©Journal of Sports Science and Medicine (2019) **18**, 207-212
http://www.jssm.org

**Research article**

# Acute Injuries in Male Elite and Amateur Mountain Bikers: Results of a Survey

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**Abstract**
Together with the growing popularity of mountain biking, the number of riders at risk for an acute injury has increased. A cross-sectional observational study was performed to describe the prevalence of acute injuries among elite and amateur riders and to determine predictive factors leading to a severe injury. A retrospective questionnaire was created comprising questions aiming on demographics, training volume, injury events and wearing of protective gear items. The survey was conducted during the Swiss Epic Mountain Bike Event in 2017. Complete data sets of male mountain bikers were used to determine prevalence. To evaluate injury related factors, only data sets reporting one or more injuries were included in the final analysis. Ninety-nine questionnaires were included to calculate the injury prevalence of 74% for elites and 69% for amateurs ($p = 0.607$). For the analysis of injury related factors 56 questionnaires were processed. Elites were significantly younger ($p = 0.004$) and had a significantly higher exposure time per year as amateurs ($p < 0.001$). The groups did not differ in number of injuries ($p = 0.437$) and number of severe injuries ($p = 0.225$). No predictive factors for a severe injury event were found. Both groups wore an equal amount of protective gear items ($p = 0.846$). A significant medium, respectively small correlation was found in both groups for mean hours of training per week and number of races per year (elites: $r = 0.597$, $p = 0.023$; amateurs: $r = 0.428$, $p = 0.005$). An equal prevalence of acute injuries was found in elite and amateur mountain bikers. Elites are at higher risk for an injury event due to their exposure time but do not suffer more or more severe injuries than amateurs.

**Key words:** Mountain biking, off-road cycling, acute injury.

## Introduction

Mountain biking has developed to a popular sporting activity since its beginning in the early 1970s (Chow and Kronisch, 2002; Gaulrapp et al., 2001; Kim et al., 2006). Recreational and competitive athletes likewise follow this sport, promoting the onset of racing events for all kinds of riding levels and mountain biking styles (Jeys et al., 2001; Lareau and McGinnis, 2011). Consequently, mountain bike related injuries increased, affecting simultaneously the health-care and socio-economic costs (Cumps et al., 2008; Ozturk and Kilic, 2013). Following the literature, overuse syndromes occur more frequently than acute injuries, but the latter force athletes to stop riding more often (Campbell and Lebec, 2015; Oehlert et al., 2004). Contradictory statements for the prevalence of acute injuries in recreational bikers are mentioned in the literature (Kim et al., 2006; Nelson and McKenzie, 2011). Following Nelson and McKenzie (2011) acute mountain bike related injuries requesting treatment in an emergency department significantly dropped by 56% between 1994 and 2007, whereas Kim et al. (2006) reported a threefold increase over a 10-year period of 1992-2002. The present study aimed to assess the prevalence of all acute mountain bike injuries a rider has received during his to-date mountain biking career. To the authors' knowledge, there is a lack of data on acute injuries in elites. Therefore, in the present study, elite and amateur riders were analyzed separately. The authors hypothesized that elite riders train more, wear more protective gear items, get injured less frequently and less severely compared to amateur riders. Additionally, this study aimed to reveal predictive factors, which determine events of severe injuries for elite and amateur riders separately.

## Methods

### Design and participants

In this cross-sectional observational study, male elite and amateur mountain bikers, attending the Swiss Epic Mountain Bike Event held in Valais in 2017, were asked to fill out a retrospective survey on mountain bike related injuries. The Swiss Epic Mountain Bike Event 2017 comprised four racing formats; 1) Swiss Epic = five stages over five consecutive days with in total 342 km riding distance and 11'800 m uphill altitude difference, 2) Swiss Epic flow = five stages over five consecutive days with 285 km riding distance, 6'350 m uphill and 13'400 m downhill altitude difference, 3) Swiss Epic two days = 130 km and 4'700 m uphill altitude difference, and 4) Swiss Epic two days flow = 88 km, 1'950 m uphill and 3'800 m downhill altitude difference. All four race formats can be contested as team or one-man race, which makes the event attractive for amateur and elite mountain bike riders. No ethical approval was required for this observational study as no personal data was collected.

### Inclusion criteria

Inclusion and exclusion criteria were set a priori. In a first step, incomplete data sets in terms of gender, age, riding level and injury reporting were excluded. In a next step, due to the low number of female respondents, female participants were excluded to ensure comparability and homogeneity of the data. The remaining data sets were used to assess the prevalence of injuries. In a last step, to document injury related outcomes and predictive factors for severe injuries of elite and amateur riders, participants never been injured were excluded from the final analysis.

Received: 21 November 2018 / Accepted: 28 January 2019 / Published (online): 01 June 2019

## Measurement

A face-validated questionnaire was designed in accordance with existing literature (Gaulrapp et al., 2001; Lareau and McGinnis, 2011). To access a maximum range of participants, the questionnaire was translated into English, German, Spanish, French and Italian by bilingual persons familiar with mountain biking. The participants were asked to tick the most appropriate answer. The questionnaire aimed to assess the athletes' 1) basic demographics, riding level and years of experience, 2) number of races per year and mean hours of training per week, 3) number and kind of suffered injuries related to mountain biking and medical treatment requirement, 4) and amount and kind of protective gear items.

## Data processing

Self-reported riding levels were classified into recreational, amateur, semi-professional, and professional mountain biker. For this study, the authors grouped recreational and amateur as *amateur*, semi-professional and professional as *elite* mountain bikers. *Injury* was defined as stated in Chow et al. (1993), namely, 'the presence of pain, discomfort, or disability'. An injury was categorized as *severe*, when a concussion and/ or bone fracture and/ or joint injury was reported. Skin and soft tissue injuries were classified as *mild* injuries as defined in previous studies (Gaulrapp et al., 2001; Kim et al., 2006). The number of races per year and the mean hours of training per week were used to estimate the total exposure time per year, meaning the total time at risk to suffer a mountain biking related injury. For that purpose, considering that a cross-country race lasts 1 to 4 hours (Lareau and McGinnis, 2011), the number of races per year was multiplied by factor 4 to transform 'racing hours' into 'training hours'. The injury rate per 1000 hours exposure time was calculated. First, the hours of exposure time per year were multiplied by the number of years practicing mountain biking to get the total hours at risk. Then, the total amount of injuries ever was divided by the total hours at risk, multiplied by 1000 hours to get the injury rate per 1000 hours of exposure time.

## Statistical analysis

Data analyses were performed using the Statistical Package for Social Sciences (SPSS), version 24.0 (IBM Corporation, Armonk, NY, USA). Descriptive statistics [means ± standard deviations (SD) and relative frequencies (%)] were retrieved. Pearson correlations were used to assess correlations between the outcome variables. Chi-squared tests were applied to determine group differences of injury prevalence and the occurrence of severe, respectively mild injury events. Multivariate logistic regressions were performed to evaluate predictive factors among the outcome variables (independent variables) of severe injury events (dependent variable; no severe injury = 0 versus severe injury = 1) in elites and amateurs separately. Independent samples *t*-tests were used to evaluate mean group differences in demographics, and training and injury related variables between the elite and the amateur mountain bikers. *P*-values < 0.05 were considered as statistically significant. According to Cohen (1992), effect sizes were calculated for the correlation analyses and defined as follows; r = 0.20 small, r = 0.50 medium, r = 0.80 strong.

# Results

## Flow of included participants and injury prevalence

A total of 139 questionnaires was returned, which corresponded with a response rate of 43%. Out of them, 99 (31 elites and 68 amateurs) were included for the calculation of the injury prevalence. The results showed a total prevalence of acute injuries among all male respondents of 71%. Next, riders reporting no injury (23 elites and 47 amateurs) were excluded from the study, while another 8 elites and 6 amateurs were omitted due to missing answers of injury or training relevant questions. Thus, 56 participants were included in the final analysis (see Figure 1). Table 1 illustrates the basic demographic information and riding experience of the finally included elite and amateur riders. Their participation in the four racing formats of the Swiss Epic Event was as follows; Swiss Epic: 13 elites, 19 amateurs; Swiss Epic flow: 2 elites, 12 amateurs; Swiss Epic two days: 8 amateurs; Swiss Epic two days flow: 2 amateurs. Table 2 displays injury related factors comprising the number of injuries ever related to MTB, injury rate per 1000 hours of exposure time, number of severe and mild injuries, number of injuries requiring medical treatment and amount of worn protective gear items.

**Table 1. Demographic and training specific characteristics grouped by elite and amateur riders reporting an injury (mean ± SD).**

| | Elites (n = 15) | Amateurs (n = 41) |
|---|---|---|
| **Age (yrs)** | 32.47 ± 12.12 | 40.7 ± 7.6* |
| **MTB experience (yrs)** | 15.73 ± 6.78 | 15.29 ± 8.89 |
| **Mean hrs of TR/week** | 12.57 ± 3.86* | 8.24 ± 3.97 |
| **N races/yr** | 22.6 ± 12.9† | 3.68 ± 4.23 |
| **Exposure time hrs/yr** | 743.86 ± 238.12† | 443.10 ± 214.13 |

hrs = hours, MTB = mountain biking, n = number, TR = training, significant difference between elites and amateurs at p < 0.05*, p < 0.001†

**Table 2. Injury related factors grouped by elite and amateur riders reporting an injury (mean ± SD).**

| | Elites (n = 15) | Amateurs (n = 41) |
|---|---|---|
| **Injuries related to MTB (n)** | 4.6 ± 5.5 | 3.5 ± 4.3 |
| **Injury rate [a]** | 0.39 | 0.52 |
| **Severe injuries (n)** | 1.93 ± 3.33 | 1.82 ± 2.74 |
| **Mild injuries (n)** | 1.87 ± 5.19 | 0.61 ± 1.27 |
| **Injuries requiring MT (n)** | 10 | 16 |
| **Amount of worn [b]** | 3.20 ± 0.77 | 3.24 ± 0.73 |

[a] Injury rate per 1000 hrs exposure time; [b] Amount of worn protective gear items; MT = medical treatment, MTB = mountain biking.

## Mean group differences between elites and amateurs

The injury prevalence did not differ between elites (74%) and amateurs (69%) (p = 0.607). Elites were significantly younger (p = 0.004), showed more training hours per week (p = 0.001) and a higher number of races per year (p < 0.001) compared to amateurs (see Table 1). No differences were detected for years practicing mountain biking (p = 0.863) and the number of injuries due to mountain biking (p = 0.437). The results showed no differences in the number of severe injuries (p = 0.581), the number of mild injuries (p = 0.849), the number of required medical treatments

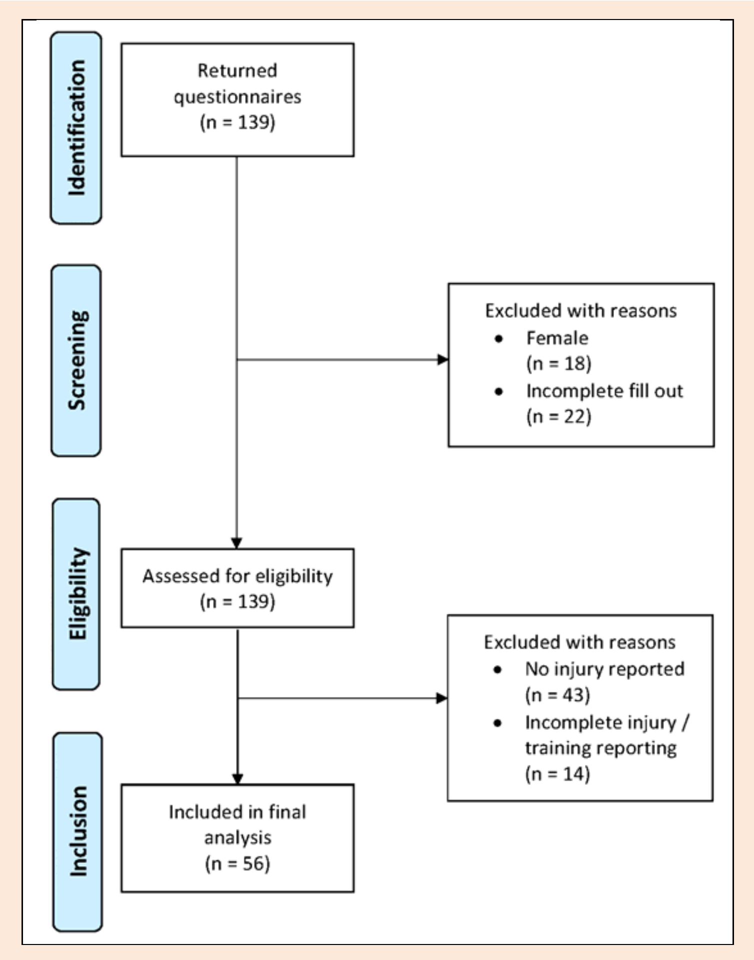


**Figure 1. Flow chart of participant selection process.**

(p = 0.066) and the amount of worn protective gear items (p = 0.846) (see Table 2).

## Frequency distributions of injury related factors and injured body regions in elite and amateur riders

The frequency distribution of the protective gear items worn and injured body sites for elites and amateurs are illustrated in Figure 2 and Figure 3, respectively. In elites, 66.5% of all injuries were severe (bone fracture 39.9%, joint injury 26.6%, and concussion 0%). The most affected body region by bone fractures was the knee/ calf region (53.5%), the hand/ finger region (30%), and the hip/ thigh region (13.3%). The shoulder and the foot/ ankle region were affected by 6.7% each. Joint injuries mainly affected the knee/ calf region (53.3%), followed by the hand/ finger (20%), the hip/ thigh (13.3%), the shoulder and the foot/ ankle region with 6.7% each. In elites, 33.5% were rated as mild injuries. Medical treatment was required in 66.6% of all reported injury events.

In amateurs, 63.4% of all injuries were severe (bone fracture 34.1%, joint injury 24.4%, concussion 4.9%). The frequency distribution of body region affected by bone fractures was equal for the hip/ thigh, the knee/ calf, and the shoulder region (26.8%, respectively), followed by the hand/ finger (14.6%), the trunk (12.2%), the head (7.3%), and the foot/ ankle region (4.9%). The joint injuries followed exactly the same frequency distribution order as described for the bone fractures. In amateurs, 36.6% of all injuries were skin and soft tissue injuries, and thus classified as mild injuries. Overall, 39.0% of all reported injuries in amateurs required medical treatment.

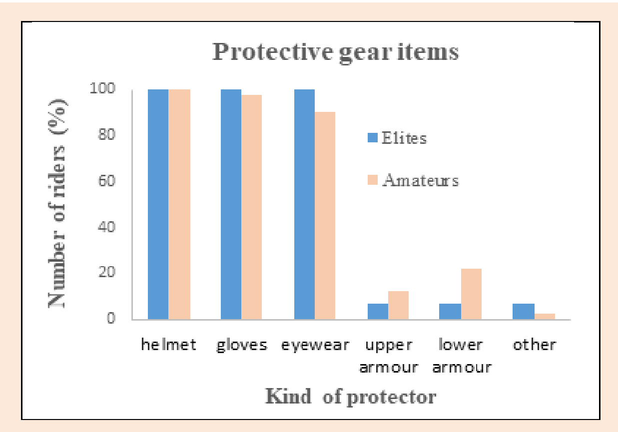


**Figure 2. Frequency distribution of worn protective gear items among elites and amateurs.**

## Correlations among injury related factors in elite and amateur riders

Within the elite riders, a significant medium correlation was found for years practicing mountain biking and amount of worn protective gear items (r = 0.582, p = 0.023). A significant medium correlation was detected for the number of injuries due to mountain biking and the number of races per year (r = 0.597, p = 0.019). A significant medium correlation was found for mean hours of training per week and number of races per year (r = 0.670, p = 0.006). No corelation was found between the amount of worn protective gear items and the number of injuries ever had due to mountain biking (r = -0.180, p = 0.521).

Within the amateur group, a significant small correlation was detected for mean hours of training per week and number of races per year (r = 0.428, p = 0.005). No correlation was found between the amount of worn protective gear items and number of injuries ever had due to mountain biking (r = -0.202, p = 0.206).

## Predictive factors for the event of a severe injury in elite and amateur riders

Multivariate logistic regression analyses showed no significant predictive for the event of a severe injury for both groups (see Table 3).

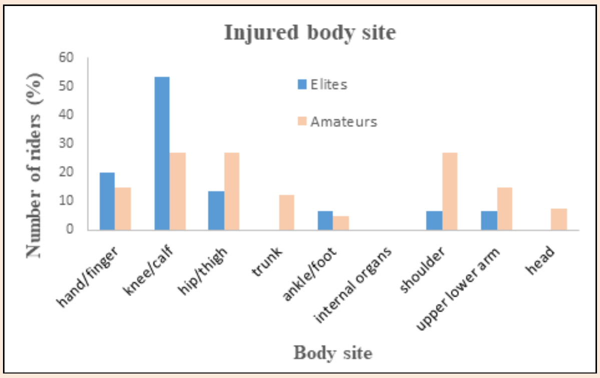


**Figure 3.** Frequency distribution of injured body sites among elite and amateur riders.

**Table 3.** Coefficients of the logistic regression model for the predictive factors of a severe injury event in elite and amateur riders.

| | Odds Ratio Elite / Amateur | *p*-value Elite / Amateur | 95% Confidence Interval Elite / Amateur | |
|---|---|---|---|---|
| | | | Lower bound | Upper bound |
| **Age (yrs)** | 1.044 / 0.961 | 0.950 / 0.209 | -1.300 / -0.103 | 1.386 / 0.022 |
| **Exposure time (hrs/yr)** | 2.518 / 0.998 | 0.224 / 0.141 | -0.566 / -0.004 | 2.413 / 0.001 |
| **Number of injuries ever** | 1.613 / 0.912 | 0.468 / 0.168 | -0.814 / -0.223 | 1.771 / 0.039 |
| **Number of races per year** | 4.304 / 0.946 | 0.178 / 0.177 | -0.666 / -0.136 | 3.585 / 0.025 |
| **Mean hours of training per week (hrs)** | 2.158 / 0.909 | 0.287 / 0.193 | -0.647 / -0.238 | 2.185 / 0.048 |
| **Amount of protective gear items (n)** | 1.404 / 0.775 | 0.594 / 0.491 | -0.907 / -0.979 | 1.585 / 0.470 |

## Discussion

The aim of this study was to assess the prevalence of acute mountain biking injuries in elite and amateur riders and to compare both groups in terms of injury related outcomes. As the survey of the present study was conducted during the Swiss Epic Mountain Bike Event, which mainly attracts cross-country riders, the findings of the present study may uniquely be transferred to a cross-country mountain bike population. Further, a selection bias may have occurred due to this specific cohort. A majority of participants (71.0%) reported at least one event of a mountain biking related injury. Existing literature reported contradictory injury prevalence although the same definition for injury event was applied (Chow et al., 1993). Also Gaulrapp et al. (2001) mentioned a non-comparable prevalence value. This difference may be explained by the use of a different injury definition, namely, 'an event preventing the athlete from at least one day of mountain biking' (Gaulrapp et al., 2001). Further, the latter two studies were conducted in different decades compared to the present study, questioning their comparability due to technical development and awareness of injury risk in this developing sport. This contradiction is supported by previous studies on the development of injury events seeking treatment in an emergency department or trauma center over a comparable period and point in time (Kim et al., 2006; Nelson and McKenzie, 2011).

The finding of the significant group difference in mean hours of training per week and number of races per year was hypothesized. All of the elite respondents participated in the five-stage racing format highlighting their need for specific training. However, this survey missed to assess whether the races were performed alone or as a team. Further, elites might perform several mountain biking styles, where specific mountain bikes are used (Becker et al., 2013) and therefore technical and performance skills need to be adapted accordingly (Burr et al., 2012; Impellizzeri et al., 2005).

Both groups train and focus on race preparation according to the correlations found, indicating the professionalism in this sport to get prepared for a racing event. Concerning the number of injuries per 1000 hours of exposure time, the findings of the present study are comparable with a previous study by Himmelreich et al. (2007).

The observed elites and amateurs in the present study used an equal amount of protective gear items. The amount of protective gear items was not predictive against injuries. Elites tend to wear more protective gear items with increasing years of practicing mountain biking, whereas this correlation was not found in amateurs. They might take more risk during races with increasing experience and try to avoid injuries by wearing protective gear items. The higher percentage of required medical treatment of elites for all kinds of injuries may be influenced by the availability of medical staff within a professional team and/ or professional racing event.

A recent study publishing preliminary data reported that wearing a helmet correlated with an increased injury rate in non-professional cyclists (Bogusiak et al., 2018). Further, another study mentioned that the injury risk of bicyclists for a serious event was not impaired by wearing a helmet (Rivara et al., 2015). An explanation for those findings could be that injury risk includes all injuries regardless of the affected body region. Wearing a helmet might not prevent a rider from upper or lower extremity injuries. All riders in the present study reported the wearing of helmets. Concussions occurred in amateurs, whereas they did not in elites, suggesting a higher impact of falls in amateurs compared to elites. The finding that amateurs suffered bone fractures of the shoulder region may be explained by the falling mechanism over the handle bar.

In the present study, both groups mainly suffered from bone fractures of the lower extremity. In the literature, bone fractures of the upper extremity (Bogusiak et al., 2018; Jeys et al., 2001; Lea et al., 2016; Nelson and McKenzie, 2011) and/or tibia (Kim et al., 2006) were reported as the most commonly fractured body site in non-competitive cyclists and mountain bikers. In contrast with the present study, McGrath and Yehl (2012) describing the same rider population and bike race event as presented in the present study, reported skin and soft tissue injuries as the most common injury event. An explanation for this discrepancy could be that they focused on a point prevalence of injuries occurring during the racing event rather than assessing the total suffered injuries since performing mountain biking. Furthermore, in the present survey, recall bias may have led to underreporting of mild injuries (as people tend to remember severe injuries better than mild injuries).

Future studies should consider the most appropriate injury definition concerning the study's purpose and requested comparability within the research field. The definition of injury of the present study was chosen in accordance with Chow et al. (1993) to ensure the inclusion of a wide range of events. To enhance the homogeneity of injury severity grading, upcoming studies are advised to evaluate the application of the injury severity score (ISS). In the present study the application of the ISS was not considered since the questionnaire used was performed as a self-evaluating tool without any assistance of a medical professional, who would had been able to rate the ISS. An improvement for future studies might be in-depth interviews as survey technique. Further, the authors recommend the use of a validated questionnaire to increase the validity of the reported outcomes. As possible limitation of the present study could be mentioned that athletes might have experienced problems to rate their performance level as no official classification was applied. This study did not focus on the kind of training. It might had been interesting to detect differences in training content between elite and amateur riders and to evaluate training content as a predictive factor for the occurrence of a severe injury. As a previous study suggested, isometric strength training might be required for the sufficient control of the handlebar (Impellizzeri and Marcora, 2007).

## Conclusion

This study aimed to show injury-related outcomes of acute mountain bike injuries of male elite and amateur riders separately. An equal prevalence of acute injuries was found in elites and amateurs. Elites train significantly more and wear the same amount of protective gear items compared to amateurs. Despite their higher exposure time, elites do not get injured more frequently and not more severely than amateur riders. No predictive factors for the occurrence of a severe injury were found for either group.

### Acknowledgements

The authors like to thank the "Thim van der Laan" foundation, Landquart, Switzerland, for the financial support. The experiments comply with the current laws of the country in which they were performed. The authors have no conflicts of interests to declare.

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## Key points

- Male elite and amateur mountain bikers have an equal prevalence of acute mountain bike injuries.
- Elites have a significantly higher exposure time per year compared to amateurs.
- Elite and amateur riders do not differ in injury occurrence and injury severity.
- Bone fractures affecting the lower extremity are the most prevalent severe injuries in elites and amateurs.

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