Extreme Mountain Biking Injuries

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12.1 Introduction

In the last decades, "extreme mountain biking" (EMB) has become a popular extreme sport introducing many subdisciplines such as downhill mountain biking (DMB) or freeride (FR) which draw increasing numbers of participants at both competitive and noncompetitive level. It is performed during summer in countries all over the world, especially in mountainous areas where competition venues have been built recently.

The year 1973 is generally considered as the birth year of mountain biking (MB) and the Mount Tamalpais in Marin County, California, as place of birth. From a historic point, the concept of off-road bicycles was applied already in the expedition of Buffalo Soldiers from Missoula, Montana, to Yellowstone and back in August 1896. "Cyclo-cross" is another early example for off-road cycling introduced in the early 1940s by road racing cyclists to keep fit during the winter. Later on this sport became its own rights and the first world championship was held in the 1950s. Between 1951 and 1956, the French Velo Cross Club Parisien (VCCP) members developed a sport in the outskirts of Paris that was very similar to the today's mountain biking. In the United Kingdom, in 1955, cyclists founded the Roughstuff Fellowship and in 1966 D. Gwynn invented a bicycle for off-road terrain which he named "mountain bicycle." Geoff Apps, an English motorbike rider, started to experiment with off-road bicycle designs in 1968. By 1979 he had developed lightweight metal frameworks that were customized and perfectly suited in combination with thick tires for muddy off-road cycling.

The so-called Schwinn cruisers, a sturdy and heavy bike type with thick balloon tires from the 1930s and 1940s were used and modified by a group of bikers like Gary Fisher, Joe Breeze, and Charles Kelly to speed down the dirt roads of Mount Tamalpais in Marin County, California, in the 1970s. Due to its geometry, the "Schwinn excelsior" was the frame of choice. Their modification by using motocross or BMX style frame parts created the so-called klunkers.

In the USA the development of bikes for off-road purposes started in the late 1970s and was pushed by several bikers such as Joe Breeze, Gary Fisher, Charlie Kelly, and Tom Ritchey. Joe Breeze is credited with the introduction of the first mountain bike in 1978. Tom Ritchey, Charlie Kelly, and Gary Fisher founded the partnership "MountainBikes" introducing the first original mountain bikes. They were basically road bikes with wider frame and fork to allow thicker tires. Tom Ritchey was credited with the development of

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Fig. 12.1 Extreme mountain biking can be performed at incredible places, especially in mountainous areas (Photo courtesy of Manfred Stromberger)

the first mountain bike frame with transverse-mounted handlebar. The company "MountainBikes" pioneered with the first mass production of mountain bikes, followed by Tom Ritchey, who dissolved later from the company, and specialized.

The first mountain bike competitions were started in 1976 at Mount Tamalpais as well. These competitions were the impulse for a whole series of technical modifications, which was the beginning of the development of the today's mountain bike technical features. Gary Fisher was the first biker who introduced a gear shift fixed to the handlebar, which made it much easier for the biker changing gears in stand-up position during competition. However, the exact technical development cannot be traced back due to a lack of documentation. Since the beginning many subdisciplines have been introduced, and the corresponding technical development was always orientated to the appropriate need of bike discipline.

In the last decade extreme mountain biking (Fig. 12.1) became very popular, and nowadays at nearly every undulating landscape with favorable tracks or off-road trails, bikers can be admired doing long uphill tracks. It almost looks like mountain biking became one of the most popular summer sports in mountainous areas.

The idea of practicing mountain biking during the summer season in areas with sufficient undulating landscapes with favorable trail conditions seemed to be a natural progression. However, going up- and downhill in some matter may not be enough. It is in our nature to develop and adapt competences. Making use of the same principle of transforming strength and energy into a propelling force, downhill mountain bikers are able to reach high velocities (Fig. 12.2). Freeriders or dirt jumpers perform spectacular jumps combined with BMX style tricks due to the vertical lift created by artificial or natural redoubts (Fig. 12.3).

So far many subdisciplines with varying technical features have been introduced. Basically they differ according to meet their sporty demands. Nevertheless the frame's center of gravity or weight stays in focus. In the following section, each subdiscipline and its equipment are going to be introduced.

12.2 Mountain Biking

12.2.1 Disciplines

12.2.1.1 Cross-Country (XC)

Cross-country (XC) is one of the most popular mountain bike disciplines, and nowadays it is already an official Olympic discipline. Compared to a Formula 1 race in cross-country (XC), a round

Fig. 12.2 A compact and low frame with a low bottom-bracket height gives the downhill biker the best possible traction and an easy handling while riding at high velocities (Photo courtesy of Felix Weilbach)

Fig. 12.3 High velocity enables the athlete performing breath-taking jumps and tricks (Photo courtesy of Felix Jäger)

course is established which has to be completed multiple times by the athletes. The race is over either when a certain number of rounds are completed or when a certain time interval expired. The racetrack is usually between 3 and 9 km long and has to include the following terrain features:

- Amount of brick floors or asphalted streets less than 15 %
- Forest and country tracks
- Meadow trails
- Multiple gradients and descents

12.2.1.2 Downhill Mountain Biking (DMB)

Downhill mountain biking (DMB) is the general sense of to racing-oriented downhill riding. This sport is performed in the summer all over the world, especially in mountainous areas. It involves high velocities that runs up to 70 km/h, bolds maneuvers, turns, and jumps. In combination with hard and rocky underground spiked with natural or wooden obstacles, the difficulty consists of finding the best line between the highest speed and lowest danger of accident.

12.2.1.3 Freeride (FR)

Freeride (FR) includes elements from DMB however without fenced-off racing tracks and race clock. It is a "do anything" sports category of mountain biking. It combines breath-taking stunts with BMX style tricks and riding trails. The athletes require more technical skills and body control than XC athletes. "Big mountain freeride" is another and much more extremer style than FR. This sport was shaped through the biggest drops and most dangerous runs on off-road terrain with often 40° of slope. Events such as Red Bull Rampage in Utah, USA, made this style of FR very popular.

12.2.1.4 All-Mountain/Enduro (AM)

The all-mountain (AM) category resembles the traditional mountain biking the most. All athletes have to overcome a track with climbs and descents on a variety of terrain in the shortest time as possible. While traditionally called all-mountain riding, this style has been adopted to the Enduro World Series. There are three types of Enduro riding. The first is "Big Mountain" Enduro and very similar to DMB but much longer. A defined and timed course with incorporated climbing sections has to been overcome and sometimes it takes the whole day to complete the course. The second "Gravity" Enduro style has the same amount of climbing and downhill sections, but the climbing sections are not timed. However, there is a maximum of time in which an athlete has to reach the top of the climb. The third "Super D" Enduro style is similar to XC race with climbs followed by descent sections on a defined track.

12.2.1.5 Four-Cross/Dual Slalom (4X)

In both sports the athletes compete in slaloms either in short slalom tracks as in four-cross (4X) or on separated tracks as in dual slaloms against other athletes.

12.2.1.6 Dirt Jumping (DJ)

As its name implies, the idea behind this sport is to ride the bike over a shaped hill of soil or mud and to become airborne after riding over the "takeoff" and to perform rotations and tricks while aiming a clean "landing."

12.2.2 Equipment

To practice each subtype of EMB, basic and individual equipment is needed and has to be adjusted according to the athlete's weight, skill level, and different track and weather conditions.

12.2.2.1 Bike Technique

Typical characteristics of a mountain bike are wide tires with 559 mm rim diameter. Derailleur gears are also typical with 21–30 gears being frequently employed. Common translations are 44/32/22 in the front with triple chainrings and 11–32, 34, or 36 at the rear with eight, nine, or ten sprockets. In downhill and dirt bikes, only one chainring with chain guide is used.

Mountain bikes have a relatively small frame with steeply sloping top tube. Usually large pipe diameters are used especially in aluminum frames. Aluminum was the material of choice used to build frames, but increasingly carbon fiber reinforced plastics are employed. They are much lighter but also vulnerable to breach. Already a stone impact or scratches can damage fibers and weaken the structure of the frame after a fall. Frames made of titanium are also an alternative option. They are particularly comfortable and corrosion safe but also very expensive. Mountain bikes with frames made of steel or titanium are found almost exclusively in the high-price sector.

Cantilever brakes (V-brakes and hydraulic rim brakes) were frequently installed on mountain bike frames. Today's bikes are often equipped with disk brakes. Shock-absorbing forks are now standard equipment as well. In addition to the shock-absorbing front fork, rear suspension in mountain bikes is also increasingly used. In contrast to full suspension bikes ("fully"), bikes with rigid rear are called hardtail.

12.2.2.2 Suspension Systems

At the beginning of this sport, suspension systems were based on elastomers. Later on, they were replaced by steel suspension and air suspension. Steel suspension systems are usually preferred in downhill bikes in which the material is exposed to high-energy loaded forces and the

need of high reliability is required. Air suspensions are primarily used in cross-country bikes due to the importance of the bicycle's weight.

12.2.2.3 Front Suspension

The so-called forks are the suspension of the front wheel basically consisting of two tubes on each side in which one contains the suspension and the other one the dumping. Oil can usually be found as damping medium in suspension forks and air or steel as spring. Forks with air spring have the advantage that they are usually mild and the spring hardness can be adjusted via a valve. The steel spring has a linear force-way curve and responds more easily because it has less friction. There are numerous suspension fork systems that can be manually adjusted.

12.2.2.4 Wire Tires

This type of tire is the most prevalent tire used in bike sports. At the bottom of the tire flank, a solid core is incorporated, which forms a ridge with the surrounding material. Different types of wire tires exist and, for example, tubeless tires are widely used in downhill mountain biking. The advantage is the ability to drive it at low pressure without the risk of damage to the tube.

12.2.2.5 Tube Tires

In tube tires the outer tire is sewn together building a closed shell in which the tube lies inside. The advantage of this design is the low weight and usually a very low rolling resistance. Broken tires can be fixed by replacing the tube, but the costs are high and therefore they are only used in professional sports.

12.2.2.6 Solid Rubber Tires

Solid rubber tires are mounted on same rims as wire tires. Their advantage is the high puncture resistance, and their disadvantage is their high rolling resistance and extreme weight.

12.2.2.7 Air Pressure

The optimum air pressure in tires depends on different aspects but also by the personal taste: In mountain bikes, downhill or cross-country bike traction and suspension have priority. The pressure in all terrain is between 1.8–2.5 and 2–4 bars for tubeless tires and 7–13 bars for tube tires. Each athlete adjusts the pressure depending on the ground and his weight. The individual setting has advantages and disadvantages such as lower pressure for higher traction in rough terrain but less stability in curves and higher pressure for less rolling resistance on asphalted streets. In combination with every bike system, every rider can set the suspension individually dependent on route conditions and athlete's weight including pitch of spring, compression, and rebound damping.

12.2.3 Subdiscipline-Specific Equipment

12.2.3.1 All-Mountain (AM)

The advantage of fully suspended AM bikes is the range of application from simple tours on plain landscapes up to alpine crossing tracks. More focus lies on reliability, comfort, and reserves in range of spring and less on the weight. The seating position is less stretched than a cross-country bike but still not as upright as compared to an Enduro bike.

The variability and the adjustment possibilities are essential for an AM bike. The range of spring is 120–160 mm. In some systems it can be entirely blocked for better uphill riding. On the other hand, some AM bikes offer the adjustment of the rear shock system. The weight starts at about 10 kg and goes up to 14 kg depending on the model. Wider and more profiled tires are used in AM compared to cross-country. AM bikes need to meet different requirements during the course of a race.

12.2.3.2 Downhill Mountain Biking (DMB)

Downhill bike frames mostly weight between 15 and 20 kg and are much heavier compared to all-mountain or cross-country bikes. Depending on the height of the athletes, different frame sizes are used ranging from extra small to extra large. The main keys and differences to other bikes are the center of gravity and front and rear suspension. Their construction allows the absorption of the bumpiness of the area leading to independence of driving and brake forces. The wheels

Fig. 12.4 *1* top tube (length, 560–620 mm); *2* seat tube (430–480 mm); *3* front suspension; *4* rear suspension; *5* upper linkages consisting of two wheel articulations which act in one axis; *6* regarding the suspension centers of rotation on each side absorb the bumpiness of the area additionally

have reinforced rims and spokes, four flask brakes, and a lower bottom-bracket height (ground to bottom-bracket height, 355 mm). The special construction of such downhill bikes with low frame, high suspension, and wide wheels offers easy handling and high traction (Fig. 12.4).

12.2.3.3 Cross-Country (XC)

Compared to DMB bikes, XC bikes are rather designed for unpaved roads than for heavy terrain. Both hardtail and full suspension bikes exist. Due to cost, durability, and weight, many drivers prefer hardtail bikes. Bike weights below 8 kg are achievable but costly. Their range of spring is between 80 and 100 mm and disk brakes are the state of the art.

12.2.3.4 Enduro

Enduro bikes have full suspension systems and in comparison to XC and mountain bikes, their range of spring is between 150 and 180 mm. Due to their different frame geometry, their weight lies between 12 and 16 kg and fitted with an adjustable landing gear, broader and more profiled tires. The handlebar is often cranked and the position is upright. The difference to FR bikes is that Enduros are much more crossing tour suitable. The large range of spring provides enough cushion in downhill parts or in drops and jumps – with lowered fork the Enduro is pleasant to ride uphill.

12.2.3.5 Freeride (FR)

FR bikes are very similar to DMB bikes – designed for use in heavy, steep terrain and fully suspended with a long range of spring from 150 to 200 mm. In contrast to the DMB, they are designed not only to departures. Due to modern suspension systems, it is possible with such heavy 20 kg bikes to go uphill as well. They prevent seesawing during pedaling and climbing sections are possible to attack.

12.2.3.6 Dirt Jumping (DJ)

Dirt bikes are sturdy mountain bikes with small, agile frames but also fitted with suspension leading to 65–100 mm deflection. The wheel size is not limited by 26 inches; also 24-inch wheels are often found. The weight stays in focus and kept mostly low in order to facilitate jumps. Also, the low weight favors rotations of the driver or of the bikes.

12.2.3.7 Four-Cross/Dual Slalom (4X)

4X bikes are pretty similar to dirt bikes. Mainly hardtails are used by the athletes and the frames are constructed slightly longer to maintain smooth running at high speeds.

12.3 Injury and Fatality Rates and Specific Types of Injury Related to the Sport

In recent years, extreme mountain biking has become a popular extreme sport drawing increased numbers of participants at both competitive and noncompetitive level. This sport involves high-velocity runs including jumps,

turns, and various maneuvers. In combination with hard, rocky, and slippy underground, it leads to high risk of serious injuries. To defy these demands, the athletes use bikes, which provide the best possible traction and suspension in order to enable the athlete to perform its best run. Up until recently, little was known about the true risk, incidences, and causes of off-road biking injuries.

Pfeiffer was the first who started reporting about acute injuries in off-road bicycling among competitive and recreational cyclists [1]. In 1995 he published an overview stating that off-road bikers sustain more severe injuries. However, the reported risk for injury was still low ranging from 0.2 to 0.39 injury per ride for competitive venues compared to 0.30 % for recreational bikers. One year later a comparison between cross-country and downhill mountain races investigating injury rates and pattern was published by Kronisch et al. [2]. No significantly difference for injury rate in cross-country (0.49 %) and downhill mountain biking (0.51 %) races could be determined. However, while racing in a competition, 4.34 downhill mountain biking injuries per 100 h of exposure compared to 0.37 cross-country injuries were recorded ($p=0.01$) indicating a higher risk for downhill mountain bikers. Most common injury types determined in cross-country vs. downhill mountain biking were abrasions (64 % vs. 40 %), followed by fractures (7 % vs. 15 %) and sprains (5 % vs. 10 %). The lower extremity was the most commonly injured body part for both disciplines (40 % vs. 30 %) followed by the upper extremity (38 % vs. 25 %). Bikers who fell over the handlebar exhibited a higher mean injury severity score compared to athletes who fell off to the side (3.0 vs. 1.3; $p=0.01$) leading to a higher rate of emergency room visits (6/10 vs. 1/10; $p=0.01$). Female competitors were more likely to be injured than men (5/6 vs. 5/14; $p=0.05$). Nevertheless, most injuries were minor and the calculated risk of being injured was rather low. Interestingly, another report investigating acute traumatic injuries during off-road races reported similar results [3]. In 16 cases injuries were reported as severe by preventing the athlete to complete his run leading to an overall injury rate of 0.40 %. Together all 16 athletes had 44 injuries ranging from lacerations to fractures. However, abrasions were the most common injury type, followed by lacerations, contusions, fractures, and concussions. The mean injury severity score was 3.0 of which 81.2 % were sustained by bikers going downhill. Due to such investigations, first thoughts have been expressed suggesting that the risk factor for acute traumatic injury varies with the type of competition involved.

The first prospective report in the literature regarding injury types and rates among extreme mountain biking was published in 2001 by Jeys et al. [4]. They reported a total of 133 injuries in 84 patients ranging from one to six injuries per patient over 1 year. The injury type ranged from minor soft tissue lacerations to life-threatening injuries. The most common injury was the fracture of the clavicle (13 %), followed by other shoulder girdle injuries (12 %) and fracture of the distal radius (11 %). Moreover, they reported six patients with open or closed fractures of the femur and tibia. Even one patient sustained a dislocated C2/3 fracture with neurological deficit requiring operative stabilization. The second most severe injury in this series was a patient requiring nephrectomy to control hemorrhaging. However, most of the injuries were minor.

Similarly severe injuries have been reported retrospectively by Apsingi et al. [5] including acute cervical spine injuries in three cases. In all three cases, a neurological examination revealed either an incomplete or complete tetraplegia due to subluxation of a vertebral body of the neck or spinal cord compression.

In 2005, Arnold et al. [6] presented a questionnaire-based study analyzing causes and pattern of different subdisciplines such as XC, DMB, and mountain biking. In professional bikers, the most injured region was the shoulder including the clavicle and AC joint (25 %), followed by the knee (21 %) and elbow and forearm and hand (18 %). In less experienced bikers, the shoulder girdle was the most frequently injured body part as well (15 %). The head and neck

(11 %), likewise the wrist and hand (11 %), were the second most injured regions followed by the knee (7 %). Overall they reported 6.8 injuries for men and 12.0 injuries for women per 1000 h of exposure; most of them were minor.

An interesting retrospective study was published in 2007 by Himmelreich et al. [7] in which injury rate and incidence among competitive and recreational XC and DMB athletes were investigated. A total of 80 % of the World Cup athletes reported at least one severe injury compared to recreational riders of whom only 50 % sustained one. They showed that DMB athletes (1.08 injuries per 1000 h of exposure) had more than a double times higher injury rate compared to XC athletes (0.39/1000 h). Interestingly, for competitive and recreational bikers, injuries of the lower (47 vs. 35 %) and upper extremity (40 vs. 41 %) showed similar prevalence. Abrasions and lacerations were the most common injury for recreational athletes, while competitive bikers had a significant higher fracture rate ($p<0.01$). Forty head injuries were detected during the World Cup series. However, participation in the World Cup did not increase the injury rate. Only a higher injury risk for DMB athletes could be determined.

Gaulrapp et al. [8] performed a retrospective questionnaire-based study assessing risk factors, types, and body site of injuries occurring in a population of 3873 EMB athletes. Overall 3473 bikers, of whom 36 % participated in competitions, reported 8133 single injuries. Most of the injuries were minor resulting in a total injury risk rate of 0.6 % per year and one injury per 1000 h of biking. Personal factors, such as excessive speed, riding errors, or poor judgment, were the most common risk factors besides slippery road surface. While abrasions and contusions were the most injury types leading to a total of 75 % of all reported injuries, 10 % severe injuries were reported requiring a prolonged hospital stay.

In a recent study performed at the authors' institution, 249 downhill athletes from Germany, Luxembourg, Switzerland, and Austria were prospectively surveyed over one summer season ranging from April until September to determine injury rate, cause, and patterns [9]. A total of 494 injuries during 29.401 downhill hours occurred; of these 65 % were mild, 22 % moderate, and 13 % severe. The calculated injury rate was 16.8 injuries per 1000 h of downhill mountain biking. This is distinctly higher than the reported injury rate for cross-country mountain biking above. Nevertheless, no catastrophic injury was reported. Of all athletes 80 % reported multiple injuries over the course of the season, and in 47 % of all cases, multiple body sites were affected.

The most commonly injured body part while Downhill Mountain biking was the lower leg (27 %). Second was the forearm with 25 %, followed by the knee with 21 % (Table 12.1).

The most commonly reported types of injury were abrasions (64 %), contusions (57 %), and distorsions (15 %; Table 12.2).

As further analyzed most common lower leg injuries were abrasions (81 %) and contusions (55 %). In forearm injuries abrasions (93 %) and contusions (60 %) were predominant as well. Overall 32 fractures were reported in this study of which six were clavicle fractures. Five bikers reported rib fractures of which two cases were

Table 12.1 Affected body region in case of injury ($n=494$)

Anatomic region	*n*
Calf	134
Forearm	121
Knee	103
Elbow	97
Hand	93
Shoulder	86
Thigh	85
Wrist	64
Hip	63
Ankle	43
Head/face	38
Ribs	36
Upper arm	33
Pelvis	28
Neck/cervical spine	21
Foot	19
Upper back	17
Lower back	17
Clavicula	17
Abdomen	13
Others	21

Table 12.2 Sustained injuries in case of accident ($n=494$)

Injury type	n
Abrasion	316
Contusion	279
Distortion	72
Laceration	62
Strained muscle	45
Fracture	32
Concussion	23
Ligament strain	23
Joint dislocation	15
Joint inflammation	7
Ligament rupture	4
Torn muscle fiber	2
Others	23

multiple rib fractures, followed by three finger fractures as the third most common fracture type. The most severe injury sustained by an athlete was a concussion with an intracranial hemorrhage in combination with multiple rib fractures (rib III-XI) and fractures of two fingers.

Due to the character of the sport, the runs are mostly performed over the whole day. Most injuries occurred at the middle of the day (58 %), whereas the rest was distributed evenly between the beginning (21 %) and the end (20 %) of the day. Most accidents occurred in curves (43 %), followed by accidents during jumps (32 %) likewise sloping terrain (32 %). In 63 % of the injury events, the athletes lost control on soil, followed by stones (45 %) and roots on the ground (33 %). Following a jump, most frequent landing zone terrain leading to an accident was soil (66 %), stone (44 %), or roots (24 %). Thirty-one percent of the injury events were associated with greater irregularities, excessive roots, and slippy underground considered as rather poor trail conditions. However, 30 % of the injuries were reported despite rather good trail conditions (small irregularities, scattered roots, and no slippy underground). Conversely, at the time of injury, 51 % of the athletes reported good weather conditions. Multiple causes were reported as injury circumstances, of which the most common were riding errors (72 %), poor trail conditions (31 %), and unforeseen trail obstacles (16 %; Table 12.3).

Table 12.3 Causes of accidents ($n=494$)

Cause	No.
Driving error	355
Trail conditions	155
Route obstacles	81
Overfatigue	50
Weather	40
Wrong choice of materials	38
Poor sight	18
Technical failure	16
Collision with other driver	8

Multiple causes possible

We determined a significantly higher injury rate of 17.9 (per 1000 h of exposure) for experts compared to professional riders (13.0 injuries per 1000 h of exposure; OR 1.34; 95 % CI, 1.02–1.75; $p=0.03$) assuming that the injury risk tends to become less for DMB athletes gaining more experience by practicing higher jumps with higher velocities. Moreover, a significantly higher rate of injury was reported during competition (20.0 injuries per 1000 h of exposure) than during practice (13.0 injuries per 1000 h of exposure; OR 1.53; 95 % CI, 1.16–2.01). However, no significant differences have been determined in the rate of mild (OR 1.26; 95 % CI, 0.90–1.75; $p=0.17$) versus severe injuries (OR 1.40; 95 % CI, 1.16–2.01; $p=0.01$). In the course of this study, only a few head and neck injuries have been recorded.

12.4 Common Treatments for Each Sport and Relevant Rehabilitation

Most injuries in extreme mountain biking are minor or moderate, but serious injuries, including internal organ damage and bleeding, are also possible (Fig. 12.5).

Contrast-enhanced computed tomography (CT) showed a laceration of the upper pole of the right kidney (point of arrow), associated with perirenal hematoma with a maximum thickness of 24 mm in the axial scans, with signs of extravasation of contrast material within the hematoma (arrow).

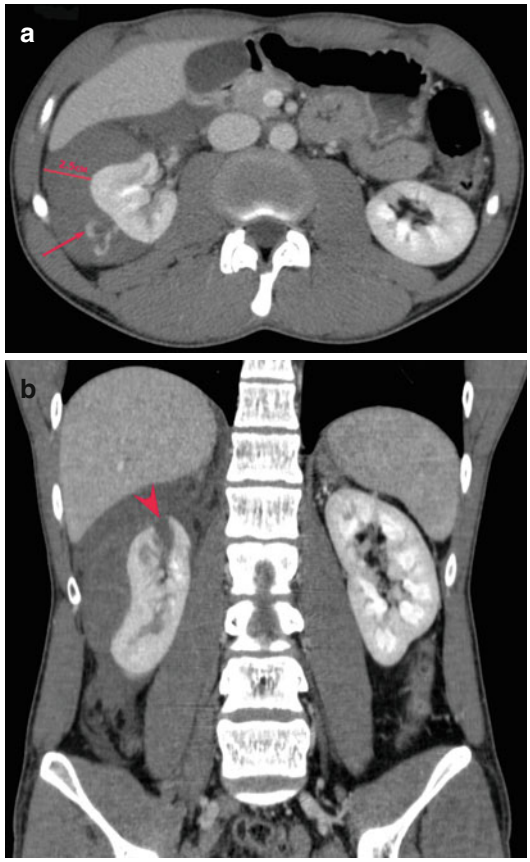

Fig. 12.5 (**a**, **b**) Case of a 25-year-old mountain biker who suffered renal damage and perirenal hematoma following a fall during a downhill session (Courtesy of Dr. Feletti, own case series)

Since the patient was hemodynamically stable, the laboratory parameters showed no significant alterations, and signs of hematuria were absent, and a conservative treatment approach was adopted, involving bed rest, ice packs, and a strict monitoring of the patient's clinical status and laboratory values, with an initial reassessment by CT after 6–8 h.

At CT follow-up, the hematoma showed no significant increase in size, and the signs of active bleeding had disappeared. Clinical and laboratory parameters were stable.

The patient was successfully treated using an ongoing conservative approach, involving the monitoring of clinical status and laboratory parameters, together with periodic follow-up ultrasounds (courtesy of Francesco Feletti; own case series).

In the two largest prospectively observed studies reported in the literature regarding off-road cycling and downhill mountain biking injuries, only 8–13 % were severe without any catastrophic injury documented. Even the retrospective surveys had similar results. However, due to the recall bias, such surveys are not comparable. The prospective survey of downhill mountain biking published by the authors is the only study, which tells us an accurate relationship between mild and moderate injuries. In this survey the relationship was 3:1.

In general injury treatment follows general guidelines of trauma care and sports medicine. Obviously, extreme mountain bikers suffer more frequently from mild injuries such as skin lesions. Abrasions and lacerations are often soiled, and therefore, adequate quick primary wound care management regarding cleaning and disinfection represents an important aspect already as first-aid measurement. Conservative treatment using splints or joint ortheses is the treatment of choice for joint sprains, muscle sprains, and minor ligament injuries.

Fractures represent the main part of moderate injuries. The decision on surgical or nonsurgical treatment depends on several factors and must be made by the trauma surgeon individually.

Signs of concussion, loss of sensibility, and motoric function after a fall should be taken seriously resulting in an adequate transport of the patient to a trauma center.

Rehabilitation times are injury dependent and have to be assessed individually by the treating physician. An important aspect after long injury-related abstinence from sports represents the general physical condition and fitness. To gain full convalescence, not only injury-specific rehabilitation measures should be taken, but general fitness and physical training programs are also recommended.

12.5 Proposed Prevention Measures

Extreme mountain biking is considered to be an extreme sport and therefore potentially dangerous. Beginners without appropriate instruction should

not attempt some subdisciplines especially downhill mountain biking. Basic riding skills are recommended as minimum competence levels before practicing in mountainous landscape. This includes all aspects of safe handling of bikes on street and off-road terrain concerning to be in control during uphill rough terrain, slippy underground while riding downhill, curves on the street or on off-road trails, vanquishing artificial trail obstacles, high-speed downhill sections, and landing unaided in the landing zone after a jump.

All extreme mountain bikers are required to respect general safety guidelines, as staying clear on the off-road trail or in the case of downhill mountain biking fenced-off trails. Weather conditions should always be taken in consideration. Particularly athletes of subdisciplines with downhill sections such as DMB, XC, or Enduro should use the right set of tires increasing the bike's traction under wet conditions. If riding off-road in unknown terrain, an accompanying experienced biker should be present.

An often-underestimated risk factor is the own assessment of riding skills. Depending on different biking venues or off-road trails, the athletes should always have information about the difficulty of the trails.

Certain prevention measures should be considered when performing EMB. Beginners should be introduced to this sport by a professional instructor or more advanced rider in order to be informed about the correct technique, usage of adequate equipment in different weather and trail conditions, and potential hazards to be aware of. Many extreme mountain bikers like to perform their sport on high-speed sections. Due to the higher speed, such trails convey an increased risk of injury. Even in known biking venues, it must be paid close attention that no unexpected obstacles are present on the trail, such as fallen trees or hikers. The use of safety equipment is of crucial importance. Athletes without helmets are at greater risk to sustain fatal head injuries leading to disability or death. Neck braces are often used, and in combination with full-face helmets, it should be part of every safety equipment while riding high-speed downhill sections. Body protection including gloves, safety glasses, protector jackets, shin guards, and back and wrist protectors should be worn accordingly to each subdiscipline. Both the spine and the back are at great risk of injury when trying high jumps or riding high speed on a hard and rough terrain. Of course, many other kinds of protectors that are available can be of benefit in case of an accident and should be considered. Further factors regarding the equipment should be taken into consideration. Every product has its limitations, which are depicted by the manufacturer's instructions and safety guidelines and have to be followed. A regular check and maintenance of the equipment are necessary to warrant its safety before riding. The development of more advanced devices is admittedly difficult but would increase the safety of the riders significantly, when functioning properly.

Finally, each subtype of EMB has to be considered an extreme sport. This means for all athletes practicing these sports, good physical condition is required including muscular strength, endurance, and mental fitness for competition as well as for practice. For untrained athletes a special physical preparation should be completed before the season. In order to reduce the risk of injury and to resist physical demands, the training should focus on endurance, strength, balance, and coordination.

All in all, it can be said that extreme mountain biking is becoming one of the most popular extreme sports in mountainous areas. Of course, as every extreme sport, it conveys a certain risk of injury. However, with the right instructions, equipment, and safety precautions, those risks can be diminished.

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