

## Performance measurement in Judo: main KPIs, cluster categorization and causal relationships

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**Abstract:** Performance measurement in Judo usually focuses on some KPIs whose values indicate the final performance of the athlete. This paper deals with firstly identifying which these main Key Performance Indicators (KPIs) in Judo are. Once this is done, the KPIs are classified into four different clusters: Physical training, Specific training, Psychology and Lifestyle. Then, it moves into analyzing possible quantitative techniques to identify cause-effect relationships between KPIs in order to link not only the impact of the Judo KPIs with the achievement of the judoka's strategic objectives but also to identify both the relative and the global importance of each of these KPIs. Finally, it points out the Analytic Network Technique as the one that could be ideally applied in this context and offers future research actions.

**Key words:** Judo, KPIs, performance measurement, causal relationships, ANP.

### 1. Introduction

Performance measurement is widely applied within industry in order to provide decision-makers with information about the situation of some specific important variables, Key Performance Indicators (KPIs), which will mainly lead to check whether the target value (usually a range value) associated to these KPIs is being reached or not. Widening the approach, performance measurement has been also applied to service organisations such as hospitals, tourism, governments, etc. In many of these cases, performance measurement has gone a step further, forming a structure of not only KPIs but also strategic objectives, where the achievement of the latter is linked to the real values measured by the former. Such an evolved structure represents the so-called Performance Measurement Systems (PMS) (Folan and Browne, 2005). However, the existence of these

PMS does not imply that there are still organisations that use only KPIs to manage their performance. This fact is more frequent in sport organisations, as they rely only on the KPIs not only to control the evolution of achieved values but also to make more strategic decisions. These organisations, from a performance measurement viewpoint, count with lots of measures of their KPIs overtime and they rely on making their decisions on these historic values.

This research focuses on performance measurement applied to sport management and, more concretely, to Judo. The main goal is to highlight the main KPIs associated to Judo, categorizing and grouping them into clusters for finally presenting an approach via multi-criteria techniques to link these KPIs with the defined strategic objectives, quantifying and ranking the importance of the KPIs and of the clusters to achieve the strategic objectives.

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Then, this paper tackles this line of research, and it is structured as follows: Section 2 presents a literature review on the main KPIs for Judo performance; in Section 3 these KPIs are classified into clusters; Section 4 offers a classification of different quantitative techniques that could be applied to identify cause-effect relationships between the KPIs and the objectives of the judokas. Finally, Section 5 presents the main conclusions and future research work are highlighted.

## 2. Literature review

In the scientific literature, it is possible to find multitude of KPIs used to measure performance in sport. Bringing the discussion to the Judo field, there is a crescent trend to publish in academic journals. Then, Peset et al. (2013) carried out a bibliometric analysis whose main findings were that there were 383 papers and scientific reviews published in both the Science Citation Index and the Social Science Citation Index during the time period of 1950 and 2011. These papers were published in 162 different journals, in 78 categories of the Web of Science and the publication of Judo papers was mainly reduced to journals mainly referred to do with both sport science and sport medicine. Alike other sport disciplines, Judo is starting to gain a position within the scientific literature, constituting an interesting potential growing field.

From these conclusions, it is possible to affirm that, regarding Judo and its scientific position, the application of techniques/approaches of other disciplines would lead to advances and interesting applications.

Next, this research provides a resume of the main KPIs found and their area of application regarding Judo scientific literature:

- Coordination. Perrin et al. (2002) identified coordination as a key variable for performance in Judo, stating that the training and improvement in coordination will lead to develop sensorimotor adaptabilities, as revealed their experiments with postural skills of elite jodoist.
- Strength. Hassmann et al. (2010) mentions strength as the most important variable to train and improve, as it concludes from their experiments with several Olympic Judo athletes. In this sense, Ache-Dias et al. (2012) compares the handgrip strength performance between judokas and non-judokas, discovering that judokas were not stronger than non-judokas but they had a higher level of resistance to fatigue.
- Speed. Almansba et al. (2008) categorises the importance of the speed in Judo through a comparative study of speed consisting in the number of throws between lighter and heavier Judo categories.
- Heart rate. Thun et al. (2015) carried out a study to determine how circadian rhythms and sleep affect to performance, concluding that the time of the day affects greatly to the desynchronisation of circadian rhythms. On the other hand, Houvenaeghel et al. (2005) observed different heart rates during training of judokas to establish whether low rate levels were associated only with low intensity exercises trying to identify if the different heart rates were due either to a good physical condition or a bad execution.
- Aerobic and anaerobic fitness. Franchini et al. (2014) assessed the effect of high-intensity intermittent training to improve judo-training results.
- Technical and tactic preparation. Bocioaca (2014) demonstrated that the optimization of the technical training lead to the basis for the tactical preparation, which paves the way for preparing Judo medium-long term training planning. In this sense, Franchini et al. (2015) carried out a complete revision relating both technique and tactic in Judo.
- Age. Franchini et al. (2012) carried out a study to compare the motion-time performance of judo fighters with different ages.
- Weight. Escobar-Molina et al. (2016) highlighted the weight as one of the main differential factors in Judo, fostering loss weight to compete in a lower category as a competitive advantage. However, Calvo Rico et al. (2018) alerts against extreme weight losing.
- Focus and concentration level. Grosu et al. (2014) evaluated the role of the cognitive process of attention for judo and alpine ski athletes, concluding that there is a relationship between both focused and the perception of attention.
- Stress. Arnold et al. (2018) studied the competitive stress process. They concluded that social support moderates the relationship between organizational stressing elements and subjective performance.

- Motivation. Gillet et al. (2010) explored the role of the coaches and the effect on athletes' motivation.
- Activation level. Cohen-Zada et al. (2017) studied the psychological momentum of different judo athletes by gender. They concluded that men Judo fighters' performance is influenced in a higher degree by the psychological momentum than women Judo fighters.
- Nutrition. The focus here is to evaluate nutritional supplements and their effect on performance. Then, Ramezani et al. (2019) carried out a systematic review to assess the effect of glutamine supplementation on athletes' performance. On the other hand, Sousa et al. (2016) assessed whether using nutritional supplements has to do with nutritional inadequacy coming from food. Finally, Hung et al. (2010) assessed the effect of supplementation of B-hydroxy and B-methylbutyrate (HMB) on reducing body fat during energy restriction in female Judo fighters. They found that HMB during energy restriction may help to decrease body fat, having no relevant effect on lean body mass or performance in female Judo athletes.
- Dual career. Muñoz-Bullón et al. (2017) studied the effect of sports participation on high education academic performance, finding a direct and positive relationship.
- Sleep. Knowles et al. (2018) studied the effect of inadequate sleep on resistance training, concluding that there is a direct and negative relationship between them. On the other hand, Rosenbloom and Grossman (2018) affirmed that to take short naps in any scenario would have a positive impact on performance.

### 3. Cluster aggregation

Once the main KPIs that affect performance in Judo found in the scientific literature have been previously highlighted, it is time to classify them into common groups or clusters. This will facilitate a posterior application of multi-criteria techniques and, more concretely, of the Analytic Network Process. This will be further developed in the next point of the paper.

Then, Table 1 presents both the formed clusters and the KPIs that constitute each of them.

**Table 1.** Clusters formed with the main KPIs.

Cluster	KPI
Physical training	Coordination
	Strength
	Speed
	Heart rate
Specific training	Aerobic and anaerobic fitness
	Technical and tactic preparation
Psychology	Age
	Weight
	Focus and concentration level
	Stress
Lifestyle	Motivation
	Activation level
	Nutrition
	Dual career
	Sleep

Then, we propose 4 clusters: Physical training, specific training, psychology and lifestyle. These 4 clusters have been built based on not only on the extensive international experience in Judo of 2 of the authors (having participated in the Olympic Games and being European Champion) but also on the main characteristics of the KPIs.

Each of these clusters is constituted by, at least, 3 KPIs found to be important regarding Judo performance. The next question is: Are there KPIs from all these to be more important than others regarding performance? It is obvious that the answer to this question is yes. Then, the next work to develop is to find out which ones are more important and under what circumstances.

In this sense, it is necessary to consider these KPIs not only individually but also globally. This is due to the fact that it is reasonable to expect that exist relationships between and among these KPIs, which should be taken into account, as the improvement of one of these KPIs will surely affect to other/s KPIs. For example, it could be expected that the improvement of a lifestyle KPI such as Sleep or Nutrition will have a positive impact on the judoka's performance. Then, it would be interesting to apply some sort of technique to establish such KPIs relationships.

Additionally, it is possible to think of a further scenario in which, besides finding relationships between and among KPIs, it is possible to quantify the impact that has got each one of these on the athlete strategic performance, understood the latter as the specific formulation of objectives such as to

become national champion, to win the classification for the Olympic Games etc.

This approach would offer a ranked list of the KPIs, from a higher to a lower relative importance regarding their impact on achieving the defined objectives. Such a list would constitute an additional information for Judo fighters, who would know what factors (KPIs) they should potentiate first in order to achieve their specific objectives.

Then, the next section presents some quantitative techniques that could be used to identify cause-effect relationships.

#### 4. Quantitative techniques to identify causal relationships

There are many technique that could be applied to both identify and quantify causal relationships between and among KPIs and the defined strategic objectives. Table 2 highlights some of these techniques, classifying them according to the data they use (historical or based on experience), the type of the relationships found between the variables (dyadic or multiple) and the capacity of finding interrelationships between and among the variables.

As it can be seen in Table 2, there are many techniques candidates to be applied to solve this problem however the authors recommend a multi-criteria approach, as these techniques offer the possibility of not using historical data. This is of great importance as the Judokas can obtain historical data for each one of the KPIs mentioned previously, but some problems arise when trying to correlate them with the evolution of the performance objectives defined. In this sense, KPIs in Judo usually gather data with a daily frequency; i.e. times in successive running series, weight lifted, weight of the athlete, etc. On the other hand, the frequency of the strategic objectives is yearly (become national champion) or even wider (4 years: Participate in Olympic Games). This make

necessary to aggregate the data from the Judo KPIs to the yearly frequency before to carry out the correlation process, which augments the difficulty of the process. In addition, it will be necessary to carefully assess the correlation results to avoid interpretation mistakes; for example, if it results that Speed turns out to be the most important KPI for the objective of Participate in the Olympic Games the decision-makers (coaches, athlete) will need to decide what it the relation of Speed with the others Judo KPIs and their reciprocal relative importance to achieve all the objectives.

Then, the multi-criteria Analytic Network Process (Saaty, 1996) offers the possibility of carrying out all these operations at once. The main limitation of ANP when compared with statistical techniques in our context is that it is based on subjective comparisons carried out by an expert group. On the other hand, correlation analysis takes into account only historic data, being therefore an objective technique.

As stated above, the application of ANP would provide results to identify and quantify to what extent the different Judo KPIs are contributing to achieve defined strategic objectives. The ANP is a technique that, depending on the size of its components, it may turn to be of quite high complexity. In the context of this problem, ANP should be used indicating which the inputs or clusters of Judo KPIs are and which the alternatives or performance strategic objectives are. Then, the model of the problem as an ANP network should include the next elements:

- Inputs. The four clusters of Judo KPIs above presented. Physical training, specific training, Psychology and Lifestyle.
- Alternatives. The strategic objectives of the judokas.

It is important to keep in mind that this problem is unidirectional, from the inputs to the alternatives. In other words, we aim to quantify the relationships from the inputs (at both the clusters and the KPIs

**Table 2.** Clusters formed with the main KPIs.

Technique/s	Data	Type of relationships	Interrelationships
Correlation analysis	Historical data (from KPIs)	Dyadic	Not captured
Partial Least Squares	Historical data (from KPIs)	Multiple	Captured
Factorial Analysis	Historical data (from KPIs)	Multiple	Captured
Principal Component Analysis	Historical data (from KPIs)	Multiple	Captured
Structural Equation Modeling	Historical data (from KPIs)	Multiple	Captured
Analytic Hierarchical Process	Based on experience/subjective judgement	Pairs	Not captured
Analytic Network Process	Based on experience/subjective judgement	Pairs	Captured

levels) to the alternatives. Then, the first step is to define the relationships matrix, which relates the direct relationships between all the different variables. When such a relationship exists, the intersection cell between the two variables will get a 1 value, otherwise it will get a 0 value. Once this has been done the next steps are:

- The expert group carries out the comparisons between nodes and clusters.
- To compute the unweighted, weight and limit matrices.
- To interpret the obtained results.

## 5. Conclusions and future research work

This paper has presented which the main KPIs for measuring Judo performance are. Then, these KPIs have been grouped into four clusters: Physical training, Specific training, Psychology and Lifestyle. Next, it has pointed out the problematic of obtaining the relative importance of these KPIs and clusters when measuring their importance in achieving strategic objectives of the judokas. Then, different techniques that could be applied to solve this matter have been presented and classified, recommending the usage of the ANP technique as the tool to solve this problematic. At this point, the next research work should start completing all the necessary ANP steps, obtaining then results to identify which the main Judo KPIs that affect performance are.

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