

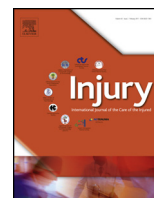


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## A prospective injury surveillance study in canyoning

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### ABSTRACT

**Introduction:** Little is known about injuries in canyoning. It was the purpose of this study to determine injury rates, patterns, causes and risk factors in canyoning; and to identify targets for future injury prevention strategies.

**Methods:** From May to October 2015, 109 participants from 17 different countries were prospectively followed via a monthly e-mail-based questionnaire.

**Results:** During 13,690 h of canyoning, 57 injury-events occurred. The overall injury-rate was 4.2 injuries/1000 h of canyoning. The hand (23%) and lower leg and foot (25%) were most frequently involved. Most of the injuries were mild (n = 27, 49%) and limited to the soft-tissue. There were seven severe injuries (12%) with two lateral malleolar fractures, both necessitating surgery. The majority of injuries were due to material failure (44%) and significantly more injury-events were reported when the tour included rappelling (p = 0.037). Canyoning guides suffered from significantly less injuries compared to beginners and advanced canyoneers (p < 0.001).

**Conclusions:** The majority of canyoning injuries are mild. On the other side, roughly one-tenth suffered from severe injury. Canyoning guides are less prone to injury-events and beginners should consider performing tours with experienced guides. Notwithstanding, rappelling was the most common activity associated with an injury and the material used was deemed causative for an injury-event in almost half of all cases. Further improvement in canyoning equipment, frequent equipment service, and instructional courses to ensure adequate employment of equipment might minimize the risk of getting injured.

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### Introduction

Canyoning is a growing outdoor sport, [1] which includes several different elements of extreme sports such as hiking, climbing, rappelling, diving and swimming [2]. Different canyoning organisations offer guided tours with various levels of difficulty. Tours for beginners start with hiking, swimming and sliding. Tours for experienced canyoneers consist of bouldering, rappelling and diving from rocked cliffs or waterfalls [2,3].

A core element of canyoning is the companion of guides. Canyoning guides are typically qualified in fields such as fastening, climbing, rappelling, diving, first aid and rescue techniques [2,3]. As alternatives to exit a canyon wall are often limited, canyoneers frequently encounter situations where self-sufficiency is required.

As such, advanced personal skill level and continuous guidance are prerequisites for a safe canyoning tour.

Literature about injuries in canyoning is scarce. One retrospective analysis dealing with canyoning rescue operations and one report about an outbreak of leptospirosis among canyoning participants have been published [4,5]. By now there is only one survey dealing with injury patterns and first aid training among canyoneers [1]. Hence, it was the purpose of this study to determine common injury rates, patterns, causes and risk factors in canyoning; and to identify targets for future injury prevention strategies. The current study is the first prospective trial analysing injuries in more than 100 canyoneers including participants from all over the world.

### Methods

This is a descriptive, observational study. Institutional review board approval was obtained and all participants gave their written consent.

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Study population

Participants were elected following the STROBE criteria (Fig. 1) [6]. Between May and October 2015, 109 participants from 17 different countries were prospectively followed during one canyoning season. Recruitment of participants was adopted from previous sports epidemiological studies [7], and conducted through contacting membership registries, canyoning related web portals, social media networks and personal contacts. Participants with different skill-levels, from different regions and different canyoning experience were investigated in order to avoid isolated cross-sectional data [7].

Data acquisition

Prior to the study, general information about the participants like body dimensions and information about their canyoning experience was recorded using an encrypted, anonymized online-based questionnaire [8]. Participants were also asked to state their level of performance. The definition of each performance level was established in a consensus session with the leading canyoning guides in central Europe. A modified classification was constructed based on different previous studies [7,9,10], and individuals were divided into 3 groups based on the individual level of experience: Beginner, advanced and professional canyoneers. Further details are provided under Table 1.

At the end of each month within the canyoning season, participants were asked for information about their canyoning hours and number of tours performed, tour conditions, specific preparations, equipment employed and sustained injuries. When an injury-event was reported, additional information regarding the affected body part, type and pattern of injury, reason for injury, injury severity and causes for injury were assessed.

During the season, canyoning related online-media was checked weekly by one of the authors to ensure that none of the canyoneers lost to follow-up had suffered a fatal injury.

Rappelling refers to a controlled descend with a rope. Climbing refers to every action performed to scale vertical obstacles like rock faces for example. Sliding was defined as any slide along surfaces with continuous contact to the underground and swimming was considered as any action in water. Transmigration means moving along between the aforementioned actions on passages such as ravines or tunnels. Canyoning equipment was defined as every type of equipment used during practice or competition additional to conventional swimming gear.

Injury rate calculation and risk factors

In order to enable inter-study comparability, an injury was defined according to a consensus statement as any physical complaint that results from training or competition, regardless of medical treatment requirement or absence from sports [11]. There are several different ways of expressing the injury rate [12–16]. Reporting injuries per 1000 h of sports exposure is a well-established method and was adopted for the current study [7,9,10,17–22]. The term exposure comprises everything between the start and its very end of a canyoning tour. An injury-event was defined as an incidence with possibly more than one injury type or affected anatomical location involved [7,10].

The definition of the severity of injury was based on the extent of sports impairment [10].

Injuries causing no disruption of training or competition were considered mild. Injuries resulting in a partial restriction from usual level of performance while still allowing participation in sports were defined as moderate. Injuries resulting in total absence from sports for a certain timespan were classified as severe and injuries leading to permanent disability or death were considered fatal [10].

Risk factors are defined as factors distant from the inciting event of an injury [23,24]. An individual may be susceptible for injury due to intrinsic risk factors such personal skill level, age, somatotype and history of previous injuries [23]. Such factors predispose the athlete and extrinsic risk factors like equipment,

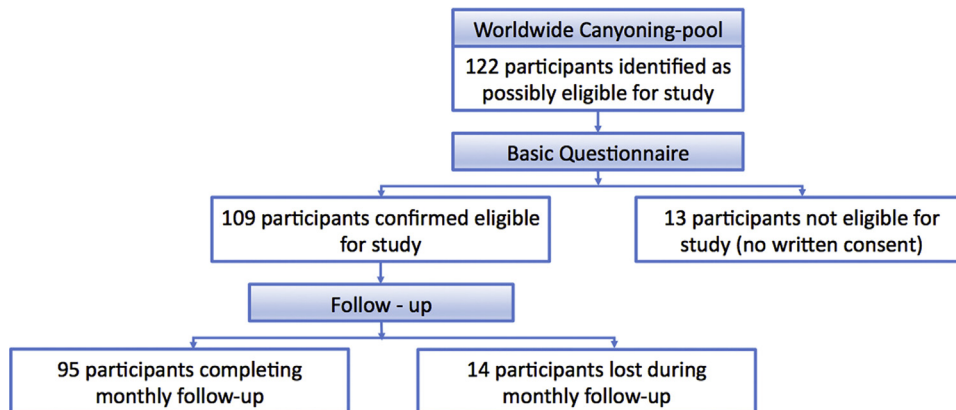


Fig. 1. Sampling procedure of all participants.

Table 1  
Classification of personal level of performance.

Variable	Level of performance		
	Beginner	Advanced	Professional
Experience	Just started	>1 canyoning season	canyoning guide
Climbing level	No experience	Guided, no leading climb, simple tracks	Independent security, leading climb, any tracks
Rappelling	No experience, distance <10 m	Guided, no leading rappelling, distance >10 m	Independent security, leading rappelling, any distance
Diving	No acrobatic elements, <10 m	Simple tricks and rotations, >10 m	All kind of dives, any diving height

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