

An approach for awareness and assessment of risks in outdoor sports activities

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Over the last few years, the practice of outdoor sports has become increasingly widespread, transforming itself from a niche activity for a few, generally expert enthusiasts, to a real mass phenomenon. This has inevitably led to an increase in the number and severity of injuries, because the increased number of people exposed to the hazards, but also because of the new type of people exposed: with less knowledge of the hazards, with less awareness of the risks associated with them and sometimes less physically prepared to face the specific sporting activity.

On the other hand, the positive social and economic impact that the diffusion of these activities favours is undeniable, in terms of psychophysical benefits for the sportsmen, jobs linked to the assistance and support services offered to the sportsmen themselves and, not lastly, touristic activities induced in the frequented places.

However, like all phenomena, it must be analysed and managed, considering the new technologies available (GPS, internet, etc.) too, which of course can support operators and sportsmen but which, if not suitable or not effective or not correctly used, can even amplify the existing risks.

This work describes the analysis carried out, extended to the entire field of outdoor tourist activities, with particular attention to the mountain environment, aimed at studying its criticalities. It also briefly introduces the tools currently being studied for some outdoor activities practiced in "No Wild" land (at a totally or partially managed risk). Inail has conducted the work together with university researchers, category associations and outdoor specialists.

First of all, the analysis revealed the need for comparison and – where possible – alignment between the terminologies of the various sports disciplines (climbing, canyoning, mountain biking, etc.) with respect to the various categories of generally present hazards (natural hazards, hazards associated with characteristics of the route, hazards associated with any equipment used, etc.).

A standardised risk analysis method was then adapted to identify hazards, hazardous situations and potential damages associated with various outdoor sports disciplines and different natural environments.

Finally, experimentation of an artificial intelligent system of image learning to detect hazards and hazardous situations is currently underway, as well as the definition of protocols for the self-assessment of the physical abilities and level of training of the tourist, sportsman or outdoor operator, to be related to the difficulty of the routes and the potentially present hazards.

The ultimate goal of this project is the development of tools to support the outdoor sportsman in assessing the risks to which he will be exposed, defining the level of risk he is willing to accept (consciously and compatibly with his desire of "adventure"), identifying safety measures and understanding when the help of experienced personnel (specialized guides) is appropriate. All this, starting from the information available on conventional means (guides,

cartography) or modern (websites) and considering its own psychophysical limits and the risks to which the rescue teams could be exposed should their intervention be necessary.

Keywords: outdoor sports activities, natural environments, awareness of risks, risk assessment, image learning

1. Introduction

Outdoor amateur sporting activities are attracting growing interest from both a social and economic point of view: models and lifestyles attentive to body care, more accessible equipment and sporting practices, induce more and more people to spend their free time hiking and climbing in the mountains, descents into canyons and along streams.

Niche activities - still practiced only up to the 60s and 70s by a small number of expert connoisseurs of the environment and its ways - have gradually transformed into sports-recreational activities spread to a wider but less aware audience.

The exponential growth of practitioners has allowed some localities - already developed tourist destinations but also areas once excluded from the classic flows of seaside or mountain tourism - to transform tourist-sport activities into an important economic resource.

Consequently, the tourism-sports sector, with its growing offer of outdoor activities that can be practiced in the different seasons of the year, is increasingly establishing itself as an interesting and new working sector. Its operators are often young people who have achieved a professional outlet in one or more sports initially practiced out of passion, and who therefore carry out - to all intents and purposes - work in environments in which certain risk factors characterize the work itself.

However, if it is true that in some places tourism-sport practices in natural environments represent a job opportunity for a significant number of young people, it is also true that targeted training courses and specific regulatory and legal protections have yet to be defined.

It was therefore considered useful to conduct a study that would highlight the multifactorial risks to which practitioners of outdoor tourism-sports activities and workers in the sector are exposed, and which derive from objective hazards and subjective factors: intrinsic and specific characteristics of the natural environment or equipped, knowledge, skills, abilities possessed and behaviors assumed. With the aim of contributing to the definition of strategies - regulatory, cultural/training, informative - which

serve to reduce the number of accidents and injuries, unfortunately very often fatal, which we sadly witness.

2. Special natural environments

The study focused on the mountain environment and on tourist-sport activities that are mainly practiced in it: hiking, mountaineering, sport climbing, mountain biking, canyoning, acrobatic routes in height. The intention is to extend the observation - in the future, once an effective method has been identified - to other special natural environments. Where "special natural environments" means those environments in which potential sources of damage - and therefore dangers - are specific characteristics of the environments themselves, which cannot be eliminated without making them something else. Thus, if in a working environment the classic approach is the "safety integration principle" (which requires the elimination of hazards, where possible, and subsequently the adoption of prevention and protection measures, and finally the management of the residual risk through organizational and procedural interventions supported by training and information actions), in a special natural environment such as the mountain, its application presents objective difficulties. In fact, the elimination of uneven ground, unstable materials at high, animals, etc., generally it is not practicable and, in any case, it would mean distorting places, depriving them of their characteristics which represents the reason why people go to the mountains.

2.1 The mountain environment

The mountain is a complex environment. To move safely in the mountains you need to know and be able to recognize the hazards to which you are exposed.

Both the objective hazards (such as uneven terrain, unstable materials at height, presence of streams, presence of wildlife, severe weather conditions, ecc.) and the subjective factors (such as lack of competence, insufficient physical capacity, inadequate clothing and equipment), have to be always taken into account.

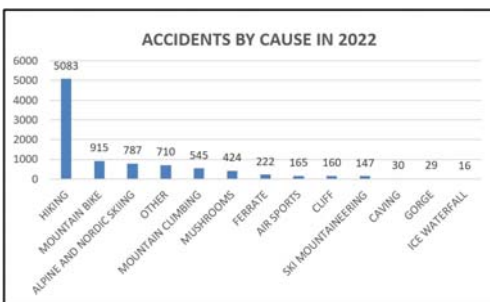


In consideration of these - and other - hazards, it is necessary to know how to use materials and means (clothing, equipment, devices for collective and individual protection, etc.) and to adopt behaviors that make it possible to reduce the risks down to a residual level - the risk zero does not exist! – which can only be estimated, accepted and managed by being aware of it and having adequate experience, competence and skills. This means 'moving safely', especially in the mountains.

2.2 Accidents in the mountains

Based on the data reported by the Italian Alpine Rescue, the tourist-sport activity in which the highest number of accidents has been detected is hiking; and the first five causes of accidents are, in order, falls and sliding, incapacity, illness, loss of orientation.

Still on the basis of the data reported by the Italian Alpine Rescue, 90% of the injured are not expert visitors to the mountain environment.



As for falling or sliding, one can fall or slide anywhere, but rough or steep terrain increases the likelihood of the hazardous event occurring. However, while falling or sliding on a city sidewalk may not have particularly serious consequences, falling or sliding in the mountains while navigating a narrow and exposed path can lead to extreme consequences.

As far as incapacity is concerned, considering that mountain attendance has exploded especially after the Covid-19 pandemic and that many people have approached the mountain for the first time in the last two years, it is not surprising that it is a of the main causes of accidents. The incapacity, the inadequacy of one's clothing and equipment; in general, inexperience: misreading a map, misinterpreting a distance, not reading the avalanche danger snow-weather report, not reading the weather report, not being adequately physically prepared are just a few examples of incorrect behavior that are often detected.

Added to all this is the risk of trying to emulate something seen on social media, without considering or knowing how to consider different weather conditions or the practicability of the terrain. Without knowing how to evaluate one's abilities with respect to those scenarios seen on social media. So most of the people who request the intervention of mountain rescue – apart from a small percentage of even prepared people who incur an 'unfortunate event', probabilistically linked to the residual risk that remains in every activity – are people who have no knew how to recognize hazards or underestimated risks.

3. Objectives and method

Within the broader objective of highlighting multifactorial risks and defining possible strategies to reduce the number of accidents and injuries, various study disciplines were involved and various topics addressed. From mountain experts and managers of environments equipped for outdoor sports, connoisseurs of places and activities, real needs and the main situations to be faced; to safety specialists, experts in "reading" accidents/events and in applying methodologies for risk assessment and reduction; to doctors and specialists in motor sciences, experts in reading and improving the potential of the human body with respect to the activities to be carried out; up to computer scientists. The contribution of the latter is linked to the awareness that technology is now pervasive in any human activity and that it can be suffered, with the risk to pass the wrong messages, or governed, with the opportunity to take some utility from them. Therefore, wanting to use them, a website was built, shared among all the subjects listed, where information and simple tools can be offered to recognize hazards and evaluate the associated risks. Among these, an AI

system capable of reading images of outdoor activities practiced in natural environments, detecting the hazards and risks associated with them.

At the moment, "objective" hazards and risks were focused, the recognition and assessment of which essentially depend on the ability to read the environment and analyze possible accident scenarios. And therefore hazardous events of a "mechanical" type (tripping, falling, falling from a height, falling rocks, injury from branches, etc.); "biological" type (insect stings, animal bites, contact with stinging plants, etc.); of a "meteorological" type (thunderstorms, blizzards, extreme temperatures, etc.). These are accident scenarios significantly influenced by "subjective" factors, capable of determining whether or not to adopt appropriate behaviors: competence, physical capacity, clothing, equipment and equipment.

4. Risk management in natural environments

The wealth of knowledge and experience of the subjects who participated in the project made it necessary to devote significant attention and time to an initial phase dedicated to sharing and integrating their respective cultural backgrounds. First of all, an attempt was made to build a common language which, while remaining habitual and easy to understand for mountaineers, would allow for a "coding" of terms and concepts that was sufficiently "rigorous" to be used for the creation of the AI tool.

Reviewed the available literature, mediated with the experience of mountain experts, it was decided to systematize the risk assessment and reduction process by adopting a taxonomy borrowed from the EN ISO 12100:2010 standard: while adequately investigating the basic issues, it remains sufficiently "flexible" - and therefore applicable where complexity of analysis is not required - even to particular cases such as those treated.

The terms that EN ISO 12100 defines are: hazard, hazardous zone, hazardous situation, hazardous event, risk. The process defined by the standard starts from the assumption that, in order to proceed with the assessment and adequate risk reduction, once the hazards has been identified it is necessary to understand the area in which it can "act", the circumstances in which a person within of that area is exposed to hazard and, finally, what

are the events that can lead that person to suffer damage due to that hazard. The probability that, due to that hazard, harm will occur to that exposed person is the risk associated with the hazard. The estimated value for this probability must be evaluated in order to establish whether it can be considered acceptable or not.



This is where the main peculiarity of outdoor sporting activities comes in, i.e. in the definition of the so-called "acceptable risk" which can take on a very different value compared to classic working contexts and is very variable in relation to the subject involved in outdoor sporting practice, in consideration of the ability to perceive risk and awareness of its acceptance. Thus, the approach to the protection of the health and safety of a worker in charge of maintenance or management of the outdoor sport environment will be different from that for the protection of the safety of a sports practitioner and, in this second case, of a "professional", of an "amateur", of an "occasional" or of a "special" (child, elderly, disabled person, etc.).

5. Risk Managed natural environments

With regard to risk management, it is possible to identify two types of natural environments in which outdoor sporting activities are practiced: those where risk management is totally in the hands of the practitioner and those where there is a third party who takes care, partially or totally, of risk management. This second type of environment has only appeared in the last two decades and is increasingly spreading thanks to the important socio-economic value that outdoor activities have assumed.

However, a first criticality is encountered in the absence of shared criteria that allow the various subjects involved to distinguish the two types of environment. This can generate dangerous confusion and lead an inexperienced practitioner to frequent environments that are not suited to his risk management ability, or generate profiles of responsibility in subjects assigned to land management. Therefore, the process of "definition" is fundamental, i.e. the adoption of shared terms capable of identifying by clearly distinguishing the first type of environment from the second. The comparison of the terminologies of different professional fields aimed at standardizing and identifying a definition that was able to communicate, at least in general terms, the risk characteristics of the two different types of environments, required considerable concentration and effort. Thus, if the term "Wild" can clearly identify a natural environment in which the relationship between the practitioner and the environment is not mediated by third parties, in contrast the term "No Wild" has a negative meaning and is not completely exhaustive of the characteristics of the managed risk environments. And since the active presence of a person who deals with risk management makes the difference more than the presence of equipment or signage, the wording "Risk Managed" appeared to be the most appropriate.

Therefore, in activities in a "Wild" environment it is the practitioner who has to manage the risk, evaluate the hazards, the consequent level of risk, decide whether to expose themselves to it, evaluate and adopt behaviors and mitigation and protection measures. In "Risk Managed" environments, on the other hand, it is the manager who assesses the risk, intervenes with mitigating actions according to the different types of activities practiced, informs practitioners of the level and type of residual risk, communicate behaviors and protection measures, check and maintain the site regularly.

Access to these environments is free and uncontrolled. It will be up to the practitioner to evaluate the contingent situation (e.g. weather conditions, current condition of the equipment, etc.), their own abilities and psycho-physical conditions, adopt the behaviors and protective measures indicated in any case appropriate to the activity. Risk management is shared between manager and practitioner.

At a higher level of delegation in risk management we find "Risk Managed with controlled access" environments such as Bike Parks and Adventure Parks. Here the manager, present on site, not only continuously evaluates the environmental conditions and equipment, but also the skills and behavior of the practitioners. It can thus inhibit access in a generalized way in the event of environmental risks or to individual users in the event of manifest incapacity. In "Risk Managed with controlled access" environments the trainee should only comply with the safety information received at the time of access or during his stay in the area. Risk management is almost entirely delegated.



However, it should be emphasized that even in managed risk environments, with free access as well as controlled access, whoever accesses them implicitly assumes acceptance of the residual risk, i.e. that part of the risk that can only be removed by significantly distorting the environmental context and experience itself.

The definition of the level of residual risk does not appear to be definable abstractly and in a generalized way, being a function both of the type of environment and of the different activities and level of practice. It is therefore up to the operator to define the acceptable level of risk following the mitigation interventions, and clearly inform the users who will thus access with full awareness of the residual risk to which they will be exposed and of the adequate measures to protect themselves.

This procedure makes it possible to effectively reduce unprotected exposure to residual risk, to share responsibility among the subjects involved, to provide concrete training for those practitioners who do not yet have independent assessment skills.

A concrete example of how this approach can contribute to increasing risk awareness and the dissemination of good practices comes from the climbing crags of the Outdoor Park Garda Trentino. Here also thanks to the continuous online communication, printed and on panels at the base of the walls, the use of the helmet - which was practically null only about ten years ago - is becoming more and more widespread.

6. The Adventure Park experience

Originally intended "only" as acrobatic routes in height between one tree and another, in recent years the Adventure Parks have become containers of rather different outdoor activities: games between trees, between artificial poles, cableways, towers from which to jump climbing, via ferratas, climbing on natural and artificial surfaces, archery, bicycle rental, orienteering, etc. In short, the market's response to the ever-increasing search for outdoor experiences is very varied and is aimed at different types of audience according to the destination and type of attendance (domestic, urban, tourists, schools). Italy has about 250 adventure parks, located mainly in the centre-north, where wooded areas are more abundant; in all they record about:

- 1,500 – 2,000 employees
- 2 million visits a year
- a turnover between 25 and 30 million Euros

Based on data from the Italian Adventure Parks Association, there is an accident rate of around 8-10 per million visits.

6.1 An example of a managed risk environment

According to the classification of the project, the Adventure Parks are "Risk Managed" environments: the natural environment in fact undergoes a transformation process that passes through the planning, authorization, construction and testing phases defined by current regulations in Italy and from the state of the art, i.e. the Consolidated Text on Public Safety Laws (TULPS) and the European technical standard EN 15567.

Among the hazard factors we commonly find:

- height difference (even up to 20 meters)
- rough terrain with obstacles (roots, tie rods, platforms etc...)
- objects placed in height (branches)
- animals (bites, stings)

- plants (shocks, allergic reactions)

Many of the risks associated with these factors remain, albeit reduced and/or subjected to individual protection measures, even during operation, as they are typical of the environment in which one operates and cannot be completely eliminated, unless there is a profound transformation of the environment itself and the type of activity that takes place there.

6.2 The educational role of Adventure Parks

Partly due to the seasonal nature of the activity, partly due to the congenital presence of risks in their environment, Adventure Parks dedicate a very significant portion of their turnover to training operators.



Through the instructor-user relationship, which is established during the visit to the adventure park, part of this cultural baggage (how to move safely at height, use of PPE, awareness of one's physical limits) is transmitted to the end users, through dedicated moments such as the briefing and during the constant supervision of the operators in the park attractions.

6.3 Individual freedoms and collective responsibility

As far as Adventure Parks are concerned, it is clear that they are environments exploited directly and continuously by an economic operator; it therefore follows that the responsibility regarding the correct organization, training of personnel, state and adequacy of the equipment lies with the person, natural or legal, who manages this environment. However, even in the case of managed risk environments such as these, it is much less clear what the level of residual risk is acceptable and accepted by the end user. To better clarify this distinction, let's consider some common examples:

- level sliding on steep terrain within the park
- falling from a height due to careless use of a fall protection device
- impact with equipment (safety device or support structure)

The cases mentioned above can have minor to serious consequences (fractures, damaged teeth, head trauma...) and, in serious cases, lead to the need for public health intervention. To date, most of these cases are the subject of a claim for damages by the injured and the related claim report by the park manager on his civil liability policy; more and more often insurance companies reject small claims, while managing the more important ones out of court, not so much on the basis of actual law as on a basis of calculation of economic convenience with respect to a possible judicial resolution of the matter.

Given the growing volumes of visits to these environments and the evolution of technology that allows the participation of an increasingly vast public, will soon have to be faced in a serious and structured way how responsibility should be shared between the community, (possible) manager and end user.

7. Efficiency of the body in outdoor sport

The scientific community agrees that the chronicization of many non-communicable diseases, increasing the individual's life expectancy, will determine the unsustainability of healthcare spending. Furthermore, the phenomenon of "presentism", a condition of functional limitation as a complication of a pathological state whose is not such as to cause absence from work due to illness, is increasing among workers. It is noted that health and well-being experts indicate a correct lifestyle as a sustainable prevention tool, more effective if active, i.e. including physical activity. In fact, a direct correlation between psycho-physical well-being and health and an inversely proportional between well-being and the risk of contracting non-communicable diseases exist. Therefore, physical efficiency evaluation tests are necessary, particularly for coordination and conditioning skills. It is also known that physical activity linked to the motor task typical of working activity does not induce positive effects on the quality of life but negative ones due to repetitive motor tasks. Therefore, emerging professional work activities, such as those performed by those

who work in "No Wild" environments as guides for users practicing "Sport Outdoor", deserve interest from those involved in worker prevention. Regarding this emerging worker figure, applying all the regulatory interventions envisaged in prevention, is important to protect the worker's health. Still, envisaging all expedients and obligations to reduce the injury risk is important. Therefore, physical efficiency is an important indicator in reducing the risk of injury in a worker who performs an activity. Consequentially, identifying a battery of tests to evaluate physical efficiency is a priority.



In this regard, as part of the research project, a study aimed:

- a) to define the physiological profile of the outdoor sport's practitioners;
- b) to evaluate the cardiovascular and metabolic effort and the related oxidative stress during typical work activities, including also possible emergency situations;
- c) to evaluate how much physical fitness was adequate respect to the physiological requests assessed during typical work activities for sport as canyoning, rock climbing, mountain bike and orienteering.

8. A website to inform and train

Building an informative and formative website in an environment such as the special natural environment has been a real challenge. Indeed, the main problem is the definition of the backbone of concepts that should drive the construction of the site.

It was wanted a website that would be a tool for experts and not a burden, but that would also attract the attention of different types of users: (1) Special Natural Environments (SNE) users, (2) responsible for safety of these environments; and finally (3) the institutions formally in charge for site safety, such as local municipalities.

Moreover, the website aimed to host two different applications: (1) a system to help SNEs users to understand whether they are efficient enough to use the particular SNE and do the particular activity; (2) a system to spot if the activity in an SNE is basically hazardous.

Hence, to meet the requirements, a website was built around an ontology of the risks in SNEs. This ontology drives the on-the-fly construction of the webpages containing texts, images, and informative videos. The ontological language itself is simple, and, obviously, the resulting ontology contains concepts, relations among concepts, and attributes of these concepts. The most difficult part has been the definition of the specific concepts used for the description of SNEs.

The construction of the ontology for SNEs has been in itself very useful. Indeed, the formal language helped domain experts to focus on the inconsistencies of what they proposed and, thus, led them to produce a better conceptualization of the domain. Moreover, the formal language fueled the discussion around specific important terms such as *risk* and *hazard*. Indeed, being forced to think about the connection between these two concepts and the others, domain experts had the chance to communicate more formally what they had in mind and, thus, they had the possibility to understand implications of their definitions.

The result is a clean and easy-to-use website, where the concepts of hazard, hazardous zone, hazardous situation, hazardous event and risk are contextualised with respect to specific natural environments and specific outdoor activities: the links between concepts and images are designed to visually describe, comparing different images, the relations between the concepts themselves.

Films are also offered which describe particular situations and provide information on the correct behaviour to adopt. Therefore there are two sections that may help users to understand how their own behaviour affects their safety: a section with simple tests to evaluate one's physical

efficiency and a section where an AI system describes an uploaded image with respect to the dangers and risks that the AI system recognises in them.

The website domain will be registered and published in the coming months.

9. Conclusions

The study carried out so far represents only the first step of a path that aims to spread awareness of the risks of outdoor activities practiced in natural environments and allow the various actors to assume the responsibilities – in the respect to the hazards that exist and the risks that are run – that belong to each of them. It will be essential to be able to create synergies between local communities, managers, operators, professionals, users, ensuring that they can share languages, knowledge and skills by certified tools and means of communication, especially in consideration of the incorrect behaviors often conveyed by social networks.

Given that "Risk Managed" environments are becoming more and more widespread, it will soon have to be found how to distinguish them from "Wild" environments completely similar in terms of morphology and presence of equipment, but where there is not a manager who guarantees risk assessment and maintenance: a typical example is the "Risk Managed" via ferratas and climbing walls, very similar to "Wild" via ferratas or climbing walls. One could think of using a brand that makes them recognizable on the ground, billboards, maps.

It is also desirable to create local or regional databases, updated and consultable online, through which to communicate in real time characteristics, conditions of practicability or closure due to weather and/or geological risks, state of maintenance, behaviors to adopt.

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EN ISO 12100:2010 Safety of machinery — General principles for design — Risk assessment and risk reduction