Effect of Throwing Method on Special Judo Fitness Test Performance in Competitive Period of Training

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Abstract: To determine the effect of modification of throwing method on changes in judo-specific test performance, seven judoists were evaluated following the SJFT protocol. On the two consecutive days, the subjects performed one-shoulder throw in repetitive practice (RT) and as solo practice (TR). The number of throws performed, heart rates, index in the SJFT, blood lactate concentration before and during 8 minute of recovery were analysed. There was a significant effect of interaction between test variant and recovery time on lactate levels. A case study was used to demonstrate typical results obtained from the analysis of the effort and body response to the exercise. In conclusion, changes in the throwing method improved the performance in TR SJFT variant. The athletes performed the majority of work during this variant using their lower limbs, whereas the throws, although with higher number, were repeated without the resistance caused by receiver in RT SJFT. Performing the throws with judoists from lower weight categories might promote development of the speed.
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1. Introduction

Testing of motor preparation of judokas is carried out throughout the training cycle. General fitness tests are used in the beginning and after completion of the preparation period, whereas the period of special preparation and competitions testing is focused on control fights and special fitness tests (Almansba et al., 2012; Special Judo Fitness Test, 2012). These principles can be tailored to the needs of verification of the effects of contemporary training that typically occurs in three blocks (accumulation, transmutation and realization (Issurin 2008; Sikorski, 2010), in which competitive readiness might be signalled by the results recorded during fitness tests (Boguszewska et al., 2010). Current study tried to determine the relationship between some structural properties (fat percentage, fat free mass and mass index) of the body in members of national female judo team with aerobic/anaerobic power (Tahere Golami Bermi 2012). The most recent literature (Detanico and Giovana dos Santos 2011) shows that the most popular among fitness tests (Almansba et al., 2011; Azvedo et al., 2007; Santos et al., 2010) is the Special Judo Fitness Test (SJFT) (Detanico and Giovana dos Santos 2012). Increased popularity of this test means that it is ecological i.e. easy to be used in the environment of sport training (Calmet, 2007). This tool offers opportunities for immediate evaluation of fitness and its changes with respect to the normative values and exhibits high reliability and validity (Franchini et al., 2009 a). Temporal test structure (Special Judo Fitness Test, 2012) reminds that of competitive fighting (Sikorski, 2010). Therefore, the researchers considered it for their experiments as an evaluation instrument, without neglecting metabolic responses to judo-specific effort (Detanico et al., 2011; Franchini et al., 2007; Franchini et al., 2009b; Fukuda et al., 2012; Katralli and Goudar, 2012; Miarka et al., 2011). Sikorski (2010) argued that „Because of intermittent effort of high intensity, anaerobic glycolysis is mostly observed in judo elite athletes engaged in a contest". In consideration of the above notion, the goal of the present study was formulated, which was finding an answer to the following question: How will modification of throwing method affect changes in SJFT results, heart rate and lactic metabolic response in athletes?

2. Material and Methods

All subjects performed SJFT under two conditions. On the first day, the SJFT protocol focused on performing one-shoulder throw Ippon-seoi-nage

technique in repetitive throwing practice (subscript RT) in which receivers are actually thrown, while on the second day, the solo practice Tandoku-renchu (subscript TR) was performed. Both performances were videotaped and the throws performed were counted. The evaluation included the variables considered in the classificatory table (Franchini et al., 2009): total number of throws performed (ABC), HR measured directly after test, HR after 1 minute recovery and index in SJFT. Index value in SJFT was calculated according to the following equation:

$$\text{Index} \frac{\text{Final HR (bpm)} + \text{HR 1-min after the test (bpm)}}{\text{Number of throws}} \quad (1)$$

Heart rate was monitored by Polar Vantage (Polar Electro, Finland). The decay in HR during passive recovery time was determined from the data recorded after SJFT. Lactate (La) was measured in blood arterialized from earlobe before, directly before the exercise and next after the end of SJFT (1st minute), in 4th and 8th minutes of recovery. Blood samples were processed by reagents made by EKF Diagnostics (EKF, Germany) and the Biosen S-line lactate analyser (EKF Germany) to determine blood lactate concentrations. The research project was accepted by Bioethics Commission at The Region Medical Chamber in Cracow, no. 118/KBL/OIL/2012.

2.4. Statistical Analyses

Shapiro-Wilk's P-value was calculated for all numeric variables. These test results showed that all data exhibited normal distribution. Mauchley test was conducted when needed. The results obtained from SJFT were presented as means and standard deviations (SD). The differences were compared using t-test for paired samples. Repeated measures ANOVA was used to analyse the main effects (Test variant/condition; Recovery time) and interaction effect on La. Further, the pairwise Tukey test was employed. The variables of test variant (SJFTRT; SJFTTR) and recovery time on ΔLa (1st minute; 4th minute; 8th minute, post-test) were considered. Means and confidence intervals (95%CI) were reported and the pairwise Tukey test was used for means comparison. The statistical significance level was set at $P<0.05$. A case study of HR decay and La concentration was presented in consideration of modelling of the HR decay line during recovery after SJFT. A monoexponential model was used:

$$y = y_0 + A_1 e^{-(x-x0)/t1} \quad (2)$$

Meanings: y0 = offset, x0 = center, A1 = amplitude, t1 = decay constant.

The adequacy of data for the fitting model according to this function was tested by calculating R2 values. The duration of the fast phase of HR recovery for both conditions of testing an ANOVA for repeated measurements was evaluated using Origin® 9.0 Pro Data Analysis and Graphing Software.

3. Results

Results of Special Judo Fitness Test performance and recovery in different conditions. Results of SJFT performance are presented in Table 1.

Table 1. Results from two variants of the Special Judo Fitness Test for judoists during their competitive period (mean ± SD).

Variable	RT	TR
Total throws (n)	27.9 ± 1.8	34.1 ± 1.6***
HR directly after (bpm)	181.0 ± 10.9	176.3 ± 8.1
HR after 1'recovery (bpm)	151.7 ± 13.9###	146.1 ± 8.4###
Index in SJFT	11.96 ± 0.82	9.47 ± 0.76***

Note: RT- total number of throws performed in repetitive throws practice; TR- total throws number performed in solo practice; HR – heart rate, bpm – beats per minute.
***- $P<0.001$ between values presented in columns,
###- $P<0.001$ between values presented in rows.

During the SJFTTR tests, statistically significant increase in the number of throws was observed compared to SJFTRT (difference 6.29 1.38, $P<0.001$), whereas HRs after SJFTRT and SJFTTR were similar. Differences in index values between SJFT variants were significant (difference -2.49 0.44, $P<0.001$). Considering metabolic response in La, test variant factor was insignificant ($F=1.173$, $p=0.320$). Pairwise comparison between La concentration showed similar results for both conditions of SJFT performance (RT=9.91; CI=7.57-12.26 mmol•l-1 vs. TR= 8.90; CI=6.51-11.29 mmol•l-1, $P=0.079$). Time effect on metabolic response in La was highly significant ($F=30.049$, $P<0.001$). Pairwise comparison revealed an increment in La concentration between 1st and 4th minutes (7.82; CI=5.59-10.05 mmol•l-1, $P=0.005$), as well as between 1st and 8th minutes of recovery (La in 8th minute = 10.22; CI=7.95-12.49 mmol•l-1, $P=0.004$). Metabolic response in La measured in 4th and 8th minutes did not differ ($P>0.05$). There was also a significant effect of tests variant x recovery time interaction on La levels. Fig.1 illustrates an increasing trend in La. The means for the subsequent three time points are gradually higher after SJFTRT performance. There were significant differences between La measured in 1st and 4th minutes ($P=0.02$) and between 1st and 8th minutes

(P=0.006). No significant changes in La levels were observed for SJFTTR condition (P>0.05). In consequence of different profile shapes, RT condition response in La measured in 8th minute was significantly higher than in TR condition (mean difference was 1.85 mmol•l-1).

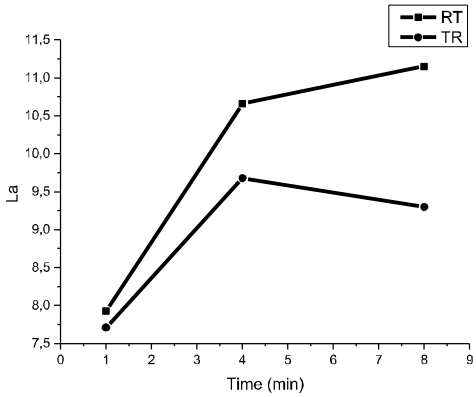

Figure 1. Means of La (mmol•l-1) during recovery time after SJFT performed in different condition. RT - repetitive throws; TR – Tandoku-renchu method

Case study

A typical HR (bpm) response kinetics for both RT and TR SJFT variants performed by judoist at the international competitive level is represented by a multiple X-Y plot (Fig. 2).

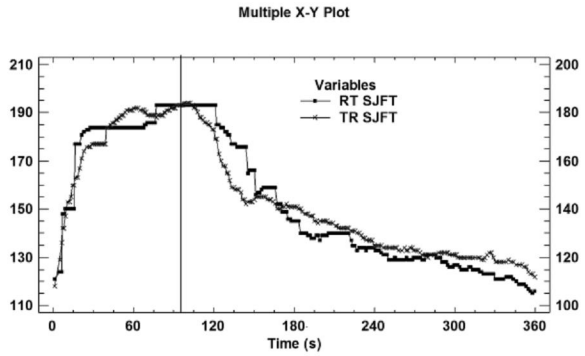

Figure 2. Example of HR (bpm) kinetics determination in representative person during SJFT and exercise recovery. Y (left axis) – bpm during RT variant performance; Y (right axis) – bpm for TR variant

After an exercise performed by this person for both test variants in the segment A of SJFT (1-15 s) heart rate was 150 bpm, whereas in the first interval (15-25 s) HR rose to 184 bpm (in RT variant) and 162 bpm (in TR variant). In segment B (25-55 s), HR in RT variant was maintained at the level of 184 bpm and, in variant TR, it increased from 163 to 184 bpm. During the second interval (55-65 s) the HR in both test variants remained at the same level (184 bpm). In segment C, HR rose to 193 bpm for RT variant and to 184 bpm for TR variant. In this case, HR measured directly after the exercise was higher after RT variant compared to TR. After one minute of rest, HR value decreased to 158 and 144 bpm, respectively. The recovery phase in both variants was presented in Fig. 3, panels A-B.

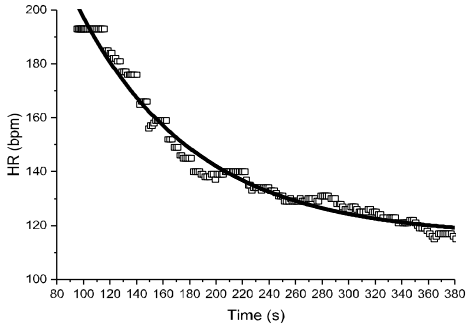

Figure 3A.Typical example of breath-by-breath HR (bpm) monitor output for recovery from $SJFT_{RT}$ variant.

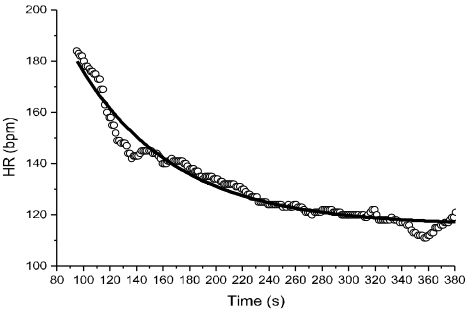

Figure 3B.Typical example of breath-by-breath HR (bpm) monitor output for recovery from $SJFT_{TR}$ variant

The adequacy of the fitting models (solid monoexponential curves) was very high (R^2=0.97). After presentation of the results on the logarithmic scale (Fig. 4AB), the duration of the phase of fast HR decay (Log bpm) in RT variant amounted to 90 s (lower slope) whereas in TR variant this phase took 45 s (higher slope). At the time of completion of the fast phase, HR reached 148 bpm for TR variant and 140 bpm for RT variant. Furthermore, La levels measured in 1st, 4th and 8th minute of the recovery was changed in RT variant vs. TR, reaching 11.11, 11.72, 14.01 $mmol \cdot l^{-1}$ vs. 12.15, 12.43, 11.63 $mmol \cdot l^{-1}$, respectively.

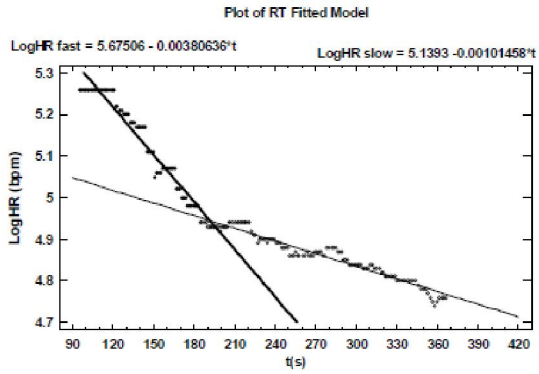

Figure 4A. Example of Log HR vs. time for post-exercise (SJFT RT variant) where Change point equaled 185-95 = 90 s

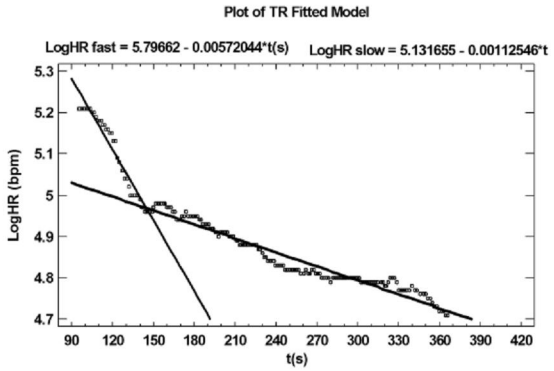

Figure 4B. Example of Log HR vs. time for post-exercise (SJFT TR variant) where Change point equaled 140-95 = 45 s

4. Discussions

The judokas studied were characterized by good special fitness, whereas individual scores ranged from regular to excellent according to SJFT standards (Franchini et al., 2009). Lower number of throws performed in SJFTRT compared to SJFTTR was presumably caused by the necessity of overcoming the resistance/inertia of Uke during SJFTRT. Group heart rates observed directly after performing both variants of tests did not differ statistically. However, their decline after one minute of rest suggested good level of special fitness. The index in SJFTRT was significantly worse than in SJFTTR (lower indices are considered to be better score). The results obtained in previous studies demonstrated that HR directly after SJFT (181.6 6.2 bpm) was close to HRmax (188.4 8.1) and exceeded the value of HR at anaerobic threshold (87.1 2.7% HRmax) (Sterkowicz et al., 1999). This case study suggests that post-exercise individual HR response (bmp) might vary from general statistical regularities. One minute after SJFTRT the subject remained in the fast phase, whereas in variant TR, the person already started the slow phase of HR recovery. HR considered inclusively with La levels represents exercise intensity, which was very high in this person. When the test began, the HR rates were disproportionately low compared to the intensity of the exercise, whereas in the recovery phase, HR was increased. This is used for observation of maximal accumulated oxygen deficit (MAOD) and excess post-exercise oxygen consumption (EPOC) by evaluation of alactic contribution during physical exertion (Franchini et al., 2011).

Duration of SJFT test amounts to 95 s, whereas La levels in the study of athletes from the Polish National Team reached 10.11±1.63 mmol•l-1, which was the range similar to the levels observed after competitive fights (9.53 – 11.10 mmol•l-1, on average). When running was excluded, after continuous repetition of throws on the approaching Uke for ninety seconds with maximum speed, the level of 9.28±1.47 mmol•l-1La was recorded (Błach, 2005). This study found similar blood La levels both after SJFTRT, and after SJFTTR. However, it should be stressed that the interaction pointed to a trend in La response related to a variant of test and recovery time when La measurements were taken. After performing SJFTTR, a characteristic increase in La level was observed until 4th minute of recovery. The exercise during SJFTRT leads to the increase in La until the 8th minute of the recovery, which might suggest different level of lactic contribution when performing the test variants compared in the study. Velocity constant of lactate elimination from the blood compartment decreases with an increase in blood lactate concentration (Beneke et al., 2005). It was confirmed that La levels depend on the duration of judo fight. It seems interesting that peak La levels measured after shorter fights (2 to 3.5 minutes, 12.0±4.1 mmol•l-1) were delayed for about 2 minutes compared to longer fights (3.5 to 5 minutes, 13.4±5.2 mmol•l-1) (Obmiński et al., 2010). From the methodological viewpoint, we cannot compare La results directly in this study because La was not reported by those authors. Despite the above, SJFT is regularly used in verification of training effects in national teams. The data of La response to different judo activities confirms that SJFT exhibits very similar lactic metabolism demands as in the fights during European championships (Błach, 2005). It was concluded in another study (Miarka et al., 2011) that the performance in the SJFT was determined by the aerobic capacity and power and muscle force. Athletes with greater aerobic ability (vAT) presented lower blood lactate accumulation after the match. To our knowledge, classification of exercises depends on the criteria adopted. Extension of these criteria showed recently that total energy expenditure in 14 Polish

male subjects during SJFT amounted to 223.6 ± 39.1 kJ, while alactic, lactic and aerobic contributions were 40.4 ± 5.6%, 26.7 ± 5.4% and 32.9 ± 3.3%, respectively. The alactic energy system presented significantly higher contribution when compared with both aerobic and lactic energy systems, and the lactic energy system had a lower contribution compared to the aerobic system (Beneke and Hoos, 2012; Franchini et al., 2011).

Considering the examination of the energy cost of the fight, we suggest that, under current conditions, one should start from fighting for grip, which determines throwing performance. Analysis of the temporal structure of the randomly selected fights recorded during the Polish National Qualification Tournament indicated that 23.9% of the duration of the fight was a preparatory phase, when a judoka moves without holding the opponent (Sterkowicz et al., 2012). This is a constant part of the fight, which would be simulated by the effort similar to Randori. Also disputable due to difficult standardization of the judo fight, this direction of the examination is important when choosing the training methodologies and nutrition of athletes. Moreover, athlete with the principles of the initial state can return to their abilities to participate in this training to maximize competition. Until lactate levels within the muscle doesn't return to its normal, the person is fully prepared to participate in the next race (Gholamhasan et al., 2012)

5. Practical application

The differences observed between RT an TR variants of SJFT should be taken into consideration when testing professional judokas. Neglecting the principle of choosing Uke according to body mass and performing the exercise with lighter partners might lead to erratic evaluation of an athlete. For example, it can be assumed that a judoist improved aerobic capacity since his La level is decreasing faster, whereas the truth might be that he performed the movement task under easier conditions (lower resistance). On the contrary, performing SJFT with the athletes from heavier weight categories might negatively affect the score. It is particularly important that testing athletes during different periods of the training cycle should be carried out after choosing testing partners with similar body mass. SJFTTR variant can be used during early stages of recruitment for judo training since it allows for evaluation of the body's response to the rhythm of the exercise specific for SJFT and sport fight, even despite the lack of perfectly performed throwing technique. La levels after different training exercises should be also monitored as it points to the consistency with the requirements of the sports fight. A case study of physiological and metabolic responses of a competitor during and after Special Judo Fitness Test variants demonstrates that the interpretation of the intensity of the exercise based on HR and La should be individual, what was also previously stressed by Houvenaeghel et al. (2005) in case of heart rate response analysis during judo-specific efforts. According to Szmatlan-Gabryś et al. (2014) an analysis of the research findings identifies f.e the Bosco test as a sensitive tool for measuring the anaerobic endurance of the lower extremities in athletes involved in speed-endurance disciplines.

This contemporary evaluation of training resources as well as their choice and verification of the effects are aimed at taking into consideration all the three energy systems contribution: alactic, lactic and aerobic.

6. Conclusions

Changes in the throwing method in Ippon Seoi-nage improved the performance in TR SJFT variant. The athletes performed the majority of work during this variant using their lower limbs, whereas the throws, although with higher number, were repeated without the resistance caused by Uke in RT SJFT.

Performing the throws with Uke from lower weight categories might promote development of the speed.

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