International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 01-04

Selection and assessment of Multi-criteria decision-analysis techniques to quantify elite judo Key Performance Indicators relationships

SugoiUriarte Marcos[1], Raúl Rodríguez-Rodríguez[2*], Juan-José Alfaro-Saiz[3], Maier Uriarte Marcos[4]

[1] *Doctorate School, UniversitatPolitècnica de València, Valencia, Spain*
[2*,3] *Research Center on Production Management and Engineering. UniversitatPolitècnica de València, Valencia, Spain*
[4] *Faculty of Psychology and Education, University of Deusto, Bilbao, Spain*

Abstract: Judo is a complex sport where many key performance indicators from different ambits (tactic, technique, psychological, etc) impact over the final result of the combat. Then, in order to design optimal training plans for the athletes, decision-makers should carefully analyse the KPI not individually but globally, identifying and quantifying cause-effect relationships between them, being therefore able to align efforts and prioritise medium-long-term actions. In order to do this, and taking into account the difficulty of using statistical techniques because of not only the lack of historic data of the KPI but also due to the subjective nature of many of them, the multi-criteria decision analysis (MCDA) techniques come up as the most appropriate ones. There are many MCDA techniques that could be applied to solve this problem and then this research presents a three-step process to select and assess the most appropriate MCDA techniques using a recent framework. The process outcome nine MCDA techniques appropriate to solve the decision-making problem, being the Analytic Network Process the highest ranked and, therefore, the recommended to be used.

Keywords: Multi-criteria decision analysis techniques, KPI, decision-making, judo

1. Introduction

The multi-criteria decision analysis (MCDA) techniques have been widely used in several knowledge fields in the last years. MCDA techniques can be applied to provide valuable additional information to decision-makers to solve their problems. Further, it is possible to affirm that the application of MCDA techniques leads to improve the decision-making process, as they are able to handle many conflicting goals and variables at the same time, ranking these goals and variables according to their relative importance within the decision problem (Mardani et al., 2015). In this sense, the MCDA techniques are specially indicated for problems whose variables are intangible ones and no historical data is available and even when such data is, to some extent, inaccurate. Then, many MCDA techniques have been developed and are available for decision-makers, who must decide which are the most adequate ones to solve their decision-making problem, existing several key factors to take into account such as the uncertainty levels, risk factors or nature of both the variables and the criteria (Ishizaka and Nemery, 2013).

Therefore, the first task is to define the decision-making problem in its context. In this research we focus on sport management and, more concretively, in elite judo. Judo is a complex sport where many heterogeneous variables or key performance indicators (KPI) play a key role and influence to the final result of the combat (Franchini et al., 2019). Examples of these KPI are: strength, speed, basic technique, age, stress level, motivation level, lifestyle or nutrition (Uriarte Marcos et al., 2019).Therefore, the establishment of a ranking of these KPI should be carried out in a subjective way, as there is not data available to correlate such a set of heterogeneous variables, being the MCDA techniques appropriate to this end. Further, in order to be able not only to design optimal training plans for the athletes but also to define realistic and achievable objectives, decision-makers (usually the trainers) should carefully analyse the KPI that affect performance. Further, such an analysis should be carried out from a global point of view, identifying cause-effect relationships between the KPI, being therefore able to align efforts and prioritise medium-long-term actions. Then, the next step would be

to select, applying some specific framework, the most adequate MCDA techniques to solve the problem. Finally, decision-makers should assess these selected MCDA techniques, providing a ranking. These steps are further developed in the next point.

Hence, this research aims to present a process to identify and classify feasible MCDA techniques to quantify existing relationships between elite judo KPI to improve not only decision-making processes but alsoathletes' performance.

2. MCDA techniques selection and assessment

Figure 1 resumes the steps previously introduced for selecting the most appropriate MCDA technique.

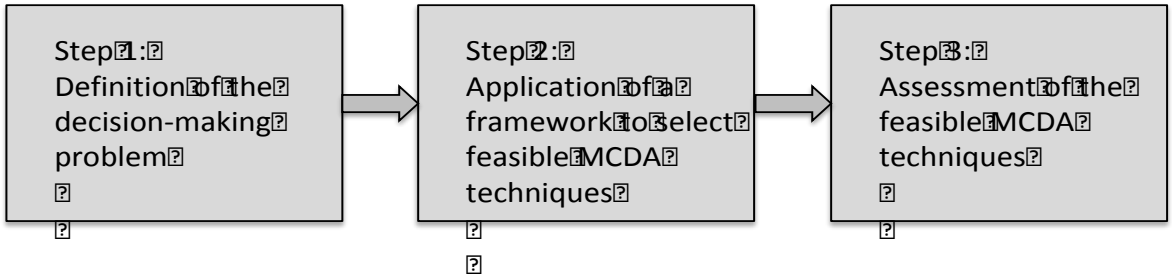

Figure 1. Steps for selecting the most appropriate MCDA technique

In Step 1, the characterisation of the decision-making problem should be carried out in terms of defining the decision-making time-horizon, the variables of the problem (judo KPI in our research), the main aim of the problem (identify and quantify KPI relationship in our research).

In Step 2, and applying an appropriate framework, the selection of feasible MCDA techniques to solve the defined decision-making problem is carried out. In this sense, it is possible to find several scientific works that present frameworks for selecting appropriate MCDA techniques, i.e. (Ceballos et al., 2016; Kurka and Blackwood, 2013). However, we propose to apply the framework developed by Watrobski et al. (2019) as we find it the most complete in terms of both assessment of factors and recent one. Such a framework, identifies 56 MCDA techniques and classifies them according to the next four criteria:

- Binary relations. The relationships between variables (KPI in our research) can be of either indifference or preference. Further, such a classification of relations can be augmented, showing weak preference, incomparability and combination of some of the previous.
- Linear effect. In many MCDA techniques, the linear effect appears due to the preferences between variables set. This effect can be either partial or totally compensated.
- Aggregation of data. In order to aggregate the performance of variants, three approaches are defined: i) Aggregation to a single criterion: ii) usage of the outranking relationship; iii) and a mixed method that combines the two previous.
- Data used. The data used can be classified into: i) either deterministic or non-deterministic; ii) either cardinal or ordinal; iii) either fuzzy or non-fuzzy.

Then, the researchers can, following these four criteria defined by Watrobski et al. (2019) select, from the 56 technique presented, these that are more adequate to solve their decision-making problem.

Finally, in Step 3, the previously selected MCDA techniques are ranked according to the criteria of:

i) necessary level of knowledge of the data used to establish comparisons between variables;
ii) level of flexibility of the technique (if changes occur; for example the need of incorporating new variables to the decision-making problem);
iii) availability of a free software to support the application of the technique.

3. Application

In Step 1, the researchers, based on both experience and the work of (Uriarte Marcos et al., 2019) chose the variables (elite judo KPI)for the research, which were: Coordination, strength, speed, aerobic and anaerobic

fitness, technical and tactic preparation, age, weight, focus and concentration level, stress, motivation, nutrition, dual career and sleep.

Then, we stated the main aim of this research: to identify and classify feasible MCDA techniques to quantify existing relationships between elite judo KPI in order to improve performance of the athletes in the medium-term.

In Step 2, the decision-making group established the criteria to select the MCDA techniques following Watrobski et al. (2019) framework:

- Binary relations. The relationships between variables (KPI) were defined as of either indifference or preference, as we felt that there were always relationships between them.
- Linear effect. This effect should be either partial or totally compensated.
- Aggregation of data. It was chosen the aggregation to a single criterion.
- Data used. The data used was classified into: i) either deterministic or non-deterministic; ii) cardinal; iii) and either fuzzy or non-fuzzy.

The result of applying these specific criteria to the 56 MCDA techniques presented by Watrobski et al. (2019) resulted into selecting the following nine MCDA techniques: Analytic Hierarchical Process (AHP), Analytic Network Process (ANP), Fuzzy AHP, Fuzzy ANP, COMET, Fuzzy TOPSIS, Fuzzy VIKOR, IDRA and REMBRANDT.

Finally, in Step 3, thesenine selected MCDA techniques were assessed and ranked according to the previously presented criteria. Table 1 presents such an assessment.

	Level of knowledge of the data used	Level of flexibility	Availability of free software	Ranking
AHP	High	Low	Yes	5
ANP	High	High	Yes	1
Fuzzy AHP	Low	Low	No	9
Fuzzy ANP	Low	High	No	6
COMET	High	High	No	4
Fuzzy Topsis	Low	High	No	7
Fuzzy VIKOR	Low	High	No	8
IDRA	High	High	No	2
REMBRANDT	High	High	No	3

Then, it is possible to affirm that the Analytic Network Process is the most adequate MCDA technique to identify and quantify judo KPI relationships because:

- The level of knowledge of the data used is high. Decision-makers must be able to value with a single number the intensity of the relationship between two KPI instead of valuing it with a range of values, as it happens with the fuzzy techniques.
- The level of flexibility of the ANP is high, as it allows tointroduce changes in the decisional network, i.e. introducing new KPI, eliminating some existing ones, changing some stated values, etc., which facilitates testing different options and have available an easily modifiable system.
- There is available a free software to support the implementation of the ANP technique, which makes easier for decision-makers to use and implement such a technique. Many other MCDA techniques do not have available such a free software, which implies that decision-makers should either program themselves the technique in programming languages or pay for licensed software, with the added investment of resources needed in both time and money.

After the ANP come the other eight MCDA techniques assessed in the following order: IDRA, REMBRANDT, COMET, AHP, Fuzzy ANP, Fuzzy TOPSIS, Fuzzy VIKOR and Fuzzy AHP. From these, IDRA, REMBRANDT and COMET are equally ranked as they achieved high values on two criteria, level of knowledge of the data used and level of flexibility, and it would be indistinct the usage of one or another technique. Then, it comes the AHP, which achieved high value on one criterion, level of knowledge of the data

used, which has been considered to be more important than the level of flexibility. After the AHP, three fuzzy-based techniques come: Fuzzy ANP, Fuzzy TOPSIS, Fuzzy VIKOR, which achieved high value on one criterion, level of flexibility. Finally, the fuzzy AHP, which obtained low values on two criteria, level of knowledge of the data used and level of flexibility, has been recommended as the last MCDA technique out of nine to be used to solve the problem of this research.

Conclusions

This study has presenteda process to identify and assess MCDA techniques to quantify existing relationships between elite judo KPI to improve not only decision-making processes but also athletes' performance. Then, based on a recent framework, the researchers applied to some judo KPI such a process, identifying nine feasible MCDA techniques, which were then assessed against three defined criteria, resulting that the Analytic Network Process is the most adequate MCDA technique to solve the decision-making problem.

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