ORIGINAL ARTICLE

Physiological responses during arm and leg aerobic power tests in elite female judokas

Tatjana Trivic[1] ✉ • Cristina Casals[2] • Patrik Drid[1]

Abstract
The aim of this study was to compare physiological responses during arm and leg aerobic power tests.

Ten elite female judokas of the Serbian National Team participated in the study. In addition to the Special Judo Fitness Test (SJFT), maximal oxygen uptake (VO2max) and anaerobic threshold (AT) were determined using an arm crank ergometer and a treadmill. Body fat percentage was estimated by bio-impedance.

The VO2max was only 3 ml·kg–1·min–1 higher on the treadmill than in the arm crank ($p<0.03$), the AT was also higher on the treadmill test (8.6 l·min–1, $p=0.005$). Nevertheless, the SJFT results were significantly correlated only with the maximal heart rate during the treadmill test ($r=0.77$, $p<0.01$ for index; $r=-0.73$, $p<0.02$ for total throws). Body fat percentage was correlated with VO2max ($r=-0.67$, $p<0.05$) and AT in the arm crank test ($r=-0.88$, $p=0.001$).

The maximal oxygen uptake was not statistically correlated with the SJFT results in elite female judokas. However, judokas who had higher maximal heart rate during the treadmill test, showed a worse judo-specific capacity on the SJFT. Female judokas with higher body fat seem to have lower VO2max and AT, with statistically significant correlations in the arm crank, and close to significance on the treadmill. On the other hand, arm crank and treadmill tests presented different results concerning aerobic capacity. However, our female judokas interestingly presented similar VO2max results during both aerobic tests, which highlights some judo-specific demands on the upper-body aerobic fitness.

Keywords Arm crank • Treadmill • Anaerobic threshold

✉ ttrivic@yahoo.com

[1] University of Novi Sad, Faculty of Sport and Physical Education

[2] Department of Physiology, Institute of Food Nutrition and Technology, Biomedical Research Centre, Faculty of Sport Sciences, University of Granada, Granada, Spain

Introduction

Judo has been characterized as a high-intensity intermittent combat sport, consisting of many different techniques and actions employed during a match (Drid et al., 2012). High level of strength and coordination is needed to overcome the adversary through rapid execution of technical maneuvers throughout the match (Drid et al., 2010). In addition to faster recovery process after high-intensity intermittent activity associated to aerobic performance (Franchini et al., 2011; Drid et al., 2015), some evidence exists for higher values of maximal oxygen consumption (VO2max) in judokas who are able to win points in the decisive moments of bout. Furthermore, those judokas were able to re-synthesis creatine-phosphate fasterin gastrocnemius muscle compared to judokas who win points earlier in the match and have better performance on Wingate test for lower extremities (Gariod et al., 1995).

Drop in aerobic performance of lower extremities in judokas prior to main competition has been found in study of Franchini, Cassio de Moreas Bertuzzi,

Takito, & Kiss (2009), in addition to increase in aerobic performance of the upper body during the same period. Authors concluded that the performance of the upper body is more important than performance for the lower part of the body, and consequently, the aerobic capacity of the upper body was more relevant than the same test for lower body. Furthermore, Jagelo, Wolska, & Smulski (2009) analyzed correlation between International Physical Fitness Test (IPFT) and Special Judo Fitness Test (SJFT) for three groups of female judokas. Highly skilled judokas were characterized by distinct and more diverse direct relationship between indicators of general and specific physical preparation compared to judokas 13 – 15 and 16 – 18 year olds. Other research, conducted on Brazilian Olympic judo team (Franchini et al., 2005) showed no significant differences in aerobic power between first team and reserves. On the other hand, Drid et al., 2009 found significant differences between judokas of A and B Serbian national team.

The aim of this study was to compare physiological responses during arm and leg aerobic power tests in elite female judokas and correlation between oxygen uptake and the special judo fitness test in female judokas.

Method

Subjects

Ten elite female judokas of the Serbian National Team participated in the study.

Procedures

Anthropometric Profile was assessed in all participants through body mass (Model 3306 ABV; Avery Ltd., Crosswell, United Kingdom) and body height (Holtain Ltd., London, United Kingdom), whereas body fat percentage was estimated through manual bioimpedance (MaltronBioScan 920-2, Edinburgh, United Kingdom).

Aerobic Profile was estimated through treadmill and an arm crank ergometer test, with maximal oxygen uptake (VO2max) and anaerobic threshold (AT) determined. For treadmill test, ventilatory and metabolic indices were measured at rest for 1 minute and then for another minute at a 5 km.h-1speed; afterwards workload incremented progressively starting at 7 km.h-1at a rate of 0.5 km.h-1 every 30 seconds until exhaustion (CPET, COSMED, Rome, Italy) with constant 2% inclination throughout the trial. The test was considered completed when the oxygen uptake reached plateau and the respiratory and ventilator quotients reached reference values. The gas analyzer was calibrated after five athletes completed tests with gas mixture of known oxygen and CO2 concentrations (20.9% O2, 0.03% CO2 and 16.0% O2, 5.0% CO2, respectively).

Second VO2max was estimated by a method of extrapolation after a standardized sub maximal test on the arm cycle ergometer (Monark, Sweden) along with telemetric monitoring of heart function (Polar, Finland) after a five day period.

Specific Judo Performance was assessed through SJFT test. SJFT is divided into three active periods (A=15 s; B and C=30 s) with 10 s rest intervals between them. During each period, athlete that is being evaluated (tori) throws two partners (uke A and uke B; separated from each other by a distance of 6 m) as many times as possible using the one-arm shoulder throw (ippon-seoi-nage) technique. All participants (tori, uke A, and uke B) involved with the test should possess similar height and weight characteristics. Immediately following, and one minute after completion of the three active periods, the tested subject's heart rate is measured (Sterkowicz, 1995). Afterwards, subsequent analysis in the number of throws completed during the active periods, along with heart rate response to the active periods, and an index calculation was conducted. The SJFT Index was calculated as follows:

$$\text{Index} = (\text{Final HR} + \text{HR1 min}) / \text{Throws} \quad (1)$$

Where: Final HR = heart rate registered immediately after the test, HR1 min = heart rate obtained 1 minute after the test, and Throws = number of throws completed during the test.

Statistical Analyses

Data are expressed as mean ± standard deviation. The Shapiro-Wilks statistic was used for checking the normality of distribution. The Pearson or Spearman correlation tests were applied where appropriate. Comparisons between treadmill and arm ergometry were performed using the Wilcoxon test. The data were analyzed using the statistical package SPSS, PC program, version 20.0 (IBM Inc., USA).

Results

Physical characteristics and the Special Judo fitness test results are presented in table 1.

Table 1. Physical characteristics and Special Judo Fitness Test results in elite female judokas

Weight (kg)		64.89±11.19
Height (cm)		166.50±7.15
Body Fat (%)		22.92±5.34
SJFT	Index	13.89±1.59
	Total number of throws	25.70±1.63
	Final HR (bpm)	188.00±9.08
	HR 1 min after (bpm)	166.80±15.31

Comparison between results obtained on arm crank and treadmill test are presented in Table 2. The VO2max was higher on the treadmill than in the arm crank ($p<0.03$), the AnT was also higher on the treadmill test ($p=0.005$).

Table 2. Heart rate (HR), oxygen uptake (VO2max) and anaerobic threshold (AnT) in different ergometry tests

	Arm crank	Treadmill
HR max (bpm)*	183.00±8.79	188.10±6.42
VO_{2max} (ml·kg–1·min–1)*	34.29±6.71	37.66±4.29
AnT (l·min–1)*	25.30±3.35	33.88±4.17

* means $p<0.05$

The SJFT results were significantly correlated only with the maximal heart rate during the treadmill test ($r=0.77$, $p<0.01$ for index, Fig 1; $r=-0.73$, $p<0.02$ for total throws, Fig 2).

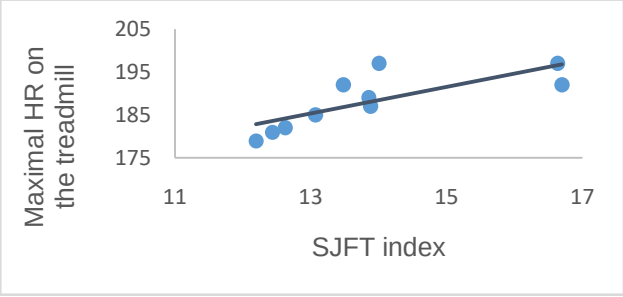

Figure 1. Correlation between HR_{max} and SJFT index

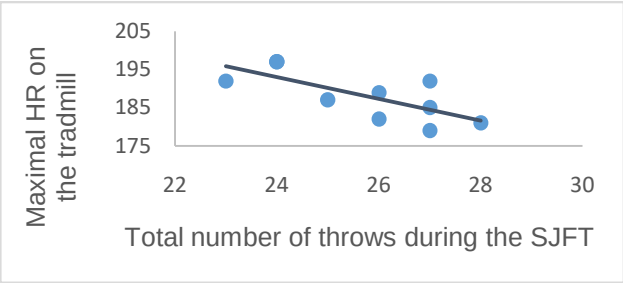

Figure 2. Correlation between HR_{max} and SJFT total number of throws

Body fat percentage was correlated with VO2max and AT in the arm crank test (Fig 3-4). Body fat percentage was correlated with VO2max ($r= -0.67$, $p<0.05$) and AT in the arm crank test ($r= 0.88$, $p=0.001$).

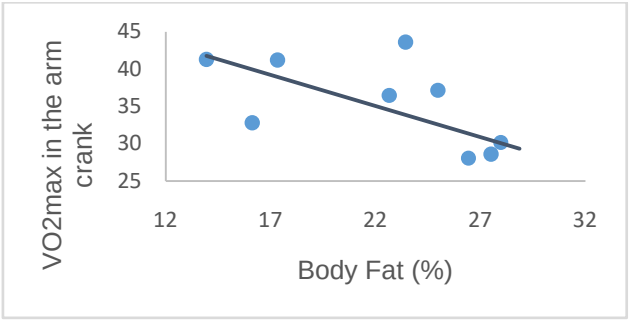

Figure 3. Correlation between $VO2_{max}$ and % of body fat

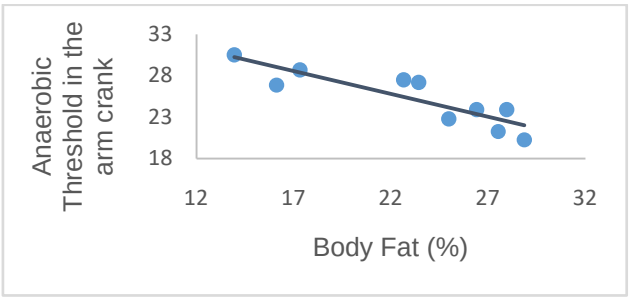

Figure 4. Correlation between arm crank AnT and % of body fat

Discussion

Higher values for all observed variables were obtained on treadmill compared to arm crank, suggesting a higher cardiovascular stress during treadmill test. These results are understandable when observing larger muscle groups involved in running on treadmill compared to arm crank test involving only upper body muscles.

ObtainedVO2max and AnT, on both arm crank ergometer and treadmill, were not statistically correlated with the SJFT results in elite female judokas. This is not in line with previous researches (Franchini et al., 2005; Franchini et al., 2007) that showed correlations of the aerobic fitness and the SJFT in male judokas. This could imply a need for additional investigation for substantial conclusions. According to the results of the present study, VO2max and AnT results do not seems to represent useful assessment tool in determining the specific performance of female judokas. Almansba et al. (2010) obtained similar results in male judokas, and noted that VO2max is highly sensitive to changes in training loads.

Female judokas who had higher maximal HR during the treadmill test, showed a worse judo-specific capacity on the SJFT, indicating a lower aerobic fitness. In addition, judokas with higher body fat had significantly lower VO2max and AnT in the arm crank, and close to significance level on the treadmill (p=0.06, p=0.08, respectively). These results are in accordance with other study in male judokas (Franchini et al., 2007) that showed lower performance in body displacement activities with judokas with higher body fat percent.

Conclusion

Arm crank and treadmill tests presented different results in the anaerobic capacity of female judokas. In addition, the same judokas interestingly presented similar VO2max results during both aerobic tests, which highlights some judo-specific demands on the upper-body aerobic fitness. However, VO2max and AnT do not seem to represent useful assessment tool in determining the specific performance of female judokas. Higher values for all observed variables were obtained on treadmill compared to arm crank, suggesting a higher cardiovascular stress during treadmill test. These results are understandable when observing larger muscle groups involved in running on treadmill compared to arm crank test involving only upper body muscles.

Acknowledgements

This work was supported by the Provincial Secretariat for Science and Technological Development (grant number 114-451-1639/2016 -01), and the Faculty of Sport and Physical Education, University of Novi Sad (2016 Annual Award).

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