REVIEW

Relationship between aerobic and anaerobic power, and Special Judo Fitness Test (SJFT) in elite Iranian male judokas

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Abstract

Introduction: The purpose of this study was to assess the relationship between aerobic and anaerobic power, and special judo fitness test in elite male judokas.

Method: Nineteen elite Judokas [age 24.3 (3.1) yr, height 1.78 (.06) m, body mass 76.4 (11.2) kg, body mass index 20.2 (3.6) kg·m⁻² and body fat 11.0 (1.8)%] performed a graded exercise test in treadmill, the Wingate anaerobic test for arms and the special judo fitness test. The graded exercise test in treadmill estimated maximal oxygen uptake (VO₂max) and the Wingate anaerobic test assessed peak and mean power, descriptors of short-term power output and local muscular endurance respectively.

Results: The index of special judo fitness test was in inverse direct relationship with VO₂max ($r = -.87, p < .01$), peak power ($r = -.74, p < .01$) and mean power ($r = -.62, p < .05$).

Discussion: Based on these findings, it was showed that the special judo fitness test is a field test that describes chiefly aerobic power, and in a lesser degree short-term power output and local muscular fatigue. Therefore, its further use from judo coaches and fitness trainers as a measure to monitor aerobic power is recommended, and the need for a field test that will describe anaerobic power is highlighted.

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Relación entre potencia aeróbica y anaeróbica y el Special Judo Fitness Test (SJFT) en judocas masculinos iraníes de élite

Introducción
Judo es un deporte olímpico que requiere alto nivel físico, psicológico y técnico. El judo competitivo puede describirse como un combate de alto nivel de intensidad en el cual el atleta trata de derrotar al oponente a su alcance o controlarlo durante un combate de campo. Los entrenamientos dependen de técnicas específicas y habilidades tácticas que favorecen la obtención de buenos resultados. El judo, como deporte de alto nivel, también se caracteriza por su efectividad en el entrenamiento y la recuperación. El entrenamiento aeróbico es una parte importante de este proceso ya que proporciona información valiosa sobre los niveles de fitness aeróbico de los judocas y establece la base para la mejora futura. En este estudio se realizó una evaluación de la potencia aeróbica y anaeróbica de un grupo de judocas iraníes de élite utilizando el Special Judo Fitness Test (SJFT).

En el estudio, se evaluaron 24 judocas de élite con una edad promedio de 24.3 (3.1) años, altura promedio de 1.78 (0.06) m, masa corporal promedio de 76.4 (11.2) kg, índice de masa corporal promedio de 20.2 (3.6) kg·m² y grasa corporal promedio de 11.0 (1.8) %. Se realizaron pruebas de fitness y aero y anaeróbica utilizando el SJFT.

Resultados: Se encontró una correlación inversa entre la potencia aeróbica y anaeróbica y el rendimiento en el SJFT. Se realizaron también análisis de correlación y regresión entre diferentes variables y se observó una asociación significativa entre la potencia aeróbica y la habilidad de los judocas en el SJFT. Estos resultados sugieren que la fuerza y la potencia aeróbica pueden ser factores importantes en el rendimiento en el SJFT y que los entrenamientos que fomenten la mejoría de estas habilidades podrían ser beneficiosos para los judocas iraníes de élite.

Conclusión: El entrenamiento aeróbico y anaeróbica son factores importantes en el rendimiento en el SJFT. Los judocas iraníes de élite pueden beneficiarse de un entrenamiento que fomente la mejora de estas habilidades. Es necesario que los entrenadores continúen investigando y mejorando las pruebas de fitness para poder darles a los judocas una mejor preparación para el deporte.

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Aerobic and anaerobic power, and special judo fitness test

and use of any medication. Nineteen elite judokas, including 11 members of Iranian National Team and eight national-level athletes, who were invited to the national training camps, volunteered for our study [age 24.3 (3.1) yr, mean (SD), height 1.779 (.063) m, body mass 76.4 (11.2) kg, body mass index 20.2 (3.6) kg·m⁻² and body fat 11.0 (1.8)%]. All participants competed to official games in weight categories —60 kg, —66 kg, —73 kg, —81 kg and —90 kg.

Measures

The study was conducted during four consecutive days. In the first day, anthropometric and body composition data were recorded, and in the following days, SJFT, Wingate anaerobic test (WAnT) and graded exercise test (GXT) were performed respectively, always after a guided standardized 15-min warm-up. An electronic weight scale (HD-351 Tanita, Illinois, USA) was employed for body mass measurement (in the nearest .1 kg), a portable stadiometer (SECA, Leicester, UK) for stature (.001 m), a body composition analyzer (TBF-410 Tanita, Illinois, USA) for percentage of body fat (BF), and body mass index was calculated.

Procedures

Maximal oxygen uptake (VO₂max) was estimated by a GXT (Bruce protocol test) on a treadmill (HC1200 Technogym, Gambettola, Italy), which included six 3-min stages against incremental speed (from 2.74 km·h⁻¹ to 8.85 km·h⁻¹) and incline (from 10% to 20%). Total time (T) was recorded in minutes and VO₂max was calculated as VO₂max (mL·kg⁻¹·min⁻¹) = 14.8 – 1.379·T+.451.72 – .01273.

Anaerobic power was measured by the WAnT. This test was performed on an arm-cranking ergometer (881E Monark, Varberg, Sweden). Braking force for the 30-s WAnT was determined by the product of body mass in kg by .5. Participants were instructed before the test that they should pedal as fast as possible and they were verbally encouraged throughout the test. Compared with the other tests, WAnT has the advantage that it provides information about both alactic and lactic anaerobic energy transfer system. The main indices of this test are: (a) peak power (Ppeak), the highest power elicited from the test taken as the average power of any 5-s period and (b) mean power (Pmean), the average power during the 30-s test, minimal power. Regarding the taxing of human energy transfer systems during the test, Ppeak is considered as a descriptor of short-term power output that relies mainly upon adenosine triphosphate-creatine phosphate (alactic anaerobic system), and Pmean as a descriptor of local muscular endurance that relies mainly upon anaerobic glycolysis resulting in lactate production (lactic anaerobic system).

Athletes performed the sport-specific test proposed by Sterkowicz, according to the following protocol: two judokas with similar height and body mass (same category) are positioned at 6 m distance from one another, while the test executor (tori) is 3-m from the judokas. The procedure is divided into three periods: 15-s (A), 30-s (B), and 30-s (C) with 10-s intervals among them. During each period, the executor throws partners using the ippon-seoi-nage technique, as many times as possible. Heart rate (HR) is recorded immediately and one minute after the cessation of the test by HR monitor (Sport-tester Polar Electro, Kempele, Finland). On the basis of the obtained results, the index (Iₓ, SJFT) was calculated:

\[ I_{\text{SJFT}} = (\text{HR after effort} + \text{HR after 1 min since effort completed})/\left[ \text{sum of throws (series A + series B + series C)} \right] \]

Analysis

All statistical analyses were performed with using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics, including means and standard deviations (SD) for the outcome variables of interest, were computed. Pearson product moment correlation (r) was used to determine the degree of association among selected variables. Significance level was set at alpha = .05.

Results

With regard to the parameters of SJFT, throws in series A were 6.3 (.6) [mean (SD)], in series B 10.9 (.7), in series C 10.3 (1.0) and their sum was 27.5 (1.8). Heart rate (HR) in the end of series C was 176.8 (6.8) beats·min⁻¹ and one minute after the end of series C HR was 142.5 (10.5) beats·min⁻¹. The Iₓ, SJFT was 11.7 (1.0). The estimated VO₂max was 54.4 (4.5) ml·kg⁻¹·min⁻¹, while the Ppeak and Pmean were 7.8 (.4) W·kg⁻¹ and 5.9 (.6) W·kg⁻¹ respectively.

The correlation analysis between anthropometric characteristics and the SJFT revealed an inverse association of height with the number of throws in series C (r = -.68, p < .05), as well as with the sum of throws (r = -.64, p < .05). A negative correlation was also observed between weight and the number of throws in series A (r = -.67, p < .05), the number of throws in series C (r = -.68, p < .05) and the sum of throws (r = -.71, p < .05). Table 1 showed the association between SJFT, VO₂max and anaerobic power.

Discussion

The close association between physical characteristics and SJFT was in agreement with early studies on judokas.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Association between VO₂max, anaerobic power and SJFT of judokas.</th>
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<tbody>
<tr>
<td></td>
<td>VO₂max</td>
</tr>
<tr>
<td>Series A throws</td>
<td>.50</td>
</tr>
<tr>
<td>Series B throws</td>
<td>.86</td>
</tr>
<tr>
<td>Series C throws</td>
<td>.78†</td>
</tr>
<tr>
<td>Sum of throws</td>
<td>.22</td>
</tr>
<tr>
<td>HR after series C</td>
<td>.89†</td>
</tr>
<tr>
<td>HR after 1 min rest</td>
<td>-.87†</td>
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</tbody>
</table>

† p < .05.  † p < .01.
that highlighted the importance of height and weight for this sport.\textsuperscript{12,13} \(I_{\text{SFFT}}\) illustrates the level of performance at the SJFT, the higher the performance, the lower the index. Participants had similar values of \(I_{\text{SFFT}}\) (11.7 ± 1.0) with Polish judokas (11.6 ± 1.2)\textsuperscript{14} and better values than Brazilian judokas (13.2 ± 1.55).\textsuperscript{11} HR at the end of the test and one minute after the test was comparable with previous studies.\textsuperscript{11,14} \(V_{O2}\max\) (54.4 ± 4.5 ml·kg\(^{-1}·\text{min}^{-1}\)) in our sample was lower than Canadian judokas’ corresponding values (59.2 ± 5.2 ml·kg\(^{-1}·\text{min}^{-1}\)).\textsuperscript{2} In other relevant research, \(V_{O2}\max\) values in state and national level judokas was 59.8 ± 3.6 ml·kg\(^{-1}·\text{min}^{-1}\),\textsuperscript{15} in a Olympic team 52.9 ± 4.4 ml·kg\(^{-1}·\text{min}^{-1}\).\textsuperscript{16} It has been suggested that \(V_{O2}\max\) ranges between 50 and 60 ml·kg\(^{-1}·\text{min}^{-1}\) in judo.\textsuperscript{6} A possible explanation for such discrepancy could be the choice of assessment method of aerobic power.

With regard to anaerobic power, \(P_{\text{peak}}\) (7.8 ± 0.4 W·kg\(^{-1}\)) and \(P_{\text{mean}}\) (5.9 ± 0.6 W·kg\(^{-1}\)) of participants were also in agreement with previous studies. For instance, \(P_{\text{peak}}\) and \(P_{\text{mean}}\) in Canadian judokas were 7.7 ± 0.9 W·kg\(^{-1}\) and 5.7 ± 0.7 W·kg\(^{-1}\), respectively,\textsuperscript{7} while \(P_{\text{peak}}\) and \(P_{\text{mean}}\) in Brazilian judokas were 8.1 ± 0.8 W·kg\(^{-1}\) and 6.2 ± 0.7 W·kg\(^{-1}\) respectively.\textsuperscript{11} Maximal anaerobic power greatly affects the competitive performance of a judoka.\textsuperscript{17} \(W\text{AnT}\) is a test that can discriminate athletes based on the level of expertise. For example, national and university varsity team judokas scored better in this test than juniors.\textsuperscript{17}

Generally, elite judokas scored better in physical fitness tests and in sport-specific tests than their sub-elite counterparts.\textsuperscript{18} Previous research suggested that coordination/strength, speed, flexibility and balance, muscle mass and bone volume, and endurance judo performance as expressed by the fight winning score were related to judo performance.\textsuperscript{19} In an analysis of junior judokas, their final national championship achievement was associated with endurance and strength, and not with anthropometry.\textsuperscript{20}

To sum up, our findings with regard the aerobic and anaerobic profile of elite judokas confirmed previous observations about their high physical fitness level. However, what was the most important finding was the strong correlation between aerobic and anaerobic power with performance in the SJFT. It was showed that the SJFT is a field test that describes chiefly aerobic power, and in a lesser degree short-term power output and local muscular fatigue. Therefore, its further use from judo coaches and fitness trainers as a measure to monitor aerobic power is recommended, and the need for a field test that will describe anaerobic power is highlighted. Moderate correlations between SJFT and indices of aerobic and anaerobic power were indicated in the past in a study in which the number of throws in the SJFT was correlated with anaerobic threshold velocity \((r = .60, p < .01)\), peak velocity in incremental test \((r = .70, p < .01)\) and countermovement jump \((r = .74, p < .01)\).\textsuperscript{21}

The significant correlation of SJFT with both aerobic and anaerobic power was not unexpected, as there are high requirements for both in judo. Judo training improves both aerobic and anaerobic performance and these changes were associated with changes in heart structure and function as compared to non-trained control.\textsuperscript{22} In addition, Gariod et al. suggested that judo players with a higher \(V_{O2}\max\) presented a faster creatine phosphate (CP) resynthesis compared with judo players with a lower \(V_{O2}\max\).\textsuperscript{23} Together with the faster CP resynthesis, a faster lactate removal and pH recovery in individuals with higher aerobic power could benefit the recovery process.\textsuperscript{24}

**Conclusions**

The agreement of our findings with other studies on elite judokas stresses the need for specific physiological characteristics in these athletes. The moderate to high correlations between SJFT and physical fitness confirmed the validity of SJFT as a field test in judo. Therefore, judo coaches should employ this test to monitor their athletes’ progress.

**Conflict of interests**

Authors declare that they don’t have any conflict of interests.

**Acknowledgement**

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**References**


