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An Approach to Physical Performance Analysis for Judo

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***Abstract*—**Sport performance analysis is a technique that is becoming every year more important for athletes of every level. Many techniques have been developed to measure and analyse efficiently the performance of athletes in some sports, but in combat sports these techniques found in many times their limits, due to the high interaction between the two opponents during the competition. In this paper the problem will be framed. Moreover the physical performance measurement problem will be analysed and three different techniques to manage it will be presented. All the techniques have been used to analyse the performance of 22 high level Judo athletes.

***Keywords*—**Sport performance, physical performance, judo, performance coefficients.

I. Introduction

IN recent years, sport performance analysis is becoming more and more important, for high level and also for amateur athletes. This trend includes many types of sports and requires a good interaction between athletes, trainers, scientist and engineers in order to create an entire measurement and analysis system in order to understand the weakness of the athlete and in order to customize the training in order to improve the performances.

For many sports like cycling, running and swimming it has been done and the results are evident: the performance at the Olympic Games are increasing. For combat sports this approach is much more complicated and in many cases it is not applied: the training it is still decided only by the experience of the trainer with few or no support from the scientific word. The main result of this is problems in well tuning the training and so in some cases is not possible to really exploit all the capabilities of the athletes. Moreover, it leads problems in the choice of the right athlete for a certain competition. he difficulties in adopting the same systems in combat sports is caused by high degree of interaction between the two opponents in the competition. In fact, the final result in a competition is influenced by three parameters: the capability of the first athlete, the capability of the second one and the interaction between the athletes. This interaction is highly non linear and creates an essential coupling between the opponents and can be hardly modelled.

To face this huge problem, it has been divided into four sub problems 1. These are easier than the main problem but they are again non trivial. They are [1]:

- Physical performance of the athlete: it is important because it drives the capability to resist for the time of the competition, drives the possibility to face to some technical mistakes and finally it gets the self-confidence to the athlete;
- Technical capability: it is only related to the skills involved to perform a technique in an ideal condition. It is important for a competition, even if it is not so straightforward: a highly skilled athlete is not necessary a champion, while it is quite sure that for winning a high level competition it is needed a high level technical capability at least in a set composed by four or five techniques;
- Strategical capability: to manage a competition is necessary to have a general vision of what is going on, on the weakness of the opponent and on how it is possible to bring the opponent in a favourable position or situation;
- Psychological aspects: this final component of the overall performance of the athletes is hard to be analysed but it is as important as the others in a competition.

In this paper, the authors want to present three different techniques for facing the first sub-problem: the physical skills of a athlete in a combat sport. These three techniques will be explained and then applied to some high level Judo athletes. Finally the results of these techniques will be compared in terms of ranking.

The paper is structured as: in the next section, a general description of the problem related with the analysis of the physical performance in combat sport will be presented and an innovative procedure will be introduced. In the third section, the data used for testing the methods will be presented, while in the fourth section the data analysis process will be described in detail. This description will focus on the normalization of data, on the undesired bias present in the data and finally the three different methods will be applied to the data presented in Section III and then they will be compared.

II. Physical Performance Analysis in Combat Sports

Analysing performances in sports generally requires two steps:

Fig. 1 Division of performance analysis in combat sports and especially in Judo

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- Identification of the figure of merit: it is generally quite obvious but this step is really important. The figure of merit in a sport is the quantity that quantifies the performance. In running it is the required time to tread the distance;
- Identification of a measurement techniques: also in this case it is quite trivial for many sports, but while dealing with combat sport this task becomes a big problem because the measurements of the performance can affect the performance itself or it could be impossible.

These two steps are quite hard to be identified in combat sport like Judo. For example, taking a simple Judo technique like *O Soto Gari*, a quite common throw, it is hard to find a figure of merit: in fact it involves how the athlete moves all this body. Moreover, different athletes can perform the techniques in different ways but in any case they can be effective [4]. A solution of this problem has been proposed in [5], where the authors develop and analyze [6] a test called Special Judo Fitness Test (SJFT). This test consists in three period in which the athlete should perform as many times as he can the *ippon-seoi-nage* technique with two different opponents.

The figures of merit in this test are two: the number of techniques done and an index related to the heart rate.

Doing some tests with SJFT, we have identified some problems:

- The number of techniques performed is almost the same for all the athletes, so one of the two figure of merits looses most of its meaningfulness;
- The heart rate index is influenced more by the training done before the test than the test itself. If we repeat the same test in two different days with the same athletes, the results are completely different.

Having understood that the traditional techniques are quite useless, a different way has been adopted. The physical performances of the athletes are measured by means of standard test on simple sport and than correlated with an index that is representative of the overall physical condition of the athlete.

The activities used to measure the performance are:

- Shoulder press: is a weight training exercise that consists in pressing a weight straight upwards from the shoulders until the arms are locked out overhead [3];
- Bench press: consists of pressing a weight upward from a supine position;
- Dip: the athlete has to lift his body keeping his hands on a dip bar;
- Crunch: is an abdominal exercise;
- Shooting;
- Basket;
- Jumping;
- Jumping with forward rotation;
- Jumping with backward rotation;
- Running (30 m);
- Running (400 m);
- Uchi Komi: it consists of repeating the same techniques many times;
- Shot put;
- High jump, keeping the feet together;
- Dribble.

For all these activities, it is easily possible to find a figure of merit and a way to measure it. After a proper normalization of these data it is possible to get some indexes that are here called *performance coefficients* (PC).

In Section III the data collected will be shown and in Section IV.A they will be normalized.

To relate the data obtained in the way described with some indexes of general physical performance, it is possible to apply a transformation from the performance coefficients to some other indexes that are here called *physical aspects* (PA). These are [2]:

- Force is the capability to lift or to move a high weight object;
- Speed is the capability to perform an action as fast as possible;
- Resistance to force is the capability to sustain an high force for long time;
- Resistance to speed is the capability to perform a long action at the highest speed;
- Reaction rate is the capability to react to a stimulus;
- Equilibrium;
- Space-time orientation is the capability to be aware of the position of the body with respect to the surrounding ambient;
- Motor differentiation capability is the capability to adapt the body movement to the situations;
- Motor rhythmic capability is the capability to give a rhythm to the movements;
- Motor combination capability is the capability to combine more technical elements in a single action.

All these physical aspects can be related with the performance coefficients by a proper matrix relation:

$$\underline{PA} = [C] \cdot \underline{PC} \tag{1}$$

where $\underline{PA}$ is the vector containing the physical aspects, $\underline{PC}$ is the vector containing the performance coefficients and $[C]$ is a correlation matrix.

Two different correlation matrices have been tested: a Boolean matrix (Section IV.C) and a Fuzzy matrix (Section IV.D).

III. Testing Data

The testing data available are the data of the performance on the activities described in Section II related to 22 high level Judo athletes.

The original data are shown in Table I. Some cells of the table are empty because the athlete did not perform that test. This is not a problem because that data will not affect all the others.

The *weight class* of an athlete is the division that is done in competitions accordingly to the weight.

TABLE I
DATA OF PERFORMANCES OF 22 HIGH LEVEL JUDO ATHLETES. THE ACTIVITIES ARE: SHOULDER PRESS (A-1), BENCH PRESS (A-2), DIP (A-3), CRUNCH (A-4), SHOOTING (A-5), BASKET (A-6), JUMPING (A-7), JUMPING WITH FORWARD ROTATION (A-8), JUMPING WITH BACKWARD ROTATION (A-9), RUNNING 30 M (A-10), RUNNING 400M (A-11), UCHI KOMI (A-12), SHOT PUT WITH RIGHT HAND (A-13), SHOT PUT WITH LEFT HAND (A-14), HIGH JUMP (A-15), DRIBBLE (A-16)

Weight class	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16
60	75	105	22	215	57		280	246	155	4,35	59	80	7,8	10,7	125	59
60	75	90	15	173	63	28	252	216	135	4,80	66	76	9,2	7,1	105	15
60	85	120	20	170	70	22	257	210	130	4,43	66	79	10,6	7,9	125	7
66	75	120	41	205	61		265	224	130	4,21	59	88	8,8	6,8	115	6
66	90	105	18	210	79	4	274	246	174	4,31	58	75	10,2	8,6	115	14
73	95	110	22	180	63	32	280	245	178	4,39	60	78	10,7	8,6	125	27
73	90	125	23	215		29	244	238	151			84	10,3	8,2		17
73	75	115	23	223	90	9	260	223	130			85	8,4	10,1		5
81		125	32		82	30	250	224	161	4,56	63	72	10,6	8,8		11
81	105	120	19	206	93	17	260	219	180	4,48	66	82	11,1	9,9	125	16
81	103	120	20	165	62	13	262	220	165	4,51	60	71	11,9	10,4	125	18
90	110	140	35	200		25	286	238	187	4,34	58	93	12,6	9,9	125	61
90	115	155				28	290	237	171	4,46		117	11,9	9,8	110	
90	110	135	24		58	18	250	223	155	4,45	60	101	10,8	8,1	125	12
100		130	28	210		28	280	250	178	4,20	59		13,1	8,8	125	25
100	100	110	19	215	36	13	229	241	120	4,76	69	101	9,2	11,9	105	9
100	110	170	50	210	15	19						85	11,4	9,6		18
>100	120	150	30	170	93		273	240	167	4,60	76	106	15,5	13,0	125	6
>100	110	135	42	210	58		245	225	153	4,53	66	93	13,5	10,6	125	8
>100	120	150	43	190			247			4,62	71	119	9,8	12,0	105	9
>100				145	32	23	210	185	124	5,08	73	106	12,1	9,9		6
>100		140		210		23	223			5,23	80	110	12,1	8,4	110	6

IV. DATA ANALYSIS

The raw data collected are not directly useful for the performance analysis because they are related to different unit of measures. Moreover there are some differences of performance that are only related to the weight class of the athletes. These differences, if not managed, bias the comparison of the results of the analysis.

A. Normalization of Data

As described before, the first activity that should be done is a proper normalization of the data.

Firstly all the data have to be set in such way that the higher value obtained, the better is the performance. To do so, the data related to the time needed is running and performing the *uchi komi*.

The easiest normalization is to scale all the data between 0 and 1. The results of the normalization are the coefficients of performance (PC). These coefficients will be modified in Section IV.B in order to avoid the undesired trends.

Given the value obtained by an athlete (indicated by the letter *D*) in an activity (*A*) the coefficient of performance (PC) is obtained as:

$$PC = \frac{D}{1.1 \cdot \max_A D_i} \tag{2}$$

where $\max_A D_i$ is the maximum score obtained for the activity A by all the athletes.

The performance coefficients obtained in this way are shown in Table II.

B. Analysis of Biased Trends

It is important to analyze the trends that can be related to the weight class. This is important when comparing the data of athletes of different classes: they have totally different physical characteristics and so this is reflected in the performance. This is not desired because when an athlete does a competition, his opponents will have the same weight class.

To analyze the trends, an average class performance coefficient for each activity has been evaluated doing the mathematical average between the coefficients of performance in that activity of all the athletes of the weight class. Having calculated this average performance coefficient, it is possible to plot them. The plot is shown in Fig. 2.

It is possible to get the slope of the interpolating lines shown in Fig. 2. These values are the trends and they are shown in Table III.

Positive values mean that higher weight classes gets better results, while negative values have the opposite meaning.

The absolute value of the trend represents how much this trend is. Higher values mean that the trend is highly significant while values closer to zero represent a quasi-null trend.

Having calculated the trends, it is possible to perform another normalization of the data in order to eliminate these trends.

The normalization used is:

$$CP' = CP - (T \cdot W) \tag{3}$$

where T is the trend and W is the weight class. After this operation the data have been scaled in order to be again between 0 and 1.

C. Method 1: Performance Coefficients

The first method to analyze the data normalized as shown in the previous subsection is to take the performance coefficients so extracted and to make an average. In this way, for each athlete there is a number that represents his performance. This method is much faster then the others. On the other hand, it

TABLE II
COEFFICIENTS OF PERFORMANCE (PC) OBTAINED BY THE NORMALIZATION OF THE DATA. THE ACTIVITIES ARE: SHOULDER PRESS (A-1), BENCH PRESS (A-2), DIP (A-3), CRUNCH (A-4), SHOOTING (A-5), BASKET (A-6), JUMPING (A-7), JUMPING WITH FORWARD ROTATION (A-8), JUMPING WITH BACKWARD ROTATION (A-9), RUNNING 30 M (A-10), RUNNING 400M (A-11), UCHI KOMI (A-12), SHOT PUT WITH RIGHT HAND (A-13), SHOT PUT WITH LEFT HAND (A-14), HIGH JUMP (A-15), DRIBBLE (A-16)

Weight class	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16
60	57%	56%	40%	88%	56%		88%	89%	75%	88%	89%	61%	91%	75%	91%	88%
60	57%	48%	27%	71%	62%	80%	79%	79%	66%	80%	80%	58%	77%	50%	76%	22%
60	64%	64%	36%	69%	68%	63%	81%	76%	63%	86%	80%	60%	67%	55%	91%	10%
66	57%	64%	75%	84%	60%		83%	81%	63%	91%	89%	67%	81%	48%	84%	9%
66	68%	56%	33%	86%	77%	11%	86%	89%	85%	89%	91%	57%	70%	60%	84%	21%
73	72%	59%	40%	73%	62%	91%	88%	89%	87%	87%	88%	60%	66%	60%	91%	40%
73	68%	67%	42%	88%		82%	76%	87%	73%			64%	69%	57%		25%
73	57%	61%	42%	91%	88%	26%	82%	81%	63%			65%	84%	71%		7%
81		67%	58%		80%	85%	78%	81%	78%	84%	84%	55%	67%	62%		16%
81	80%	64%	35%	84%	91%	48%	82%	80%	88%	85%	80%	63%	64%	69%	91%	24%
81	78%	64%	36%	67%	61%	37%	82%	80%	80%	85%	88%	54%	60%	73%	91%	27%
90	83%	75%	64%	82%		71%	90%	87%	91%	88%	91%	71%	56%	69%	91%	91%
90	87%	83%				80%	91%	86%	83%	86%		89%	60%	69%	80%	
90	83%	72%	44%		57%	51%	78%	81%	75%	86%	88%	77%	66%	57%	91%	18%
100		70%	51%	86%		80%	88%	91%	87%	91%	89%		54%	62%	91%	37%
100	76%	59%	35%	88%	35%	37%	72%	88%	58%	80%	76%	77%	77%	83%	76%	13%
100	83%	91%	91%	86%	15%	54%						65%	62%	67%		27%
>100	91%	80%	55%	69%	91%		86%	87%	81%	83%	69%	81%	46%	91%	91%	9%
>100	83%	72%	76%	86%	57%		77%	82%	74%	84%	80%	71%	53%	74%	91%	12%
>100	91%	80%	78%	77%			77%			83%	74%	91%	72%	84%	76%	13%
>100				59%	31%	65%	66%	67%	60%	75%	72%	81%	59%	69%		9%
>100		75%		86%		65%	70%			73%	66%	84%	59%	59%	80%	9%

TABLE III
COEFFICIENTS OF PERFORMANCE (PC) OBTAINED BY THE NORMALIZATION OF THE DATA

Activity	trend
Shoulder press	0.4990
Bench press	0.3631
Dip	0.4941
Crunch	-0.0264
Shooting	-0.3848
Basket	0.2840
Jumping	-0.1174
Jumping fw rotation	-0.0269
Jumping bw rotation	0.0267
Running 30m	-0.1026
runnin 400m	-0.2046
Uchi komi	-0.3819
Shot put (L)	0.3344
Shot put (R)	0.3066
High jump	-0.0426
Dribble	-0.1943

has some important limitations. The most evident is that is not possible to get information regarding the capability of the athlete in a particular aspect of his physical performance. This means that if an athlete is really good in activities in which is important the force and is weak in activities in which is important the speed, this data cannot be found. To fix this limitation the following two methods have been developed.

D. Method 2: Boolean Correlation with Physical Aspects

As said before, it can be useful to have a deeper understanding of the performance of athletes, more than what the method previously proposed can give. To have these information is needed another manipulation of the data, through a correlation matrix. This matrix has as many rows as the physical aspect (PA) are, and as many columns as many activities have been performed. In each cell (i, j) there is a Boolean value that represents if the physical aspect i is present in the activity j.

Doing the matricidal product between the correlation matrix and the matrix of activities is possible to get a new matrix. In this matrix there are the values of the physical aspect indexes for each athlete. This overcomes the problem of missing information seen before. Moreover, it lets much more freedom in the choice of the activities: changing one of them implicates only adding a column in the correlation matrix, but the output of the procedure is always a matrix with the same size.

For the test case analyzed, the Boolean correlation matrix is represented in Table IV.

With this technique, it is also possible to get one score for each athlete, doing the average of all the values obtained by the athlete in each physical aspect. The limit of this technique is that a Boolean correlation can be ineffective when an activity is characterized mostly by a physical aspect and only for few percentage by another aspect. To face this problem, the third method has been developed.

E. Method 3: Fuzzy Correlation with Physical Aspects

The easiest way to face with the problem of differentiating the contributions of the physical aspects in an activity is to change the correlation matrix. In fact, using numbers between zero and 1 instead of Boolean values, it is possible to add the required information in the correlation matrix. This implies to use a Fuzzy logic in the choice of the values, but the procedure to find the indexed for the physical aspects and eventually to find a score for the athlete is the same seen in the previous method. The correlation matrix used in this test case is shown in Table V.

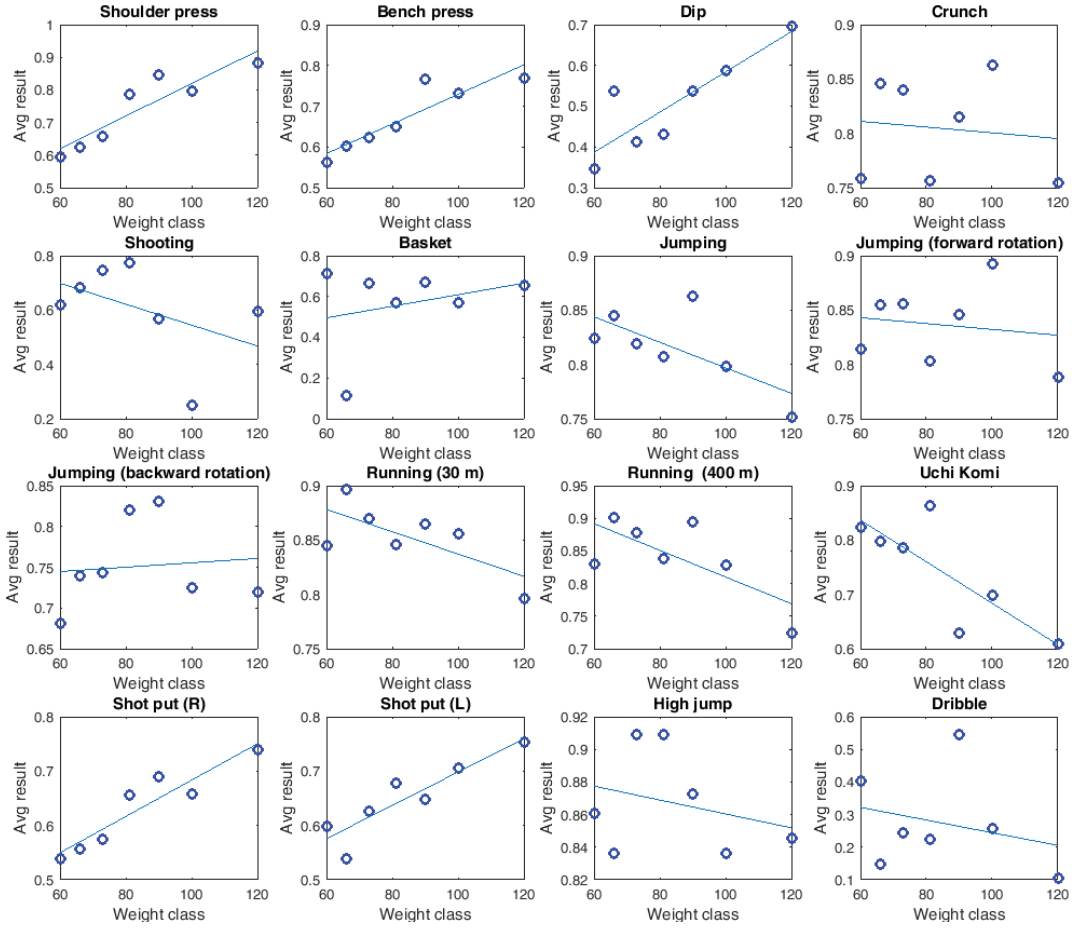

Fig. 2 Average coefficient of performance for each weight class for each activity. The line represnt the best interpolating line

F. Comparison between Methods

It is easily possible to compare the three methods seen, comparing the different score obtained by each athlete. The data are shown in Table VI and in Fig. 3.

It is possible to see both in Table VI and in Fig. 3 that the differences in the scores can be associated to two different aspects: an offset of the global score of the athletes and a change in the evaluation of an athlete with respect to another. Both these two changes can have an importance, but the second type of change is much more important.

In fact, a vertical shift of the data can be important if the data are not related only to a single time frame, but are related to different times. This can be an indicator of the efficiency of the training. The change of the ranking of the athletes derived from the changes of the relative coefficient of performances is much more important because the ranking is used by trainers to decide which athlete will participate to competitions and which not.

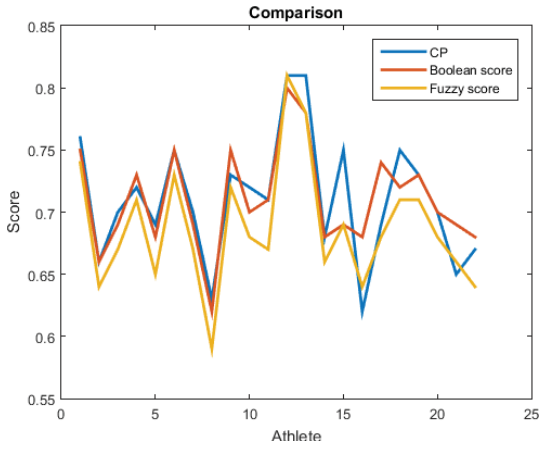

Fig. 3 Comparison between the three different methods explained

V. Conclusion

In this paper, three different methodologies for evaluating physical performances in combat sports and in particular in Judo have been shown. These techniques have different implementations and can give different results in terms of amount of information and in quality of information.

The first method seen, the average of the performance coefficients, is simple, but do not give to the trainer any information regarding the physical aspects in which the athlete has his strongess and his weakness. On the other hand the other

TABLE IV
BOOLEAN CORRELATION MATRIX. THE ACTIVITIES ARE: SHOULDER PRESS (A-1), BENCH PRESS (A-2), DIP (A-3), CRUNCH (A-4), SHOOTING (A-5), BASKET (A-6), JUMPING (A-7), JUMPING WITH FORWARD ROTATION (A-8), JUMPING WITH BACKWARD ROTATION (A-9), RUNNING 30 M (A-10), RUNNING 400M (A-11), UCHI KOMI (A-12), SHOT PUT WITH RIGHT HAND (A-13), SHOT PUT WITH LEFT HAND (A-14), HIGH JUMP (A-15), DRIBBLE (A-16)

PA / activity	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16
Force	1	1	1	1	0	0	1	1	1	0	1	1	1	1	1	0
Speed	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	0
Resistance to force	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Resistance to speed	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Reaction rate	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Equilibrium	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Space-time orientation	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0
Motor differentiation	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1
Motor rhythmic	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
Motor combination	1	0	1	0	0	1	1	1	1	0	0	1	1	1	1	1

TABLE V
FUZZY CORRELATION MATRIX. THE ACTIVITIES ARE: SHOULDER PRESS (A-1), BENCH PRESS (A-2), DIP (A-3), CRUNCH (A-4), SHOOTING (A-5), BASKET (A-6), JUMPING (A-7), JUMPING WITH FORWARD ROTATION (A-8), JUMPING WITH BACKWARD ROTATION (A-9), RUNNING 30 M (A-10), RUNNING 400M (A-11), UCHI KOMI (A-12), SHOT PUT WITH RIGHT HAND (A-13), SHOT PUT WITH LEFT HAND (A-14), HIGH JUMP (A-15), DRIBBLE (A-16)

PA / Activity	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15	A-16
Force	0,7	0,9	0,4	1	0	0	0,5	0,3	0,3	0	0,2	0,2	0,7	0,7	0,6	0
Speed	0	0	0	0	0	0	0,4	0,4	0,3	0,5	0,2	0	0,2	0,2	0,3	0
Resistance to force	0	0	0,4	0	0	0	0	0	0	0	0	0,2	0	0	0	0
Resistance to speed	0	0	0	0	0	0	0	0	0	0	0,6	0,2	0	0	0	0
Reaction rate	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0
Equilibrium	0,2	0,1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Space-time orientation	0	0	0	0	0	0,5	0	0,2	0,3	0	0	0,1	0	0	0	0
Motor differentiation capability	0	0	0	0	0,7	0,2	0	0	0	0	0	0,1	0	0	0	0,3
Motor rhythmic capability	0	0	0,1	0	0	0	0	0	0	0	0	0,1	0	0	0	0,4
Motor combination capability	0,1	0	0,1	0	0,3	0,3	0,1	0,1	0,1	0	0	0,1	0,1	0,1	0,1	0,3

TABLE VI
COMPARISON BETWEEN THE THREE DIFFERENT METHODS EXPLAINED

Weight class	CP	Boolean score	Fuzzy score
60	76%	75%	74%
60	66%	66%	64%
60	70%	69%	67%
66	72%	73%	71%
66	69%	68%	65%
73	75%	75%	73%
73	70%	69%	67%
73	63%	62%	59%
81	73%	75%	72%
81	72%	70%	68%
81	71%	71%	67%
90	81%	80%	81%
90	81%	78%	78%
90	68%	68%	66%
100	75%	69%	69%
100	62%	68%	64%
100	69%	74%	68%
> 100	75%	72%	71%
> 100	73%	73%	71%
> 100	70%	70%	68%
> 100	65%	69%	66%
> 100	67%	68%	64%

TABLE VII
COMPARISON BETWEEN THE THREE DIFFERENT METHODS IN TERMS OF POSITION IN A LOCAL RANKING OF THE ATHLETES

Weight class	CP	Boolean score	Fuzzy score
60	3	3	3
60	19	21	19
60	12	14	13
66	9	8	6
66	15	17	18
73	4	3	4
73	12	14	13
73	21	22	22
81	7	3	5
81	9	12	10
81	11	11	13
90	1	1	1
90	1	2	2
90	17	17	16
100	4	14	9
100	22	17	19
100	15	7	10
> 100	4	10	6
> 100	7	8	6
> 100	12	12	10
> 100	20	14	16
> 100	18	17	19

two methods can give these information.

The local rankings obtained from the three techniques are different.

In the future, these rankings will be compared with the international ranking of the athletes, in order to give a validation to one of these three techniques.

REFERENCES

[1] Stefano Frassinelli and Alessandro Niccolai and Tullio Marzi and Mohammadreza Aghaei and Marco Mussetta and Riccardo Zich, *Event-based measurement of power in sport activities by means of distributed wireless sensors*, International Conference on Event-based Control, Communication, and Signal Processing (EBCCSP), 2015.

[2] Stefano Frassinelli and Riccardo Zich, *Identification of the relationship between the aspect psychomotor and effectiveness of performance in judo athletes with a fuzzy system*, XXXI URSI General Assembly, 2014.

[3] Kalb JS , Hunter GR, *Weight training economy as a function of intensity of the squat and overhead press exercise*, Weight training economy as a function of intensity of the squat and overhead press exercise, 1991.
[4] Peter Clarys and Amelie Rosseneu and Dirk Aerenhouts and Ewert Zinzen, *Energy expenditure and intake in judo athletes during training campe*, Journal of Combat Sports and Martial Arts, 2011.
[5] Franchini, Emerson and Vecchio, Fabricio Boscolo Del and Sterkowicz, Stanislaw, *A special judo fitness test classificatory table*, Archived of Budo, p.127 -129, 2009.
[6] Emerson Franchini and Stanislaw Sterkowicz and Urszula Szmatlan-Gabrys and Tomasz Gabrys and Michal Garnys, *Energy System Contributions to the Special Judo Fitness Test*, International Journal of Sports Physiology and Performance, 2011.