ORIGINAL ARTICLE

Physiological responses the organism of karate athletes specialists of kata and kumite during simulated competition

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A Study Design
B Data Collection
C Statistical Analysis
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Abstract

Background & Study Aim: *Kata* and *kumite* have distinguished competition requirements, and cardio-metabolic and thermoregulatory responses to different competitive concurrence in karate remain unknown. The main aim of this study was to answer the question: whether are differences between several selected physiological indicators used to compare of karate athletes (specialists of *kata* and *kumite*) during simulated competition?

Materials & Methods: Twenty-four elite male senior karate athletes (*kata* n = 9; *kumite* n = 15) participated in this study. The participants were 21.56 ± 3.57 years old, with mean body mass of 71.02 ±6.23 kg and mean height 177 ±7.24 cm. All participants underwent simulated competition consisting of three repeated maximal duration rounds with 10 minutes break between them in order to assess their HR responses during rounds and in first minute of recovery period, blood lactates, thermal responses and rates of perceived exertion to simulated competition.

Results: No major differences were found between groups for baseline values. No differences were found between kata and kumite for HR responses, blood lactate, T_{core} and rates of perceived exertion to simulated competition observed separately and within cumulative effects (time *vs.* group), respectively.

Conclusion: *Kata* and *kumite* differ in competitive demands, yet these two karate specializations seem to have no fundamental reflections on individual functional variables.

Key words: combat sport · martial arts · specific effort · thermoregulatory and cardio-metabolic responses

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Introduction

Karate is a very popular combat sport and martial art practiced worldwide. As a combat sport, karate is practiced in *kumite* form. As a martial art can be practiced individually – *kata* (exercises without a partner or competitor). This specific relation explained by the theory of combat sport – every combat sport is martial arts but not vice versa [1]. It does not change the fact that in the ordinary meaning of the term "sport" in both *kata*, *kumite* which are practiced just as a sport - professional or recreational (for all).

Kata has a conventional structure were athletes perform predetermined series of movements and techniques in known order against imaginary opponents, whereas *kumite* has dynamic structured and involves overcoming competitor with a use of various movements, defensive and offensive techniques [2]. Physiological responses and information concerning performance analysis are relatively limited in senior *kata* and *kumite* [2-6].

Since *kata* and *kumite* have distinguished competition requirements (*e.g.* activity duration, movement patterns etc.), physiological profiles supposed to be different as well. Duration of both karate specializations is limited through official WKF rules. Performance of *kata* in the final matches of the world championships has to be done within limited time (~ 120 sec) otherwise, penalty applies. *Kumite* match lasts 180 sec (240 sec in finals) with interruptions when awarding points and penalties. In addition, several matches during a single day are needed for top results [5]. Therefore, more information is needed concerning different physiological responses to *kata* and *kumite* in competition and training. In particular, cardiometabolic and thermoregulatory responses to different competitive disciplines in karate remain unknown.

The main aim of this study was to answer the question: whether are differences between several selected physiological indicators used to compare of karate athletes (specialists of *kata* and *kumite*) during simulated competition (specific effort)?

Material and methods

Participants

Twenty-four elite male senior karate athletes, members of national team of Serbia holding the black belt (DAN) in Karate, took part in this investigation. Number of participants is in accordance with sample size calculation ($\alpha = 0.05$; power = 0.90), with nine *kata* ($n = 9$) and fifteen *kumite* ($n = 15$) athletes. All subjects gave their informed consent and volunteered to participate in the study.

The study conformed to the standards set by the Declaration of Helsinki and was approved by the local Ethics Committee. All participants were fully informed verbally and in writing about the nature and demands of the study, as well as the known health risks. Participants were healthy, with no limitations to participate in the study as confirmed through medical screening. Participants followed a usual training and nutrition plan during the study, and were obliged not to change diet and training during the study.

Experimental procedure

Four weeks prior to simulated competition, physical and physiological measurements were taken in laboratory conditions. Body mass was obtained to the nearest 0.1 kg using a balance beam scale (Avery Ltd., Model 3306 ABV), whereas height was measured using a stadiometer (Holtain Ltd.) to the nearest 0.5 cm. Fat free mass was obtained using bioimpedance analyser (Maltron BioScan 920 v1.1 Maltron International Ltd., UK). Afterwards, subjects were instrumented for maximal oxygen uptake (VO_{2max}) and telemetric heart rate assessment. Exercise test was performed according to individualized ramp protocol to symptom-tolerated maximum using a treadmill system (T170, Cosmed, Italy). Gas-exchange data were collected throughout the exercise test using a breath-by-breath respiromonitor system (Quark CPET, Cosmed, Italy) with VO_{2max} defined as the highest oxygen uptake achieved during the test [7].

On a day of simulated competition, all athletes performed individual warm-up exercises equal to those performed in competitive event and consisting of approximately 5 min of running, 10 min of dynamic stretching, and 10 min of sports-specific movements. After warm up, athletes were assigned to exercise protocol (Figure 1) [2]. *Kata* athletes performed *unsu* kata of the s*hotokan karate* style for three times, whereas *kumite* athletes performed three competitive matches, with 10 minutes break between rounds for both groups. During the exercise protocol that lasted for 140 sec for kata and 240 sec for *kumite*, blood samples were taken from the right earlobe for lactate analysis (Accutrend plus, Roche, Germany). T_{core} was measured with portable device (HT150002, HQ Inc, US). Rates of perceived exertion [8] were recorded immediately after each bout. Heart rate (HR) was determined during the test, using short-range radio telemetry (Model RS800CX, Polar Electro Oy, Kempele, Finland), and the highest HR during the

Core temperature (T_{core}) – also called core body temperature, is the operating temperature of an organism, specifically in deep structures of the body such as liver, in comparison to temperatures of peripheral tissues. T_{core} is normally maintained within a narrow range in order for essential enzymatic reaction can occur. Prolonged significant T_{core} elevation (hyperthermia) or depression (hypothermia) can lead to severe damage to human organism, even with fatal outcome.

Heart rate (HR) – represents the speed of the heartbeat and is measured by the number of poundings of the heart per unit of time, typically beats per minute (bpm). The normal resting adult human heart rate ranges from 60–100 bpm, and the activity that can provoke changes include physical exercise, anxiety, stress, sleep, illness and various medicaments.

***Kata* (form)** – is executed as a specified series of a variety of moves, with stepping and turning, while attempting to maintain perfect form. *Kata* displays a transition and flow from one posture and movement to another, teaching the karateka proper form and position, and encouraging them to visualize different scenarios for the use of each motion and technique in imaginary bout. There are various forms of kata developed through different karate styles.

Kumite – is a semi-contact karate competitive concurrence, where two athletes perform various kicking, punching and blocking techniques towards each other with maximum control in order to gain points and win the match. Destruction is fictive.

Blood lactate (La - mmol) – level raises with exercise of increasing intensity. Increased lactate production coincides with cellular acidosis and remains a good indirect marker for cell metabolic conditions that induce metabolic acidosis. If muscle did not produce lactate, acidosis and muscle fatigue would occur more quickly and exercise performance would be severely impaired.

Borg's Rating of Perceived Exertion (RPE) – is commonly used in sports activity and particularly in exercise testing in order to indicate a quantitative feeling of fatigue. Scale ranges from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion."

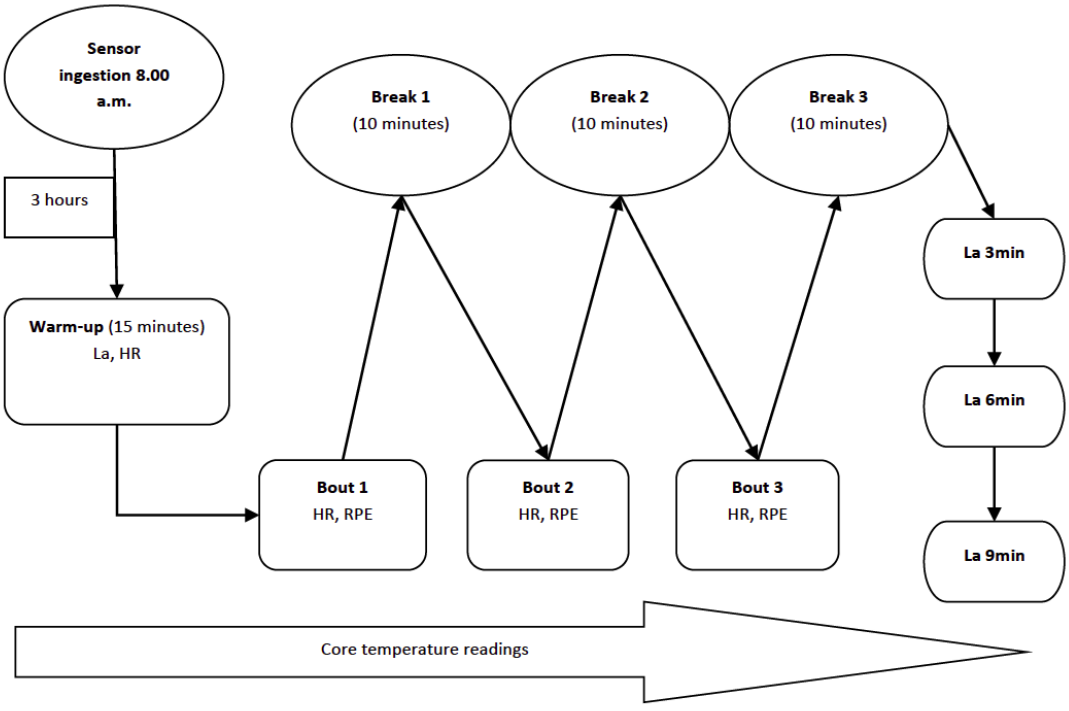

Figure 1. Scheme of simulated bouts protocol

last minute of the simulated round was recorded as HR_{max}. HRR was measured at the end of first minute upon the end of the match. All athletes were familiarized with these procedures as part of their regular training process.

Statistical analysis

Since the sample size was low, nonparametric Fisher's exact test was used to assess differences between groups, with $p = 0.05$ set as level of significance. Additionally, Two-way Repeated Measures Anova with Huynh-Feldt correction was employed to investigate cumulative effect of repeating variables during simulated competition (Table 1). All the data are presented as mean and standard deviation. Statistical analysis was performed using the statistical package IBM SPSS 20 (SPSS Inc, Chicago, IL, USA).

Results

Physical and physiological characteristics of participants were presented in Table 1. No major differences were found between groups for baseline values. No differences were found between *kata* and *kumite* for HR responses, blood lactate, T_{core} and rates of perceived exertion to simulated competition. Furthermore, when observing cumulative effects (time *vs.* group), no significant difference were found for indices of heart rate ($F = 0.574$; $p = 0.457$), thermoregulatory outcomes ($F = 1.33$; $p = 0.261$), blood lactates ($F = 0.453$; $p = 0.508$), and rates of perceived exertion ($F = 3.347$; $p = 0.081$) during simulated competition, respectively.

Discussion

This study has provided direct comparison of physiological profiles between two competitive specializations in top-level karate athletes. With a previous knowledge that competitive and training activity for *kata* and *kumite* differ, assumption was made that these two karate specializations would differ in some physiological responses to competition. However, within the current study, we found no significant differences in body composition and individual cardio-metabolic and thermal responses to simulated competition (specific effort) in elite male *kata* and *kumite* athletes.

Top-level competition in karate requires well-experienced and highly prepared athletes. When observing physical characteristics of our sample, *kata* group was older with more training experience as compared to *kumite* athletes. This could imply that longer training time and a special expertise is needed in order to learn and perform each *kata* on a high level. Furthermore, *kumite* and *kata* group seems to be of similar height and weight. This is not in line with

Table 1. Physical and physiological characteristics for *kata* and *kumite* group

Variables Mean		Kata n = 9		Kumite n = 15		Fishers exact p value
		SD	Mean	SD		
Baseline values	Age (Yr)	21.61	5.02	21.53	2.56	.036
	Experience (Yr)	15.33	5.12	13.33	2.82	.397
	Height (cm)	174.64	3.76	178.42	8.50	.886
	Body Mass (kg)	68.68	3.63	72.42	7.11	.511
	Body Mass Index (kg/m^2)	22.24	1.69	22.61	1.74	.644
	FFM (%)	88.88	1.77	88.65	1.34	1.0
	VO2max (l/min)	3.25	.40	3.66	.43	1.0
	VO2max (ml/min/kg)	47.05	4.14	48.74	3.66	1.0
	HRmax	195.11	9.71	191.33	6.39	.573
Results of simulated competition in kata and kumite						
HR (bpm)	Baseline	109.89	4.34	108.27	6.28	.999
	Warm up	125.11	2.93	126.53	4.58	.536
	End 1	189.67	13.68	184.73	8.19	.318
	End 2	188.00	13.27	189.80	6.33	.133
	End 3	189.11	10.68	192.87	7.14	.270
	Recovery 60 sec 1	165.78	14.03	167.33	9.15	.425
	Recovery 60 sec 2	163.67	12.47	171.33	7.55	.108
	Recovery 60 sec 3	167.33	8.30	173.40	7.66	.831
T_{core} (C°)	Baseline	37.20	.33	37.03	.35	.875
	Warm up	37.36	.34	37.38	.39	.225
	End 1	37.70	.22	37.80	.34	.165
	End 2	37.93	.23	38.02	.17	.946
	End 3	37.98	.25	38.17	.12	.102
	10 min after 1	37.58	.18	37.63	.26	.893
	10 min after 2	37.64	.15	37.80	.20	.148
	10 min after 3	37.54	.15	37.68	.15	.294
La (mmol/l)	Warm up	2.15	.29	2.05	.41	.954
	3 min	7.11	3.29	7.25	3.92	.130
	6 min	4.65	.86	5.92	1.69	.133
	9 min	5.07	2.14	5.35	1.56	.831
RPE (UA)	End 1	15.00	2.12	13.47	1.72	.234
	End 2	16.44	1.59	14.93	2.15	.443
	End 3	17.22	1.92	16.13	2.47	.974

* *Indicates statistical significance for cumulative effects between groups analyzed by Two-way Anova with repeated measures for HR (F = 0.574; p = 0.457), T_{core} (F = 1.33; p = 0.261), La (F = 0.453; p = 0.508), and RPE (F = 3.347; p = 0.081)*

previous studies where has been recommended for *kata* athletes to have smaller body posture for strength demanding techniques as opposed to *kumite* athletes that should benefit from superior longitudinal body dimensions in accordance to weight categories [9-11]. These discrepancies in results found might be due to small sample size in both groups.

With respect to different competitive demands for *kata* and *kumite* and concerning physiological

responses to simulated competition, collected data analysed were similar in both karate specializations. No differences between groups were found in chosen indicators of cardio-metabolic and thermal responses to simulated competition. On one hand, this could imply that cardiovascular system responds similarly to competitive load for *kata* and *kumite*, and that they have no fundamental reflections on functional variables. Furthermore, even though no significant difference was found in individual thermal responses between groups, higher thermal stress has been reported for *kumite* group. This probably occurs due to a longer duration and higher metabolic stress of *kumite* match. With knowledge that prolonged higher metabolic stress could affect sports performance, advice for reduction of thermal stress in future (e.g. hydration, longer recovery period, etc.) should be considered. However, thermal stress during simulated competition in karate *kata* (performance) and *kumite* seems to be a bit lower as compared to the levels seen in some ultra-endurance events [12, 13] or in soccer [14]. Recently, RPE has been proposed as a valid indicator of competitive exercise intensity in top-level karate athletes [5]. Interestingly, we observed higher indicators of competitive activity in *kata* than in *kumite* in the present study. This is in clear dissociation with HR and La results for *kata* obtained in this study. RPE represents subjective assessment of the activity load, where no previous experience with this kind of measurement tool could lead to disproportionate assessment.

On the other hand, results obtained in this study could imply that the chosen indicators for assessment of physiological responses to competition are low sensitive, and there is a need for additional, more sensitive tools in determining differences between *kata* and *kumite* elite karate groups. Furthermore, while our study revealed rather novel data regarding thermal stress in karate, it was also constrained by several limitations. First, relatively small sample size investigated could lead to underestimation of the results found between *kata* and *kumite* groups.

However, it was not possible to identify more athletes of such a level of practice at that moment in Serbia. Further studies with larger sample seem to be needed, as well as studies with female athletes and perhaps lower competitive level groups would be necessary. Second, a limited number of physiological indicators used in this study and a chosen measurement tools seems to be low sensitive. Therefore, an application of some more advanced methods (*e.g.* biochemical analysis, saliva hormones) might provide better information regarding physiological profile. Overall, a need of further investigations, (*e.g.* cellular level mechanisms, fuel and thermal utilization, etc.) could explain the physiological mechanisms deriving from *kata* and *kumite* competitive activity.

The results of our studies can be analysed also in the wider perspective of health and utilitarian aspects of combat sports and martial arts. Specializing either in *kata*, or *kumite* gives a very similar physiological effect. So regardless of specialization health effect it is the same. Because karate is qualified for martial art (combat sports) bases on acute means [1, 15], so kumite specializations can be applied when in given circumstances in self-defence soft means are insufficient [16, 17]. *Kata* is, however, an excellent mean of application for defensive purposes of potentiation methods (intimidation) [1, 15-17].

There are still important issues of the methodological nature. First, *kumite* as one of karate specializations fulfils all criteria of extreme sport [18, 19]. *Kata* in professional version in lesser extent, but as a recreational form of movement only in coordination dimension may be considered as extreme sport and in inconsiderable dimension. Second, not only in the diagnostic and prognostic tests for use of karate athletes are used more boldly modern simulation methods [20] but also for the diagnosis and prevention of injuries as a result of a sudden loss of balance and fall [21, 22].

Conclusion

Kata and *kumite* differ in competitive demands, yet these two karate specializations seem to have no fundamental reflections on individual functional variables. However, chosen assessment tools seem to have lower sensitivity and need for additional, more sensitive tools in further research would seem more appropriate.

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Competing interests

The authors declare that they have no competing interests.

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