitive performance and maintain the effectiveness of their techniques throughout the bout and competition day.

Consequently, competitive activity in kumite karate is characterized by a mixed energy supply, conditioned by the intermittent structure of the bout and the high density of short-term, high-intensity actions. Decisive moments of combat are primarily fueled by the phosphagen and anaerobic-glycolytic systems, while aerobic metabolism plays a key role in maintaining overall performance and recovery between bouts and bouts.

Taking into account the specific energy requirements of kumite allows for more informed training planning, combining the development of speed and strength with the development of aerobic stability and repeated high-intensity performance. A comprehensive approach to training is essential for maintaining high competitive performance in karatekas in tournament settings.

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