SPECIFIC FITNESS OF ELITE AND NOVICE JUDOISTS

by

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The aim of this study was to compare elite and novice judoists in the performance of a specific judo fitness test (SJFT) (Sterkowicz, 1995). The subjects were 80 judoists from Brazil and Poland, grouped according to age: younger (n = 50) – up to 21 years old, older (n = 30) – over 21 years old; competition achievement: elite (n = 33) – Brazilian or Polish National medallists or International medallists, novice (n = 47) – non medallists in National or International Championships; weight categories (60 kg, 66 kg, 73 kg, 81 kg, 90 kg, 100 kg and over 100 kg). Groups were compared by means of a two-way ANOVA for repeated measurements and MANOVA. The main results indicate: elite judoists performed a greater number of throws during the 3 series of the SJFT compared with novice judoists, demonstrating a higher anaerobic capacity in a specific setting. Elite judoist also had a lower heart rate after the SJFT and a lower index, interpreted as a better anaerobic-aerobic performance. These results indicate the capability of the SJFT to correctly differentiate elite from novice judoists and could be used in a control of training and talent identification process.

Key words: judo, anaerobic performance, specific fitness test, elite athletes

Introduction

Judo is an Olympic sport that requires a high physical, psychological and technical preparation (Little, 1991). According to official rules there are 7 weight categories in competition (Sports, 1999). The evaluation of physical characteristics is an important part of the training process because it gives information about the variables that need to be improved and about the

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effectiveness of a given training program. However, judo athletes evaluation is usually made in laboratory settings (Thomas et al., 1989) with little validity to competition performance. Like other sports, judo has some specific tests: BT3 proposed by Heinisch (1997) and the special judo fitness test (SJFT) proposed by Sterkowicz (1995). Both tests are intermittent and use specific judo movement patterns.

Some variables of the SJFT showed to have a good correlation with both aerobic power (treadmill test) and anaerobic capacity (Wingate test) (Franchini et al., 1999; Sterkowicz et al., 1999). Blood lactate concentration after the SJFT was very similar to that obtained after judo combat, indicating similar metabolic responses in these situations (Franchini et al., 1998). Furthermore, Sterkowicz (1996) observed that elite Polish judoists (medallist in the National Championship) presented a better index compared athletes representing a lower sport level. However, no previous study had considered the differences between weight categories with a large sample. Thus, the aim of this study was to compare the performance in the SJFT of elite and novice judoists with consideration of weight categories.

Material and Methods

The special judo fitness test (SJFT) was applied as described elsewhere (Sterkowicz, 1995; Franchini et al., 1998). The test is performed in 3 series of 15, 30 and 30 sec with 10 s rest interval between them. During these series, the athlete throws two other judoists (6-m apart from each other) as many times as possible using the *Ippon-seoi-nage* technique. Heart rate (HR) immediately and after 1 min. after the cessation of the test was measured by Sport-tester device (Polar Electro made in Finland) and an index was calculated (Index = HR after + HR 1 min / total number of throws). Thus, a lower index indicates a better performance (Sterkowicz, 1995).

The subjects were 80 judoists from Brazil and Poland. Individual results were entered into a computing system. When forming age groups, we took into account the median criterion and the groups were determined according to age, i.e. 1- younger, i.e. to 21 years (n = 50) and 2 – older (n = 30), i.e. above 21 years. The subjects were also grouped also according to their competition

achievements: elite (n = 33) – Brazilian or Polish National medallists or International medallists, novice (n = 47) – non-medallists in National or International Championships; weight categories: lighter – LC (n = 52), i.e. 60 kg, 66 kg, 73 kg and heavier – HC (n = 28), i.e. 81 kg, and 90 kg, 100 kg and over 100 kg). The groups were compared using two-way ANOVA for repeated measurements and MANOVA.

The dependent variables assessed were the results of the SJFT and the independent variables included the competition experience, and the weight category.

We assumed that subjects would demonstrate the peak potential of physical fitness in series A. Thus, the peak potential in the first 30 s was estimated. The twofold number of throws in series A*2 results and those obtained in series B and C were compared in ANOVA with repeated measures design.

The main effects of age, sports level and weight category were calculated for repeated measurements in series A*2, B, C and the heart rate immediately after exertion and after 1 minute of recovery. Also, the main effects were evaluated in MANOVA for both the total number of throws and the Index SJFT.

Results

a) Characteristics of participants and their scores in the Special Judo Fitness Test

Most of our subjects (62.5%) were classified as younger athletes, whereas 37.5% of all participants composed the older group. We found no relation between the age group and weight (in kg), or weight categories, body height and Rohrer's Index. However, there was a significant statistical association between the age category and sport level of our participants (Chi-square with Yates correction = 11.17). Table 1 presents the main characteristics of subjects participating in the Special Judo Fitness Test.

Table 1

Main characteristics of subjects participating in the Special Judo Fitness Test.

Variable	Whole group (n = 80)			Younger (n = 50)			Older (n = 30)			P-value
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	
Weight [kg]	79.6	77.75	14.3	79.79	77.77	15.31	79.4	78.3	12.67	0.907
Height [cm]	177.5	177.0	8.0	177.6	177.0	8.08	177.3	177.0	7.89	0.854
Rohrer's index	1.42	1.41	0.17	1.41	1.41	0.18	1.42	1.38	0.15	0.883
Sports level: E –group	100%			26.0%			66.7%			<0.001
Sports level N – group				74.0%			33.3%			
Weight: LC	100%			66.0%			63.3%			0.999
Weight: HL				34.0%			36.7%			

Remark: E – elite, N – novice, Weight LC – first four lighter categories (60 kg, 66 kg, 73 kg, 81 kg); weight HC – three heavier categories (90 kg, 100 kg and over 100 kg)

Table 2

Mean scores on Special Judo Fitness Test according to age, sports level and weight category of participants

Factors	Series A [n]	Series B [n]	Series C [n]	Total throws [n]	HR after [beats· min^{-1}]	HR 1 min [beats· min^{-1}]	Index in SJFT
Age (p)	0.937	0.103	0.081	0.127	0.003	0.067	0.016
Younger (n = 50)	5.8 (0.6)	10.4 (1.0)	9.6 (1.1)	25.8 (2.3)	185.3 (9.4)	156.8 (15.9)	13.4 (1.5)
Older (n = 30)	5.8 (0.9)	10.7 (1.3)	10.1 (1.3)	26.8 (3.4)	178.6 (9.5)	149.8 (17.2)	12.3 (1.7)
S. level (p)	0.002	<0.001	<0.001	<0.001	0.043	0.306	<0.001
Elite (n = 33)	6.1 (0.8)	11.2 (1.1)	10.4 (1.2)	27.7 (2.9)	180.1 (10.0)	151.9 (18.1)	12.1 (1.6)
Novice (n = 47)	5.6 (0.5)	10.2 (0.9)	9.3 (1.1)	25.1 (2.2)	184.7 (9.6)	155.8 (15.5)	13.6 (1.4)
Weight Cat. (p	0.048	0.014	0.039	0.013	0.834	0.861	0.066
Lighter LC (n = 52)	5.9 (0.8)	10.8 (1.2)	10.0 (1.2)	26.7 (2.8)	182.9 (9.9)	154.4 (17.2)	12.8 (1.7)
Heavier HC (n = 28)	5.6 (0.6)	10.2 (0.9)	9.4 (1.3)	25.1 (2.4)	182.5 (10.4)	153.7 (15.9)	13.5 (1.4)

Remark: all results are presented in mean and (SD); (p) – p – value

There was a significant difference ($p = 0.003$) between the two age groups in HR immediately after the termination of the test (Table 2). The mean score was higher in the participants who were younger, whereas the older ones had lower scores. No significant differences were found between age groups for the other results of the SJFT. The results concerning the HR immediately after test were corroborated in relation to the two sports level groups ($p = 0.043$). The elite group had significantly lower HR immediately after the three series of *Seoi-nage* throws, than the novice group. The mean number of throws in successive series A, B, C and the total were different between groups E and N. The scores of Group E were better at individual series A ($p = 0.002$), and series B, C as well as the total throws series ($p < 0.001$), and in the SJFT Index ($p < 0.001$). We found an opposite direction of differences in the Index while comparing the younger with the older competitors. There was no significant difference between the lighter and heavier weight categories in either case of HR ($p > 0.8$) and no difference in the index ($p = 0.066$). In comparison with group HC, the group LC scored better on all the series of throws in the SJFT. The difference was statistically significant ($p < 0.05$).

b) Differentiation of the results in repeated series of judo throws and heart rate response of the competitors in terms of age and sports level

Three series of throws were designed for the research. The rationale behind these three series of throws was the assumption that each consecutive motor task would be performed with more exhausted energy sources of the subjects. In consequence, different results in series of judo throws should be observed. That was the tendency to obtain higher values of age along with higher number of throws performed by judoists should probably be confirmed by Two-way ANOVA with repeated measurements.

The significance of differences was tested between mean values according to the age factor in relation to the results in A*2, B, and C series. An age factor ($F = 1.47$; $p >. 0.05$) showed not significant influence on the number of throws performed in series A*2, B and C, whereas the number of throws in consecutive series substantially decreased ($F = 125.27$; $p < 0.001$).

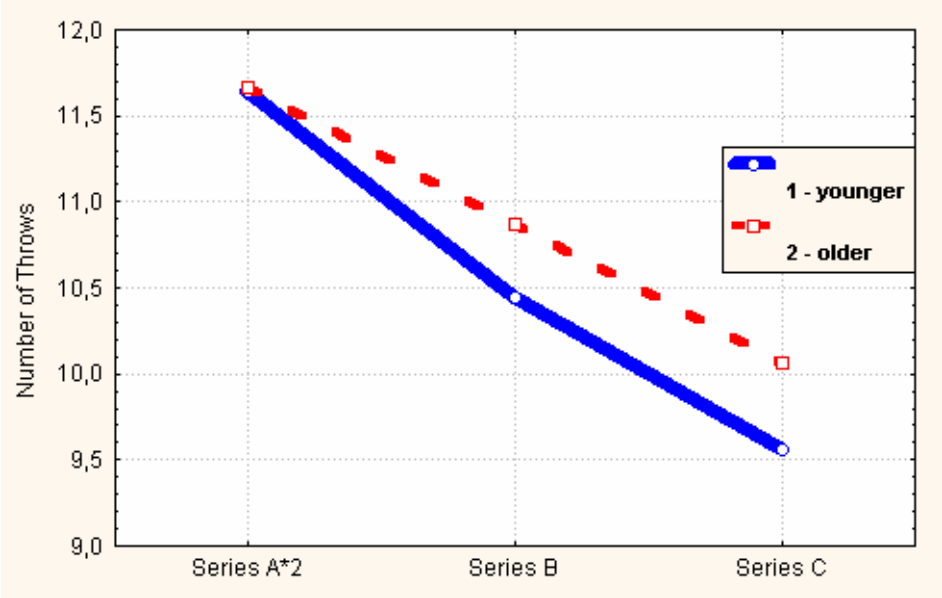

Fig. 1. Average number of throws of the tested group for younger (1) and older (2) categories across three series of throws

In general, the two groups did not perform in a significantly different way in the SJFT across the consecutive series of throws, although figure 1 does show some differences between the two groups. The older group (2), with similar potential to start with, seemed to maintain a steadily deteriorating trend in the number of throws. In contrast, the younger subjects (1), having had a good result in series A*2, seemed to be falling below the performance characterizing the older group (2). However the interaction effect was not big enough to reach a significant level ($F = 2.44$; $p = 0.091$).

In both age groups the heart rate response decreased significantly ($F = 335.33$; $p < 0.001$) as a result of the 1-min. recovery (time effect) and was different between the groups at the time ($F = 6.67$; $p < 0.05$). Immediately after series C and after the 1-min. recovery the younger competitors presented higher HR values (185.3 beats.min^{-1} and 156.8 beats.min^{-1}, respectively) than the older competitors (178.6 beats.min^{-1} and 149.8 beats.min^{-1}, respectively). There was no significant interaction between age category and time ($F = 0.009$; $p = 0.924$).

The effect of age in both groups E and N, which had different mean values, can be interpreted as an indirect influence of judo training experience. In further

analysis of the sports level, we isolated variance in the response variable due to the age. The analysis of variance included the sum of squares, for the effects were adjusted for the confounding age variable. The correlation of age and number of throws that was pooled within groups was negative and insignificant in series A*2 (r = -0.34) and B (-0.22). There was no substantial correlation between age and throws in series C (-0.08).

The results using the adjusted cell means as follows: the number of throws performed in series A*2, B and C was significantly different across the different judoists' level of elite and novice (F = 25.70; p < 0,001), and the average number of throws was also significantly different across the consecutive series of throws performed in the SJFT (F = 133.64; p < 0.001). Figure 2 represents the interaction of the two factors (p > 0.05).

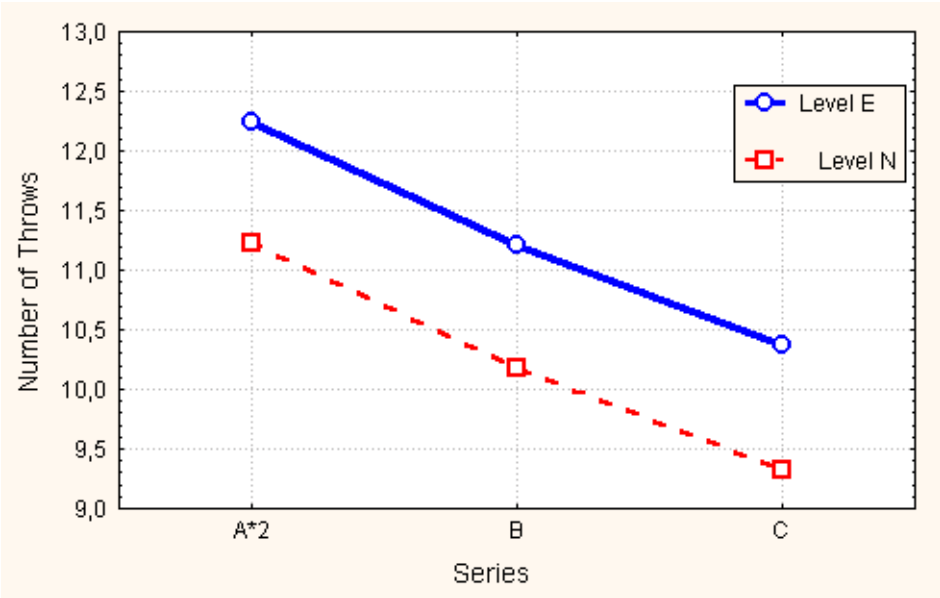

Fig. 2. Interaction plot of number of throws performed in consecutive series of SJFT by elite (E) and novice (N) judoists (A*2 – potential estimated in series A)

The two lines on the graph represent two of the judo groups (E and N). The lines connect the least squares means for the three levels of time/series. There was no interaction, because the lines are parallel. The time trend is very similar between the two groups. The estimated initial results (A*2) naturally dropped in

successive trials and the patterns of the slope are very similar in both groups. The data analysis in the consecutive series of throws A*2, B, and C showed a phenomenon of fatigue of the subjects in both groups.

The initial number of throws in series A*2 showed a full potential of the performance of the athletes which were estimated in 30 s. That peak potential in the special judo fitness was significantly higher in the elite group (12.2 throws). In the novice group the average results in series B (10.2 throws) and C (9.3) were lower than the results of series C in the elite group (10.2 throws), respectively. The results estimated in series A*2 for the novice group (11.2 throws) were equal to the elite group in series B (11.2 throws). Difference between the groups' mean values of peak potential in A*2 and performance in series C were –15.4 (group E) and (group N) –17.0%, respectively.

In both groups the heart rate response significantly decreased ($F = 344,57$; $p < 0.001$) as the results of the 1-min recovery (time effect) and it was not different between the groups at that time ($F = 0.013$; $p = 0.909$). The interaction of sports level*time was also not significant ($F = 0.049$; $p = 0.825$).

b) Differentiation of the results in repeated series of judo throws and heart rate response of the competitors in terms of weight category

A two-way ANOVA for weight category with repeated measurement (for time factor) corroborated the previously stated fact, that as the inclusive outcome, the number of throws decreased significantly for all weight categories as an exertion proceeded. The competitors were more powerful in the test phase A*2 than in series B and C ($F = 123.81$; $p < 0.001$). The interaction of the two factors was not significant ($F = 0.21$; $p > 0.05$). Figure 3 shows the main effect of weight category analysis ($F = 2.41$; $p < 0.05$).

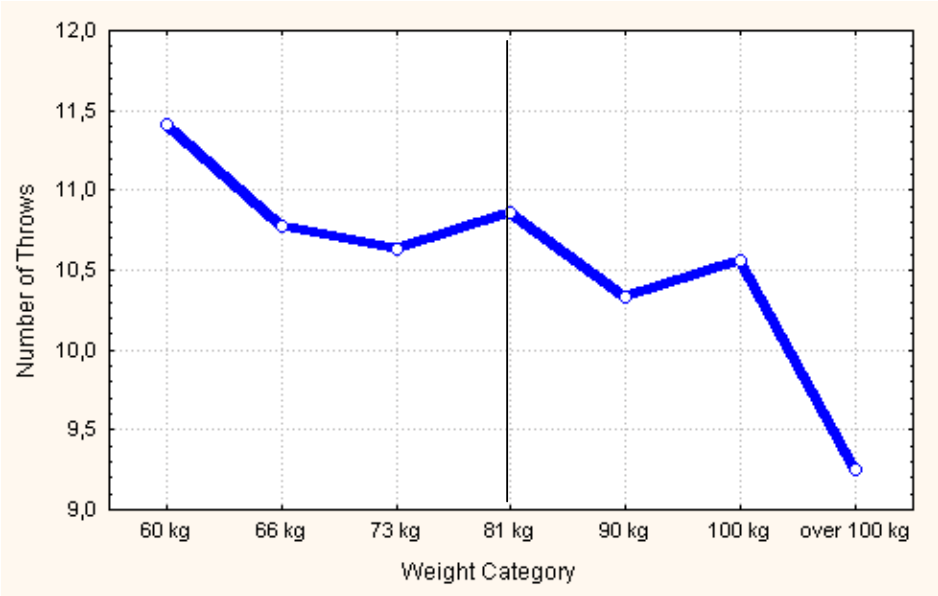

Fig. 3. Plot of weight category main effect

In general, the competitors of lighter categories LC (60 – 81 kg) revealed better specific fitness, whereas the heavier athletes, especially category over 100 kg, were characterized by worse results in respect to the SJFT. The Multiple Range Test confirmed significant differences among mean values of the heaviest category and the subset of first four weight categories ($p < 0.05$). The number of throws performed by competitors, who fought in the heaviest category, was homogenous with the closest neighbor weight categories (i.e. –100 kg and –90 kg).

Also, we observed that the heart rates immediately after the throws naturally decreased as a result of recovery process into values after 1 min (time effect $F = 276,74$; $p < 0.001$), but it was not different between the weight categories at any time ($p > 0.110$). There was no significant interaction between weight category and time either ($F = 0.049$; $p = 0.825$)

c) Effects of age, sports level, and weight category on the Total number of throws and Index in the Specific Judo Fitness Test

The MANOVA decomposes the variability of total throws into contributions due to various factors. Since Type III sums of squares have been

used, the contribution of each factor is measured having removed the effects of all other factors. The F-ratio for sports level was 24.23 and for weight category was 12.86. Since p-values are less than 0.001, these factors have a statistically significant effect on the total number of throws at the 95,0% confidence level. The age factor was not significantly affected by the total amount of throws performed on the SJFT (F = 0.05; p = 0.8217).

Table 3 presents the mean total throws for each level of the factors.

Table 3

Least Squares Means for Total throws number and Index in SJFT with 95% Confidence Intervals

Total throws number					
Level	Count	Mean	Std. Error	Lower Limit	Upper Limit
GRAND MEAN	80	26,1			
Age category 1	50	26,2	0,37	25,4	26,9
2	30	26,0	0,45	25,1	26,9
Sport level E	33	27,5	0,42	26,7	28,4
N	47	24,6	0,40	23,8	25,4
Weight category LC	52	27,1	0,34	26,4	27,8
HC	28	25,1	0,45	24,2	26,0
Index in SJFT					
Level	Count	Mean	Std. Error	Lower Limit	Upper Limit
GRAND MEAN	80	13,0			
Age category 1	50	13,2	0,22	12,7	13,6
2	30	12,8	0,27	12,3	13,4
Sport level E	33	12,2	0,25	11,7	12,7
N	47	13,7	0,24	13,2	14,2
Weight category LC	52	12,5	0,20	12,1	12,9
HC	28	13,4	0,27	12,9	14,0

This table shows the mean index for each level of the factors. It also shows the standard error of each mean, which is a measure of its sampling variability. The rightmost two columns show 95,0% confidence intervals for each of the means.

Although factor interaction was not significant, figures 4 and 5 graphically show that these factors have an influence on the average of total throws and index in the SJFT. The better results were observed in the lighter weight categories, than in the heavier ones.

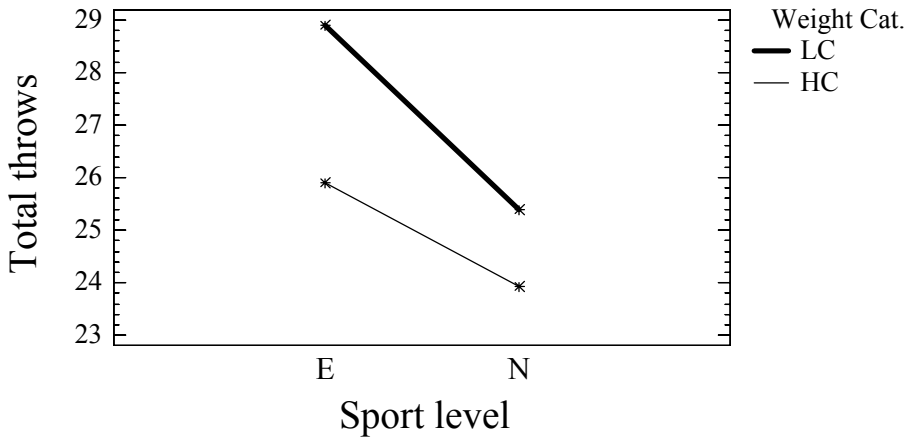

Fig. 4. Interaction plot of total number of throws performed in SJFT by elite (E) and novice (N) judoists presented lighter (LC) and heavier (HC) weight categories

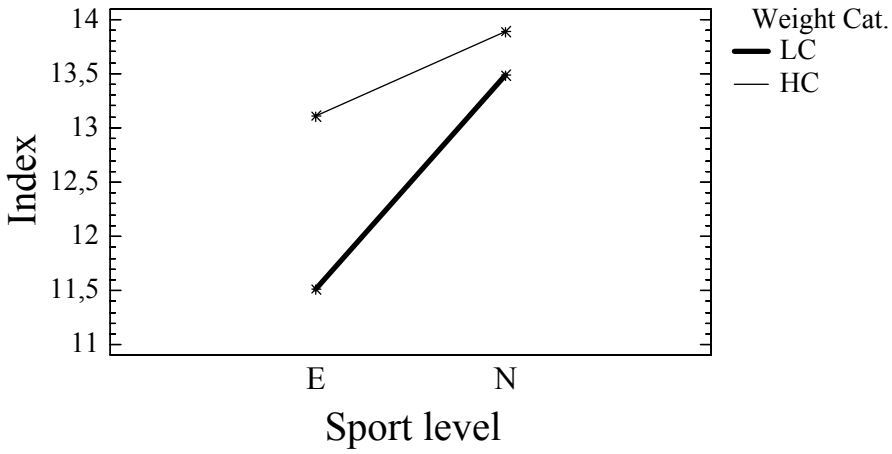

Fig. 5. Interaction plot of total number of throws performed in SJFT by elite (E) and novice (N) judoists presented lighter (LC) and heavier (HC) weight categories

d) An evaluation of two cases

The results of testing by the SJFT give us a possibility to answer the question related to evaluation of peak performance directed at a precise time (Figure 6).

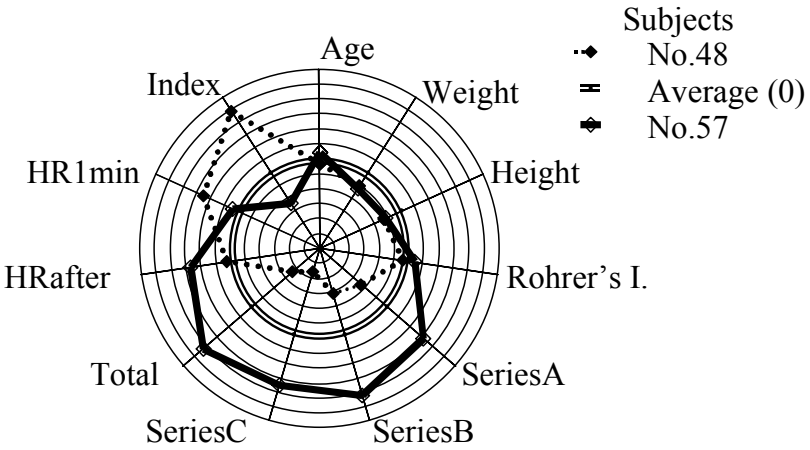

Fig. 6. Comparison of standardized results of two subjects, who performed SJFT differently (group mean = 0,0, scaling from –3 to 3 SD, by 0.5 SD).

This spider plot is designed to display the values of 11 variables on the average basis (double line). Each of the polygons represents one subject. The distance from the center of the polygon to each vertex represents the value of one variable for that

result. The ends of the rays are located at the mean of each variable plus three standard deviations, while the center is at the mean minus three standard deviations.

Figure 6 shows, that in age, weight, height and Rohrer's index the competitors No.48 (N) and No. 57 (E) were very similar. Those characteristics of both judoists oscillated between $\bar{x} \pm 0.5$ SD. When the standardized results of novice judoist in consecutive series of throws and total throws were compared to the group average, they were inferior by 1 – 2 SD. After the throws, his results in HR were near the average. However, his HR after 1min recovery was superior by 1 SD (his HR 1min was 175 and fall slow into average line), and by 2.5 SD in the SJFT index.

When individual results of the elite competitors were compared to the group with average results, it was found that No. 57 excelled by 1.5 SD in series A, and by 2 SD in series B, and by 1.5 SD in series C, and by 2 SD in total throws of *Ippon-seoi-nage*. HR immediately after the throws was 1.5 SD higher than the group average (double line), whereas HR 1 minute after the test indicated very little difference in comparison with the whole group average. However the SJFT index, which characterized special work capacity, was 1 SD lower than average in the whole group. Comparing characteristics of figure 6, we can find a very big gap between individual results marked on the rays. Differences of direction distinguished elite competitor No. 57 as the more fit, than novice judoists No. 48.

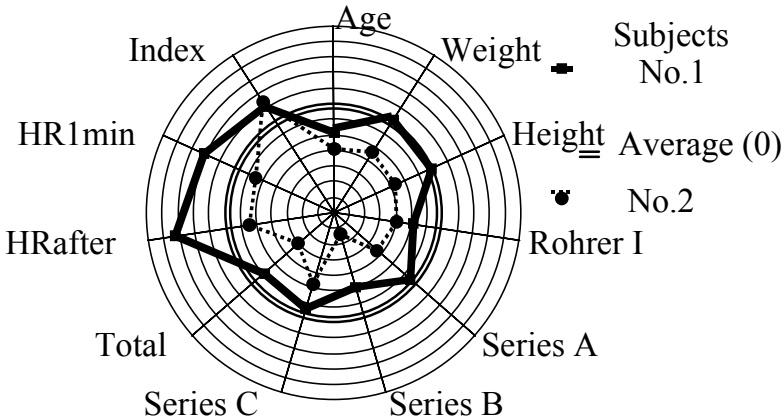

Fig. 7. Comparison of standardized results of two subjects who performed SJFT (mean = 0,0, scaling from –3 to 3 SD, by 0.5 SD)

An example on the figure 7 shows another two subjects who had similar index in the SJFT, but simultaneously they had different levels of performance in consecutive series of throws and heart rates.

The graphical characteristics of subject No. 1 show him as an average participant in the whole group. His standardized characteristics of age, weight, height, Rohrer's index, and throw performance are rather average. But his heart rate responses are higher about 1 SD than average of the whole group. The index can be evaluated as second-rate (1 SD over the mean). Subject No.1 has similar index to Subject No 2, but his standardized characteristics are completely different. Subject No. 1 has the advantage over subject No.2 in weight, height and body build Rohrer's index, and also in the results in the series ABC and the total number of throws. Because his heart rates after {no article the} effort were higher above 1.5 SD than in subject No. 2, his index was similar to No. 2. These data indicate that individual values of index in the SJFT have to be interpreted alongside with complementary results of other subjects. [1]

Discussion

The results of this study showed that the SJFT is capable to correctly discriminate judoists according to their performance in competitions. Thus, this shows that the SJFT evaluates physical characteristics that are important to judo performance. Previous studies on the SJFT reported that number of throws in series A, B and C were correlated positively with performance in both upper body (Franchini et al., 1999) and lower body Wingate test (Sterkowicz et al., 1999), indicating the anaerobic character of this periods. As anaerobic performance has been considered an important factor to judo performance (Thomas et al., 1989; Little, 1991) it can be concluded that the differences between elite and novice in the number of throws in the SJFT is a consequence of differences in anaerobic capacity in a specific setting.

[1] Claessens and Lefevre (1998) also used a multivariate perspective in analysis of drop-out phenomenon in gymnastics. Gymnast performed better than drop-outs in Bent arm hang in Eurofit test battery, whereas drop-outs were older and had higher values on anthropometric characteristics and gymnastic – specific tests.

However, some authors (Bogdanis et al., 1996; Gaitanos et al., 1993; Tabata et al., 1996) have observed that high intensity intermittent exercise has an important aerobic contribution when stimulus is repeated. The higher aerobic contribution in third or fourth series of 30sec of high intensity intermittent exercise is in part responsible for the decreased performance compared to the first 30 sec in cycloergometer exercise. The time structure of the SJFT is intermittent in nature with very short intervals (10s), which can accentuate the metabolites accumulation (lactate for example) and low phosphocreatine resynthesis. These factors (lower glycolytic flux and CP system impairment) would anticipate the requirements of aerobic metabolism and the consequent decrease in performance in the last series, contributing to the fatigue index observed in the subsequent series (Figures 1 and 2). Confirming this theoretical assertion, Sterkowicz et al. (1999) found a positive correlation ($r = 0.665$; $p < 0.01$) between number of throws in series C and VO_2max during a treadmill test. Thus, elite judo athletes studied here probably presented a higher aerobic power compared with novice judo players.

The other factors that can explain the capability of the SJFT to correctly discriminate the level of the judoists are: (1) the time structure of the SJFT are based on real combat time structure, which has effort's duration of about 30 sec and interval of about 10 sec as expressed in other studies (Sikorski et al., 1987; Monteiro, 1995; Castarlenas & Planas, 1997), resulting in similar physiological requirement in both the SJFT and combat; (2) blood lactate concentration after the SJFT was very similar to that found after judo combat as presented in the previous article (Franchini et al., 1998), indicating that the anaerobic glycolysis requirement was similar in both activities.

The differences in the performance between weight categories can be explained by some factors as: (1) the inverse correlation between relative VO_2max and weight category (Thomas et al., 1989); (2) higher fat body percentage in the heavier categories (Iida et al., 1998) and the velocity impairment associated with this; (3) lower relative anaerobic capacity in heavier subjects (Inbar et al., 1996). However, it is important to note that the elite heavier athletes had higher performance in the SJFT compared with novice ones, indicating that the factors related to the SJFT could be improved in the heavier athletes to enable them to achieve higher competition performance, i.e.

an improvement of relative VO_2max and anaerobic capacity and a decrease in body fat percentage. The coach might want to compare performance across seasons or against the tested athletes' rivals in his team (Alderson et al. 1984).

Final Remarks

The main observations of the present study were:

- The elite judo players presented higher performance in the SJFT compared to the novice ones. The Special Judo Fitness Test can be used for talent identification.
- The heavier judoists tended to have lower performance in the SJFT.
- The Special Judo Fitness Test can be used for training control.

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