DOI: https://doi.org/10.53350/pjmhs2115102971

ORIGINAL ARTICLE

Risk Analysis and Assessment Using Decision Matrix Risk Assessment Technique in Sports: The Case of Boxing

MERVE UCA[1], LEYLA ALIZADEHEBADI[2]
[1] *Assistant Professors, Department of Physical Education and Sports Teaching, Faculty of Sports Science, Istanbul Aydın University*
[2] *Assistant Professor, Department of Coaching Education, Faculty of Sports Science Istanbul Aydın University*
Correspondence to: Merve Uca, Email: merveuca@aydin.edu.tr, Cell: 444 1 428 - 27502

ABSTRACT
Background: The decision matrix risk assessment (DMRA) is a systematic approach widely adopted in risk management in occupational health and safety to make a risk analysis and assessment and assist in decision-making for risk tolerability. Risk is a substantial part of sports organizations as well as other organizations and daily life; therefore, it is inevitable in any activity. One may encounter various risks of injury since sports fields and equipment are not ergonomic for performing sports activities healthily

Aim: Ultimately, to help improve the conditions of sports activities, the present strummed to determine the activities to be maintained as a result of a risk assessment using the decision matrix risk assessment technique where accidents are classified by their severity and probabilities.

Methods: The present study adopted DMRA (L-shaped matrix); it is among the systematic methods widely used in occupational health and safety (OHS) risk assessment. In general, it is an assessment technique where one may obtain a risk assessment value by considering two factors.

Results: Likewise, we identified those requiring control measures and a cease at the last resort.

Conclusion: Overall, we proposed some corrective actions that may help prevent the occurrence of the presented accidents through the implementation of occupational health and safety regulations published by the correspondent institutions.

Keywords: Risk assessment, sports activity, health and safety, decision matrix, risk analysis

INTRODUCTION

Risk is defined as the combination of the severity and probability of occurrence of harm, which is an inevitable part of daily life[1,2]. In this context, nations and organizations involve identifying, assessing, mitigating all possible risks to increase safety, prolong human life, and document results[3]. Risk assessment is a significant means for the safety policy of a company or an organization[4]. Therefore, it is essential to select an appropriate assessment method among the abundance of them available for all conditions. The relevant literature proposes various techniques to assess risks, and these techniques are often divided into two main groups: qualitative and quantitative [4,5,6,7]. Indeed, risk reduction has become a key priority of every institution or organization, as well as among the priorities of governments. Yet, it is obvious that people, as well as all organizations, are rather lacking in adequate risk-related knowledge. They often know little about the nature and magnitude of the risks involved because the future is full of uncertainties. In particular, they are aware of little about risk management and the various consequences of risk reduction[8].

Since risk cannot be eliminated, the main issues that one faces individually and collectively are how much risk they should live with and how they should manage risk. Even if one has chosen a set of strategies allowing for reducing a particular risk, the question arises as to what level of risk to choose. Reducing and avoiding risk is based on a certain cost and time in strategic management[9]. As in all industrial sectors, sports organizations also need to take precautions regarding accidents and occupational diseases.

Therefore, boxing, one of the dangerous sports activities like those carried out in the industry or production processes, endanger human life and health[10,11].

On the other hand, not all injuries are equally severe in sports activities, but a significant proportion of those (e.g., concussions and knee injuries) may be serious. Severe injuries often result in chronic problems, such as prolonged absence from work and sports and early-onset osteoarthritis[12]. However, there are many opportunities for preventing sports injuries, such as making sports infrastructures and equipment safer, mandating the use of protective equipment as a procedure, ensuring injury prevention an essential component in training methods and coach and trainer training, and making adaptations to the game rules[13].

To tackle these issues, analytical tools and risk ranking schemes should be used to distinguish between low, high, and tolerable risks. In this context, building a risk assessment matrix is known among the risk ranking methodologies.

Risk Analysis and Assessment Techniques: In the literature, there is an abundance of risk analysis studies published on safety and procedures in different fields such as engineering, medicine, chemistry, and biology. These studies often divide risk analysis and assessment techniques into three main categories: (a) qualitative (e.g., checklists), (b) quantitative, and (c) hybrid techniques (qualitative, quantitative, and semi-quantitative)[7]. Qualitative techniques rely on both analytical forecasting processes and the capabilities of safety managers and engineers. Quantitative techniques consider risk as a quantity that can be estimated and expressed by a mathematical relationship with the help of actual accident data recorded at a construction site. Hybrid techniques, on the other hand, present a great deal of confusion because of their purpose-built properties that do not extend their scope.

Qualitative Techniques: Many qualitative risk assessment techniques have been proposed so far. These techniques have different characteristics regarding the structure and size of the organization. The popular ones are as follows[7]:

Checklist analysis: It is a systematic assessment upon pre-determined criteria in the form of one or more checklists representing the simplest method used for hazard identification and a list of questions related to operation, organization, maintenance, and other safety-related areas. Although this analysis is highly effective in identifying various system hazards, it has two major limitations. (a) The structure of checklist analysis relies only on the information built into checklists to identify potential problems. If the checklist does not address an important issue, the analysis is likely to miss potentially significant weaknesses. (b) Also, it traditionally provides only qualitative information. Most checklist reviews produce only qualitative results without quantitative estimates of risk-related characteristics. This simple approach offers great value for minimal investment, but if only some degree of quantification is added with a relative ranking/risk indexing approach, it can possibly answer more complex questions about risk[6,14,15,16].

What-if analysis: It is an approach that uses broad, loosely structured queries assuming possible failures that could lead to accidents or system performance failures and anticipates the consequences of these situations by determining what may go wrong[6,14].

Safety audits: The procedures by which a facility, a process, or a facility's operational safety programs are audited. They describe equipment conditions or operating procedures that could result in an injury, property damage, or environmental impact[14]. An auditor or audit team reviews critical features to verify the application of appropriate design criteria, working conditions and procedures, safety measures, and associated risk management programs. The result of an audit is a report that provides corporate management with an overview of performance levels of various safety aspects of operations. Outcomes should give reasonable advice and recommendations on safety procedure improvements and safety awareness of operating personnel[6,15].

Task analysis: This process explores how people perform tasks in their work environments and how these tasks are subdivided and identifies how operators interact with both the system itself and other personnel in the system. It can be used to construct a detailed picture that incorporates the human being, using all the information necessary for in-depth analysis[17,18,19].

Sequential Timed Events Plotting: It presents a significant overview of the timing and sequences of events/actions causing the accident. In other words, it may enable one to restructure the damage process by plotting the series of events leading to the accident[20].

Hazard and Operability Study: It is a formalized methodology for identifying and documenting hazards through creative thinking. It involves a very systematic review of the facility under consideration or design documents describing the facility. It can be properly planned and managed only when the duration of each activity and the entire process are known[6,14,15,21,22,23,24].

Quantitative Techniques: Quantitative risk assessment methods are listed and briefly explained below[7].

Proportional risk assessment: It uses a proportional formula to calculate the quantified hazard-induced risk. Risk is calculated by considering the possible consequences of an accident, the exposure factor, and the probability factor. More specifically, a quantitative calculation of risk can be provided with the following proportional relationship[4]:

$R = P\ S\ F$

R: Risk,
P: Probability factor (harm),
S: Severity of harm,
F: Frequency (or Exposure) factor.

The above relationship may provide a reasonable system for safety management to set priorities for attention to hazardous situations. The validity of these priorities or decisions is clearly a function of the validity of the estimates of the P, S, and F parameters. These estimates are apparently fairly straightforward as to be based upon collecting information, visiting workplaces, and discussing their activities with employees[6].

Decision matrix risk assessment: It is a systematic approach to estimating risks, consisting of measuring and classifying risks on the basis of an informed decision regarding both probability and outcome and relative importance[4,6,7,14,25,26,27]. The combination of outcome/severity and probability range gives an estimate of risk (or a risk ranking). More specifically, the product of severity (S) and probability (P) provides a risk measure (R) expressed by the relationship:

$R = S \times P$

Quantitative measures of societal risk: The societal risk associated with the operation of a given complex technical system is assessed on the basis of a set of triads[28]:

$R = \{(S_k; F_k; N_k)\}$

where S_k is the kth accident scenario (usually representing an accident category) defined in the modeling process; F_k is the frequency of this scenario (probability per time unit, traditionally considered a year); N_k is the outcome of the kth scenario, i.e., potential losses (injury and number of deaths) or financial losses.

Quantitative risk assessment: The quantitative risk assessment technique has been developed for the external safety of industrial facilities at risk of dust explosion. It provides a consistent basis for analyzing individual and societal risks, consisting of a combination of sub-models. First, the scenarios and their frequencies are defined. Individual risk is identified as the probability (frequency) of being fatal to an unprotected person near a dangerous place. Besides, societal risk takes the de facto environment into account. For example, an industrial facility is divided into two groups of modules defined by their sizes, shapes, and structural features. Then, the relevant explosion scenarios are determined together with their frequency of occurrence. These include domino scenarios as well as scenarios involved by the modules[7].

Quantitative assessment of domino scenarios: A domino effect is considered an accident spreading to nearby equipment, triggering one or more secondary events, and posing more severe consequences than the primary event[7].

Predictive, epistemic approach: This procedure is based on a predictive, epistemic approach to risk assessment. It provides formal tools to combine factual data and subjective information, allowing the prediction of abnormal (accidental) actions in the form of mathematical models that measure epistemic (state of knowledge) uncertainties in the properties of actions. Epistemic models allow for a rough, informed estimation of the probability of harm from abnormal actions. These models are also considered the first step towards preventing (reducing) the losses associated with the harm. Harm can be assessed using deterministic or probabilistic structural analysis[7].

Weighted risk analysis: A weighted risk analysis methodology is adopted to balance safety measures from environmental, quality, and economic perspectives. It is a tool that compares different risks, such as investments, financial losses, and loss of life, unidimensionally since both investments and risks can only be expressed in money[29]. Not only technical aspects but also economic, environmental, comfort-related, political, psychological, and social acceptance are aspects that play an essential role in the analysis. In some cases or scenarios with major consequences, weighting factors are used for all risk dimensions to make them comparable to each other and relate them to actions that should be taken for possible risk reduction.

Hybrid Techniques Human Error Analysis Or Human Factor Event Analysis: Human errors are recognized as among the main causes of serious accidents/incidents across a wide range of industries. Systematic addressing to human errors in the design, operation, and maintenance of highly complex systems can lead to increased safety and more efficient operation[21,31,32].

Fault tree analysis: It is a deductive technique focusing on a specific accident and determining the causes of that event. In other words, fault tree analysis is an analysis technique that visually models how logical the relationships between equipment failures and human errors are and how external events can combine to cause a particular accident. Fault trees are created using events and gates. Basic events can be used to represent technical malfunctions that lead to accidents, while intermediate events may represent operator errors that can intensify technical malfunctions. Gates of fault trees can be used to demonstrate the various ways in which machine and human faults combine to cause an accident[6,14,15,20,22,26,33].

Event tree analysis: Event tree analysis is a technique that uses decision trees to logically develop visual models of the possible outcomes of an initial event. It is also a graphical representation of the logic model that identifies and quantifies possible outcomes following the initial event. The models explore how safety measures and external influences, called safety lines, affect the paths of accident chains[14,22,34].

Risk-based maintenance: It is a comprehensive hybrid (quantitative/qualitative) technique and can be applied to any asset regardless of its characteristics. The quantitative definition of risk is affected by the quality of the outcome study and the accuracy of the failure estimates. It is divided into three main modules: (i) risk identification consisting of defining and estimating the risk, (ii) risk assessment consisting of risk avoidance and risk acceptance analysis, and (iii) maintenance planning regarding risk factors[35].

MATERIAL AND METHODS

Decision matrix risk assessment (DMRA), a widely adopted technique, is a systematic approach to estimating risks. It consists of measuring and classifying risks based on an informed judgment regarding their probabilities, outcomes, and relative importance[7].

The present study adopted DMRA (L-shaped matrix); it is among the systematic methods widely used in occupational health and safety (OHS) risk assessment. In general, it is an assessment technique where one may obtain a risk assessment value by considering two factors: the occurrence probability of a risk and the degree of outcome severity[36]. In this study, we interviewed the trainers, athletes, referees, and managers in boxing sports in Turkey and analyzed the available boxing ring equipment by DMRA. First of all, we used the checklist technique, which is based on the logic of controlling hazards through checklists. by checking whether the steps, suggested by a systematic risk assessment technique, are followed or not.

It is not actually a detailed risk assessment technique, but it will be more appropriate to define it as a preliminary hazard assessment. A preliminary hazard assessment may help monitor the hazards OHS checklists may facilitate determining risky sections in the working environment and performing a more effective systematic risk assessment. There should be no quanititvate assessment in the checklist technique. Identified checking items should include responses such as "Suitable/Not suitable" or "Yes/No" and only be strictly assessed for suitability.

DMRA can conveniently be used in all less hazardous works and workplaces. Due to the low number of accidents in such workplaces and the lack of past data, the matrix technique gives more relevant and healthier results than other systematic methods[34].

The researcher identified each risk definition indicating each risk score, used DMRA to collect the data associated with the subjects that may create harm to health and safety, and took the averages of the scores given by the experts to increase the reliability of the assessment. According to the degree of priority, the risk control methods in the workplace should be as follows:

1. Eliminating risks at source,
2. Replacing the hazardous with the less hazardous,
3. Implementing engineering measures,
4. Taking administrative measures (signs, warnings, working hours),
5. Supplying personal protective equipment.

DMRA (L-shaped matrix) is used to assess cause-effect relationships. This technique is ideal for analysts who have to do a simple, stand-alone risk analysis, and the success of the technique varies by the analyst's experience.

a. Identifying hazards: In this step, it is needed to detect what could harm workers, products, and work equipment in the workplace.
b. Evaluation of hazards: The list of hazards created in the first step should be assessed, and one needs to decide what kind of precautions should be taken for which ones and which ones should be risk-ranked.
c. Rating of the risks: The analyst separately calculates the weight ratios for each of the hazard risks decided

on in the second step and rates and prioritizes the risks.

d. Implementation of control measures: The analyst takes necessary measures, decided in the second and third steps, for the hazards that can be eliminated immediately and determines an appropriate control period to prevent their reoccurrence. On the other hand, non-urgent measures that require a certain cost and time are discussed in implementation plans.

e. Monitoring and reviewing: All stages and implementations of risk management in the workplace are regularly audited and monitored, and deficiencies, if any, are reviewed. In this study, we made a risk assessment using DMRA (L-shaped, 5x5 matrix). In this approach, the risk size is the combination of the "probability of the event" and the "effect or severity of the event."

R = P x S
R = Risk score
P = Probability factor
S = Severity factor

As shown in the table below, severity and probability values in matrix risk assessment criteria are rated on a scale ranging from 1 to 5. Then, the risk score is calculated by multiplying the severity (S) and probability (P) factors determined as above. The table also demonstrates the definitions of the risk scores: insignificant risk (1; green), tolerable/low risk (2, 3, 4, 5, and 6; blue), moderate/medium risk (8, 9, 10, and 12; yellow) significant/high risk (15, 16, and 20; red), and intolerable risk (25; dark red)..

Table 1: Severity and probability scores and risk rating scale

5x5 L-shaped Risk Matrix			Severity (Effect)		
Probability (Likelihood)	1 Negligible	2 Minor	3 Moderate	4 Significant	5 Severe
1 Very unlikely	Insignificant 1	Low 2	Low 3	Low 4	Low 5
2 Unlikely	Low 2	Low 4	Low 6	Medium 8	Medium 10
3 Possible	Low 3	Low 6	Medium 9	Medium 12	High 15
4 Likely	Low 4	Medium 8	Medium 12	High 16	High 20
5 Very likely	Low 5	Medium 10	High 15	High 20	Intolerable 25

Table 2. Risk assessment

Risk score	Result
25=R	Intolerable risk, the operation must be stopped immediately.
15=R<20	High risk, it should be improved in the short term.
8=R<15	Significant risk, it can be improved in the long term.

Table 3. Probability and severity rankings

Probability rankings	
1	Very unlikely. No risk expected, very low or almost no probability of occurrence.
2	Unlikely. The probability is very low or may be likely once a year. Maintain existing control system.
3	Possible. The risk exists despite low and may be repeated several times a year or every six months.
4	Likely. The risk exists and may be repeated once a week. Urgent risk management is required.
5	Very likely. The risk is expected every day or any time.

Table 4:

Severity rankings	
1	Negligible. Harmless, no loss. It may need first aid.
2	Minor. No considerable harm or loss; insignificant. It may need outpatient treatment.
3	Moderate. Recoverable harm. It may result in short-term incapacity. The injury may require inpatient treatment.
4	Significant. Significant harm and loss. The severe injury may require long-term treatment.
5	Extreme. Irrecoverable harm and/or death. Permanent incapacity. Unless controlled, the operation must be ceased immediately.

RESULTS

Table 5:

	Ring floor (RF)	Ring stools (RS)	Ring ropes (RR)	Ring stairs (RSR)	Ring safety zone distance (RSZ)	Ring guard (RG)
Hazard	Ring floor	Ring stools	Ring ropes	Rings stairs	Ring safety zone distance	Ring guard
Risk	Since the underfloor is wooden, the hard surface may cause injury and bleeding when direct contact due to dismantling or tearing of the rubber-made tarpaulin. Besides,	When forgotten in the corners, stools may lead the athletes to fall during the game, resulting in spinal cord-brain-limb injuries.	The ropes may cause injuries in the arm-leg, chest-back, and neck-head regions due to leaning-rubbing during the serial maneuvers in	Crushing or falling from the stairs due to the extreme excitement and panic in the competition or possible sharp objects around may cause injuries.	Athletes may slip and fall between ring ropes during the competition.	Since the surrounding area is fully open, materials to be thrown from the environment or the tribune may cause athletes to be injured.

	injuries may occur due to slipperiness.		the game.			
Measure	Covering the floor with a trampoline softer and thicker than 1.9 cm to prevent injuries caused by slipperiness.	Meticulously checking the stools at the end of the competition, training, and round breaks. Using soft stools to minimize the risk of injury.	Applying harm-free lubricating gel to the ring ropes.	Stepping the stairs with the help of trainers and assistant trainers as much as possible. Using wider stairs than available ones.	Narrowing ring ropes or extending the safety zone distance.	Increasing the number of security guards during competitions. Surveilling the competition hall with CCTV and imposing criminal sanctions for spectators, athletes, referees, and coaches displaying harmful behaviors.
R: P X S	RF: 2x2: 4	RS: 2X4: 8	RR: 5x2: 10	RSR: 5x3: 15	RSZ: 5x3: 15	RZ: 4x4: 16
Outcome	4 – Low risk	8- Medium risk	10- Medium risk	15- High risk	15- High risk	16- High risk
Assessment	Additional control protocols may not be needed to eliminate identified risks. However, available controls should be maintained and audited in pre-determined intervals.	Certain actions should be initiated to reduce the identified risks. Risk reduction measures may take time.	Certain actions should be initiated to reduce the identified risks. Risk reduction measures may take time.	Operations should not be started or should be ceased immediately until the identified risk is reduced. If the risk is related to the continuation of operations, urgent actions should be taken. The continuation of operations should be decided as a result of the measures.	Operations should not be started or should be ceased immediately until the identified risk is reduced. If the risk is related to the continuation of operations, urgent actions should be taken. The continuation of operations should be decided as a result of the measures.	Operations should not be started or should be ceased immediately until the identified risk is reduced. If the risk is related to the continuation of operations, urgent actions should be taken. The continuation of operations should be decided as a result of the measures.

CONCLUSION

Risk assessment and management techniques have been developed to aid decision-making processes in safety investments in many areas. Expanding responsibilities and limited resources force policymakers to make difficult choices about prioritizing risk mitigation and what safety standards should be targeted. In this context, policymakers have increasingly needed mechanisms to help them set priorities, and, therefore, risk assessment techniques and optimization philosophies have emerged over the past few decades.

A risk matrix can be a useful tool for presenting the results of simplified risk analysis and help gain insight into the relative risks of the various scenarios to be encountered in a given system. Risk occurrences can logically be identified when quantitatively developed with axes structured to be relevant to the facility and operations under consideration. Logic-based risk assessments may facilitate management decisions such as delegating operations. It may also help optimize resources by showing where efforts should be concentrated for further analysis or risk mitigation activities.

Risk assessment matrices are rather efficient and widely used tools for making and improving risk management decisions. However, the question of how to ideally create risk matrices to enhance risk management decisions still remains controversial. It is not easy to answer since risk assessment matrices are typically used only as a component in informing final risk management decisions, and their performance also depends on the common distribution of probability and outcomes. The risk assessment matrix also allows sports organizations to categorize sports accidents regarding severity and probability of occurrence. Thus, it establishes assessment criteria to classify operations as green (no injury), yellow (recoverable harm; single mortality and few injuries), and red (few deaths and many injuries). With the resorting to the colors, it is possible to inform risk analysts that they should take control measures to prevent the recurrence of occupational accidents in the sector.

Using a 3x3, 4x4, or 5x5 matrix may be helpful for some organizations but not for others. A 5x5 matrix will have 25 blocks (ranks of risk); the more blocks are for representation, the greater the risk probability will be. Therefore, organizations will be able to allocate low, medium, high, and extreme risk groups to appropriate levels of responsibility within organizations. Wider choices for probability and outcome scores in a risk matrix should provide more scope to distinguish the probability of a particular risk occurring and the outcomes for different risk groups.

Acknowledgments: The authors declare that the results of this study were presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. There were no conflicts of interest.

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