enduro mountain bike medical study

funded and supported by

enduro WORLD SERIES

conducted by

Edinburgh Napier UNIVERSITY

contents

foreword

After almost three years of research, we're pleased to present the results of what is likely the largest medical study ever to be undertaken in mountain biking.

Enduro racing is simply a competitive format that replicates mountain biking, and therefore the aim of this study was not just to analyse elite sport, but also the mountain biking population as a whole.

The report is split into two distinct parts; Part One focuses on the Enduro World Series (EWS) and how, where and when riders get hurt in our own events, whilst Part Two surveyed riders of all levels to find general trends in injury in all mountain bike riding regardless of racing or events.

Part One includes over 2000 racers from 46 countries from 10 EWS events, giving us enough data to provide what we believe to be accurate findings that we can all use to help us better develop organised enduro competition in future years.

For Part Two we asked you, our riders and followers to complete an in-depth health survey detailing all history of health issues and injury suffered from mountain bike riding (enduro for want of a better word) in and out of races or events. Overwhelmingly, over 3000 of you filled in the survey and 1940 of those riders from over 60 countries provided enough detailed and complete responses for us to be able to be confident in the accuracy of the data. More than half of riders who took part in the Rider Health Survey were riders racing below EWS level, showing great engagement from amateur racers and riders too. Therefore, we feel confident that this study provides a good reflection of injury and health for not just elite racers, but the whole spectrum of rider ability and age.

A huge thanks to everyone who took part in our work and we hope you find the results as interesting and informative as we have.

Chris Ball
Managing Director
Enduro World Series

part 1

two-season enduro world series race event medical study

executive summary

During the two-season EWS race event medical study 8.9% of EWS riders were injured during the 10 EWS races.

Overall there were 9.35 injuries per 100 riders; this compares to 23.8% per 100 athletes in mountain biking during the Rio 2016 Olympic Summer Games[1], 34.4 for Snowboard Cross, and 20.7 per 100 athletes for Alpine Skiing, during the Sochi 2014 Olympic Winter Games[2]

There were 0.08 race event injuries per rider per season with 12.3 days missed per injury in the EWS (all inclusive injury definition); rugby has previously reported 1.8 match injuries per player per season with 33 days lost per injury (time loss injury definition only)[3]

Almost a third of race event injuries occurred to inexperienced riders (those who only raced one EWS event)

Shoulder/clavicle injuries were the most common injury location, with shoulder/clavicle fractures and hand fractures the injury diagnoses causing the greatest burden (total days needed to recovery from injury)

56% of shoulder/clavicle and 66% of hand fractures, occurred during falls, on rocky stages.

The rate of race event concussion injury was low, and severity mild. Overall 0.6% of riders competing in the 10 EWS race events during 2017 and 2018 seasons suffered a concussion. This equated to 0.38 concussions per 100 EWS rider races, or 1 concussion for every 263 EWS rider races.

A little over a third of all riders with a concussion did not take time off post injury, with just under a third continuing and completing their race

The majority of laceration and contusion injuries were mild in severity, and occurred largely during steep technical stages.

rider demographics

Rider race and medical data was collected from 10 EWS races (Canada, France, New Zealand, Ireland, Italy, Chile, Australia, Slovenia, Austria, and Madeira) during the 2017 and 2018 EWS Seasons.

Countries represented 46
Total number of riders 2,010
90% Male
10% Female

249 riders competed in both seasons (2017 and 2018), and 1411 riders only ever competed in one EWS race.

number of riders

Table 1. Number (and percentage) of riders by race category

u21 (17 to 20)	senior (w 21 to 34; m 21 to 39)	masters (w 35+; m 40+)	total
296	1374	359	2029*
(14.6%)	(67.7%)	(17.7%)	
women 19	women 150	women 29	women 198
men 277	men 1224	men 330	men 1831

(*19 riders raced in more than one category i.e. an U21 rider then raced senior, or senior rider then raced masters, from the 2017 to 2018 seasons)

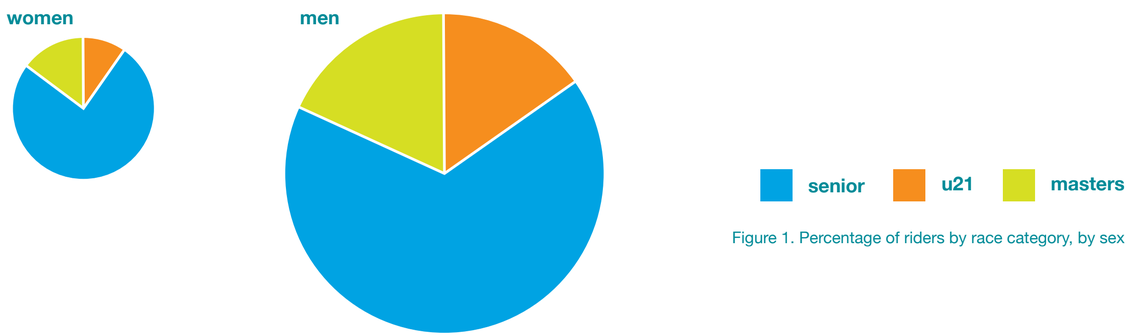


Figure 1. Percentage of riders by race category, by sex

rider injury

Rider injury data were collected by event medical staff during each EWS event, reporting any injuries where a rider sought medical treatment, irrespective of whether there was any time loss or absence from racing. Injuries were reported for all stages, across both practice and racing days.

During the two seasons 188 rider injuries were reported by event medical staff (Table 2). This equated to 8.9% of all riders in the study suffering an injury, or equivalent to 9.35 injuries per 100 riders, with on average 12.3 days missed per injury.

Table 2. EWS medical reported rider injuries

188 rider injuries

179 total number of riders injured*

8.9% percentage of riders injured

9.35 injuries per 100 riders

12.3 injury severity (days needed for recovery)

*some riders had more than 1 injury during the study

Figure 2 Percentage of riders injured and severity, by sex

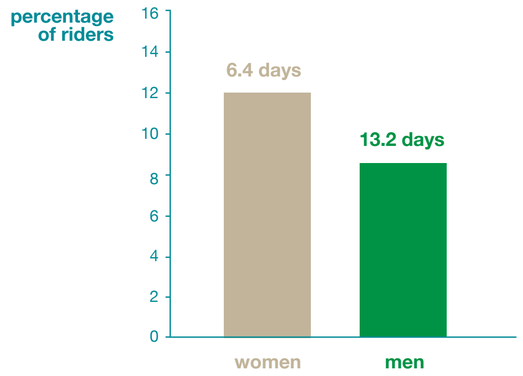


Table 3. Percentage of riders injured by race category

11.3% u21 men

0% u21 women

8.3% senior men

14.7% senior women

7.6% masters men

0% masters women

injury rates were higher for female riders but severity of injury was higher for male riders

when injuries happen

64% in race

36% in official training

71% of injuries were caused by contact with the ground and the remainder (29%) were for other reasons such as field of play conditions, recurrence, overuse.

60% of all injuries occurred on rocky stages, and a third on steep gradients (32%)

39.4% of riders who sustained an injury completed the race

race position

medical DNS	10.1%
medical DNF	45.7%
finished	39.4%
unknown	4.8%

Table 4. Percentage of rider injuries by race position

20.1% of all Did Not Starts (DNS) and Did Not Finishes (DNF) at EWS events were due to injury

injury location and type

The shoulder/clavicle was the most commonly injured body location, followed by the head, hand and lower leg (Table 5). The most severely injured body locations (mean days needed for recovery, per injury) were the thoracic spine, thumb, shoulder and ankle.

body location	no. of injuries	% of injuries	severity (days)
shoulder/clavicle	25	13.3%	24.9
hand	17	9.0%	12.2
head	17	9.0%	5.4
lower leg	15	8.0%	11.8
elbow	14	7.4%	5.1
knee	13	6.9%	8.0
forearm	11	5.9%	5.7
finger	11	5.9%	18.1
ankle	8	4.3%	23.1
hip	7	3.7%	3.4
sternum/ribs	7	3.7%	11.6
wrist	7	3.7%	15.0
lumbar spine/lower back	6	3.2%	4.5
face (inc. eye, ear, nose)	6	3.2%	1.2
thigh	5	2.7%	8.0
thumb	5	2.7%	34
neck/cervical spine	4	2.1%	0.0
upper arm	3	1.6%	5.6
thoracic spine/upper back	2	1.1%	45.0
pelvis/sacrum/buttocks/SIJ	2	1.1%	0.0
groin	1	0.5%	7.0
abdomen	1	0.5%	10
foot/toe	1	0.5%	0.0

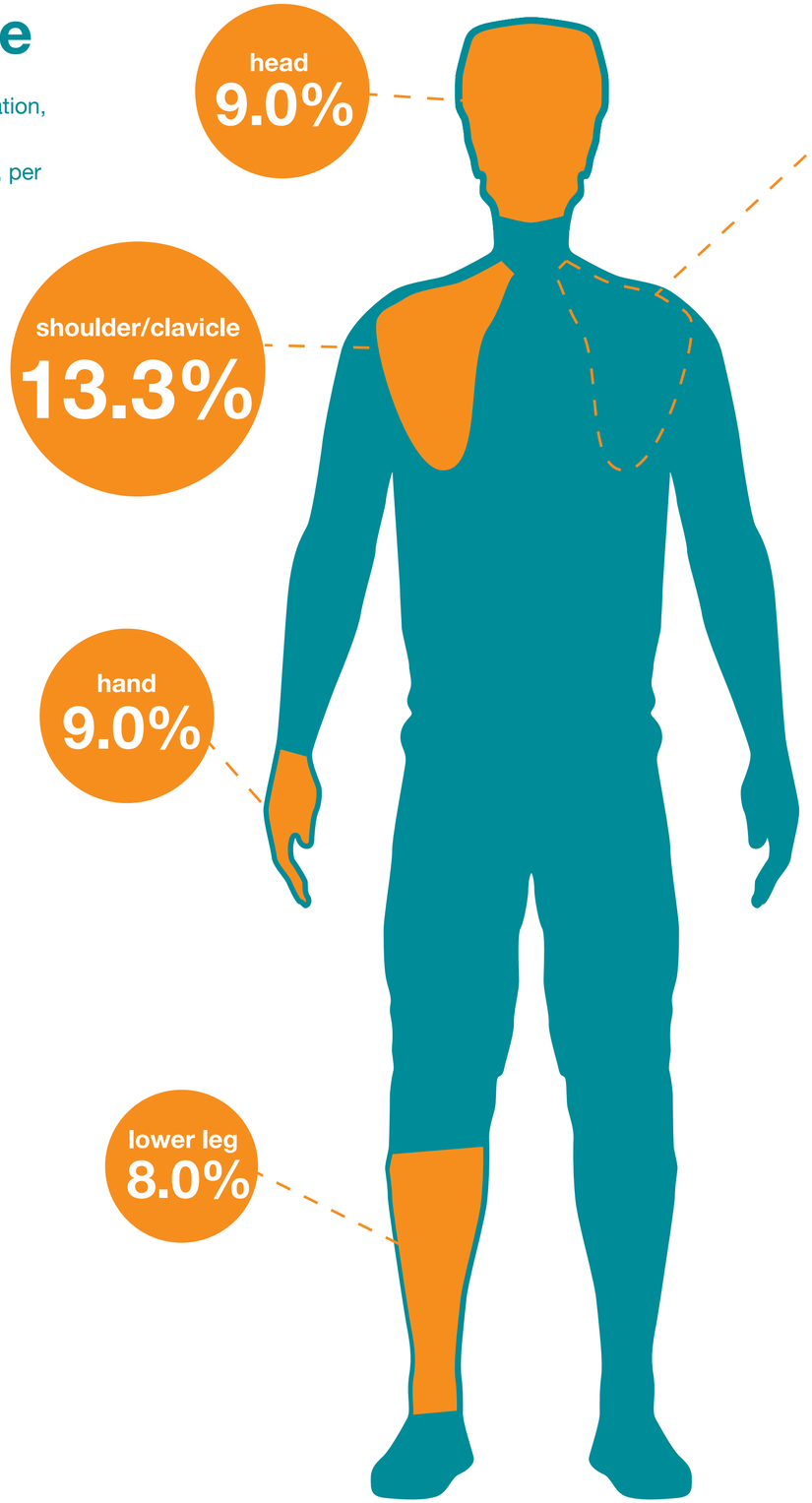
Table 5. Number, percentage and severity of injuries, by body location.

most common injury types recorded at EWS events

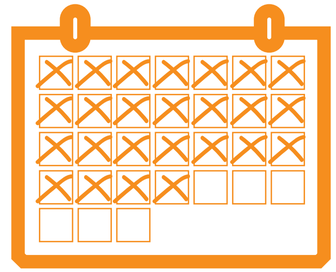
lacerations
26%
4.8 days severity

contusions
19.2%
4.7 days severity

fractures
17.7%
34.3 days severity



Shoulder/clavicle injuries caused the greatest burden (total number of days needed for recovery) with a total of 622.5 days lost due to all 25 shoulder/clavicle injuries recorded.



injury diagnosis

Shoulder/clavicle fracture injuries caused the greatest burden with a total of 442 days needed for recovery (Table 6).

injury diagnosis	no. of injuries	% of injuries	severity (mean days needed for recovery)	burden (total days needed for recovery)
shoulder/clavicle fracture	9	4.7%	49.1	442
hand fracture	9	4.7%	17.9	161
wrist fracture	3	1.6%	35.0	105
finger sprain	4	2.2%	26.3	105

Table 6. Injuries casuing the greatest burden by diagnosis

Although not very severe the most frequently reported injury diagnoses were concussion (7.3 % of all injuries), and lower leg (5.7%) and forearm (5.2%) lacerations.

Overall 0.6% of riders suffered a concussion, with on average 5.1 days lost per injury. 42% of concussed riders had the SCAT 3/5 administered, the remainder did not. 57% of riders diagnosed with concussion were reported to take time off riding afterwards, the remainder had no time loss reported post race. 71% of riders withdrew/abandoned, 29% continued racing.

Lower leg and forearm laceration injuries occurred largely during steep technical stages.

part 2

rider health study

In the second part of this report, the Enduro World Series carried out a rider health survey aimed at capturing broader information about injury across all Enduro riders, both in and out of racing and throughout rider's lives. The purpose was to provide wider insights to help direct our education and sporting development for riders of all levels in both competitive racing, training and recreational riding.

The EWS Rider Health Survey asked riders a series of detailed questions about their riding exposure and injury history. To minimise recall bias riders were asked to only report significant injuries that lasted for 1 month or more. Minor injuries lasting less than 1 month were not recorded. The present report provides a summary of what riders themselves report occurring during their own riding.

executive summary

The majority of riders responding to the rider reported health survey were amateur/domestic enduro riders

Overall 40.7% of riders reported they had suffered a significant injury (an injury lasting a month or more) during Enduro mountain bike riding

For the number of Enduro rider years reported, this equated to 0.15 significant injuries per rider per year, with 87.6 mean days needed for recovery per injury.

The higher the level of Enduro riding and racing the greater the proportion of riders reporting a significant injury

Shoulder/clavicle injuries were the most common significant injury, representing a quarter of all injuries reported, with shoulder/-clavicle fracture and shoulder dislocation injuries causing the greatest burden in terms of total number of days needed for recovery.

Concussion injury was the third most common diagnosis affecting 4% of all riders (equating 0.01 concussions per rider per year of Enduro), and occurred more frequently in female riders. Overall a quarter of riders who reported suffering a concussion said they continued their bike ride after the accident and almost two thirds of riders reported they did not follow a return-to-play (riding) protocol after suffering a concussion. Almost half of riders who reported a concussion also reported having had significant recurrences of concussion injury.

Race practice at an event shows the lowest proportion of injuries, with recreational riding or training away from events recording the highest proportion of injury for all riders.

rider demographics

Countries represented 61
Total Survey Participants 1,940
91% Male
9% Female

rider level: ews

Riders competing internationally at Enduro World Series

20.7%

rider level: ews tier 2

Riders competing in EWS affiliate events (qualifiers, continental)

23.4%

rider level: enduro domestic

Riders racing in Enduro but not at any EWS or EWS affiliate events

55.9%

The majority of responders were senior and masters level Enduro riders (Table 7).

205 (10.6%)	**u21** (17 to 20)
1203 (62.2%)	**senior** (w 21 to 34; m 21 to 39)
527 (27.2%)	**masters** (w 35+; m 40+)
1935*	**total**

Table 7. Number (and percentage) of riders by race category.
* Race category unknown for 5 riders

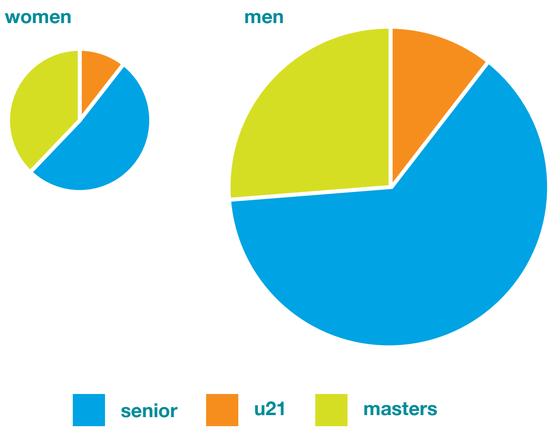


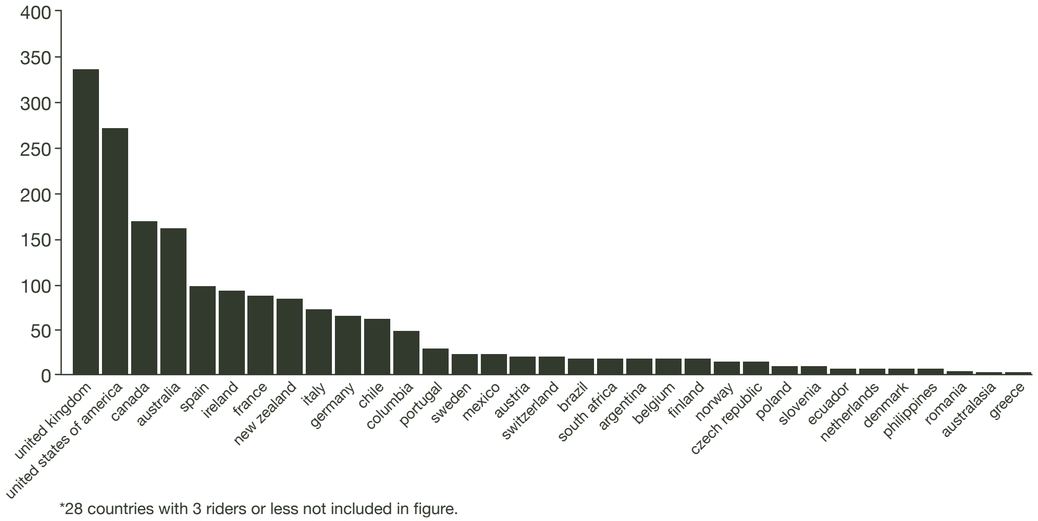
Figure 3. Percentage of riders by race category, by sex

Elite riders tended to be younger and with lower body mass compared with other levels of riding (Table 8)

female	age (yrs)	**31.1**	**32.7**	**32.1**
	height (cm)	**165.9**	**167.3**	**166.4**
	body mass (kg)	**60.7**	**62.8**	**62.7**
male	age (yrs)	**32.0**	**32.2**	**34.0**
	height (cm)	**179.1**	**179.6**	**179.3**
	body mass (kg)	**76.1**	**78.5**	**78.6**
combined	age (yrs)	**31.9**	**32.3**	**33.6**

Table 8: Mean age, height and body mass, by sex and level of riding

Of all Enduro riders responding to the survey 17.3% represented the United Kingdom, 14.0% the United States, 8.8% Canada and 8.4% Australia (Figure 4).



*28 countries with 3 riders or less not included in figure.
Figure 4. Number of riders by country of representation.

rider experience

For all riders on average each rider reported 4.3 years Enduro mountain bike riding, equating to a total of 8,344 Enduro riding years. Enduro World Series (EWS) riders reported participating in both Enduro riding and all types of mountain bike riding for more years compared to other levels (Table 9). Male riders reported more years doing Enduro and all mountain bike riding compared with female riders.

Table 9: Years riding Enduro (and riding a mountain bike), by sex and present level.

ews	4.3 (11.2)	4.8 (13.8)	4.8 (13.4)
ews tier 2	3.3 (10.7)	4.4 (13.6)	4.3 (13.3)
enduro domestic	3.0 (8.4)	4.3 (13.3)	4.2 (12.7)
grand total	3.5 (9.9)	4.4 (13.3)	4.3 (13.0)

Of all Enduro riders completing the survey 29% reported having also competed previously in cross country mountain biking, 31% in Downhill and 10% in other bike riding, while the remaining 30% had only ever ridden Enduro.

rider injury

Riders completing the survey were asked to report if they had had any significant injuries during their time doing Enduro training/general riding, or competitive racing. A significant injury was defined as - any injury that caused pain and discomfort for most days for at least one month

In total, across all levels of riding, 789 riders reported sustaining 1234 significant injuries during Enduro riding (Table 10). Relative to the total number of Enduro riding years this equated to a mean 0.12 significant injuries per rider per year.

Table 10. EWS rider health study injuries

1234 rider injuries

789 total number of riders injured*

40.7% percentage of riders reporting significant injury

0.15 injuries per rider per year

87.6 injury severity (days needed for recovery)

Figure 5. Percentage of riders injured and severity, by sex

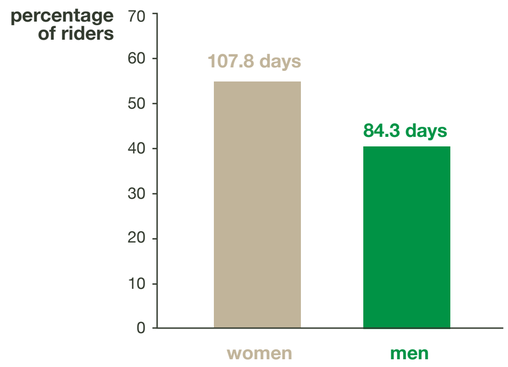
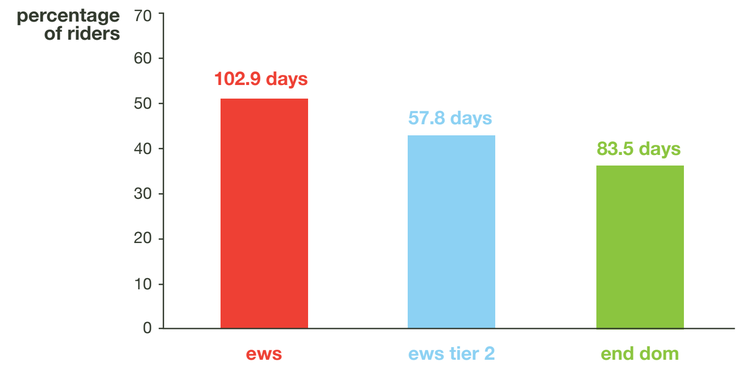


Figure 6. Percentage of riders reporting a significant injury and severity, by level of riding



more female riders reported sustaining a significant injury compared with male riders, and with a greater severity

when injuries happen

Two thirds of all injuries were reported to occur during training/general riding with the remainder either during racing or during formal race practice.

The higher the level of rider the greater the proportion of racing related injuries, conversely the lower the level of rider the greater proportion of training related injuries (Table 11).

level and activity at time of injury	ews	ews tier 2	end dom	total
racing	63 (32.8%)	27 (24.8%)	152 (16.3%)	242 (19.6%)
racing practice	31 (16.1%)	12 (11.0%)	109 (11.7%)	152 (12.3%)
training/riding	94 (49.0%)	70 (64.2%)	659 (70.6%)	823 (66.7%)
unknown	4 (2.1%)	-	13 (1.4%)	17 (1.4%)
grand total	192	109	933	1234

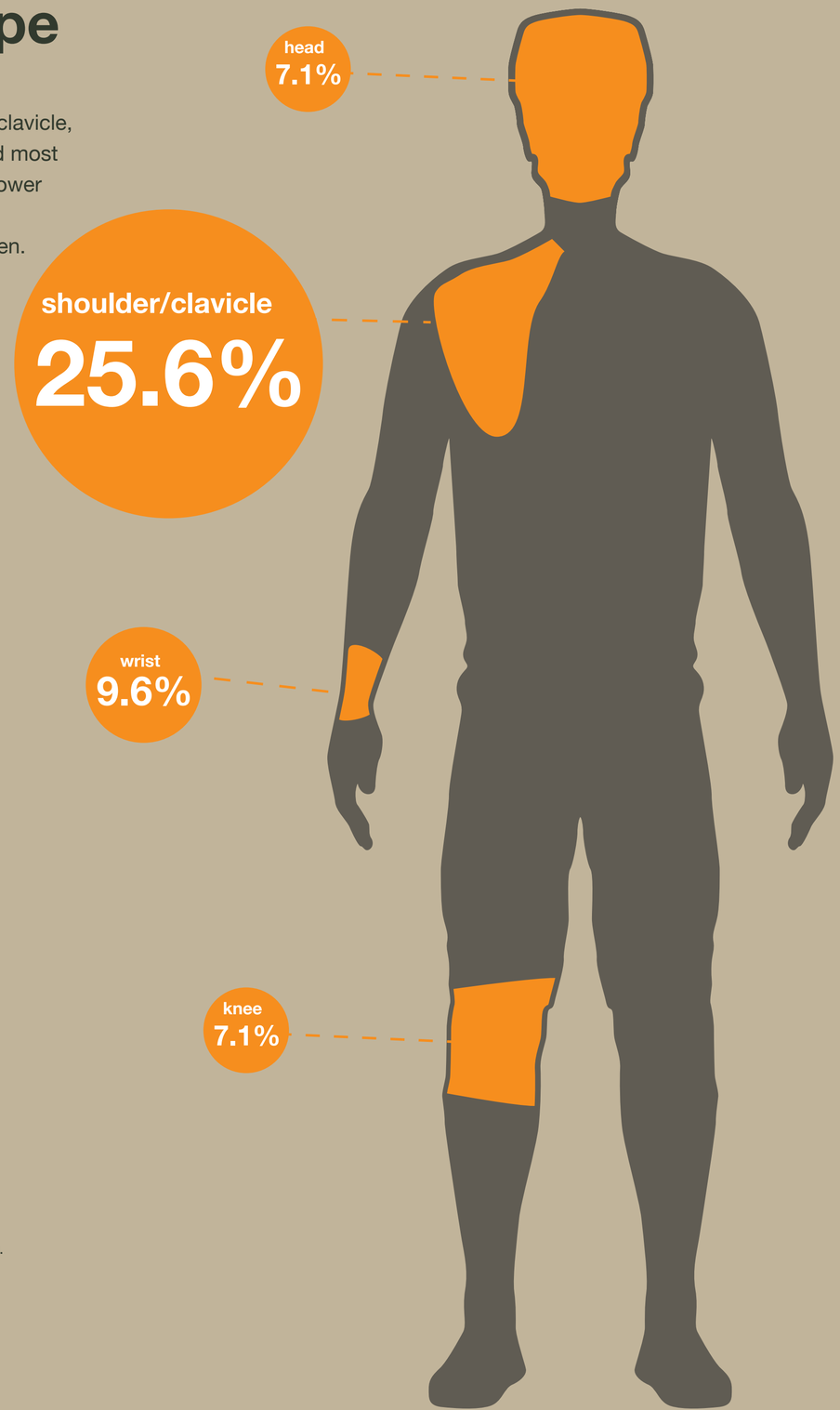
Table 11. Number of significant injuries (and percentage) by level of riding, and activity at time of injury.

injury location and type

The most commonly injured body location was the shoulder/clavicle, followed by the wrist, and then knee and head (Table 12), and most severely injured the Pelvis/Sacrum/buttock, followed by the lower back/lumbar spine and upper back/thoracic spine.
Overall shoulder/clavicle injuries presented the greatest burden.

body location	no. of injuries	% of injuries	severity (days)
shoulder/clavicle	315	25.6%	93.7
wrist	119	9.6%	109.0
knee	88	7.1%	120.8
head	87	7.1%	90.0
sternum/ribs	77	6.2%	44.9
hand	71	5.8%	70.5
ankle	49	4.0%	66.6
elbow	49	4.0%	71.5
finger	47	3.8%	62.2
lower back/lumbar spine	41	3.3%	133.1
thumb	36	2.9%	83.7
lower leg	34	2.8%	50.4
face	33	2.7%	25.3
upper back/thoracic spine	26	2.1%	131.3
thigh	25	2.0%	56.8
forearm	23	1.9%	38.4
pelvis/sacrum/buttock	22	1.8%	149.5
neck/cervical spine	20	1.6%	82.7
foot	19	1.5%	102.3
hip	18	1.5%	114.8
upper arm	11	0.9%	62.1
abdomen	8	0.6%	101.9
toe	7	0.6%	83.7
achilles tendon	5	0.4%	106.6
groin	3	0.2%	70.3

Table 12. Number, percentage and severity of significant injuries by body location.



The most common type of significant injury (all levels, racing and training combined) was a bone fracture (34.8% of all injuries) followed by dislocation/subluxation injuries (11.0%).

injury diagnosis

Shoulder/clavicle fracture was the specific diagnosis causing the greatest burden, followed by wrist fracture, concussion and then shoulder dislocation (Table 13).

injury diagnosis	no. of injuries	% of injuries	severity (mean days needed for recovery)	burden (total days needed for recovery)
shoulder/clavicle fracture	111	9.0%	76.7	8519
wrist fracture	79	6.4%	101.2	7992
concussion	81	6.6%	85.3	6913
shoulder dislocation	87	7.1%	72.7	6328

Table 13. Injuries casuing the greatest burden by diagnosis

Nearly three quarters or all shoulder/clavicle and wrist fractures occurred during training, with half of shoulder dislocation and concussion injuries occurring during training and half during racing.

Female riders had a three times greater prevalence of concussion injury than male riders. When experiencing a concussion 50% of riders said they stopped riding immediately, 25% said they stopped a little while later, and 25% said they continued riding. 74% of riders said they had not heard of the SCAT concussion assessment, and 63% of riders said they did not follow a return to play (riding) protocol post-concussion.

dissemination of education and information

Riders were asked where information, education and advice for the prevention and treatment of injury in Enduro riders should be targeted. Ranking in order of importance, riders felt that the information should be aimed firstly at the riders themselves, followed by coaches and then team managers (table 14).

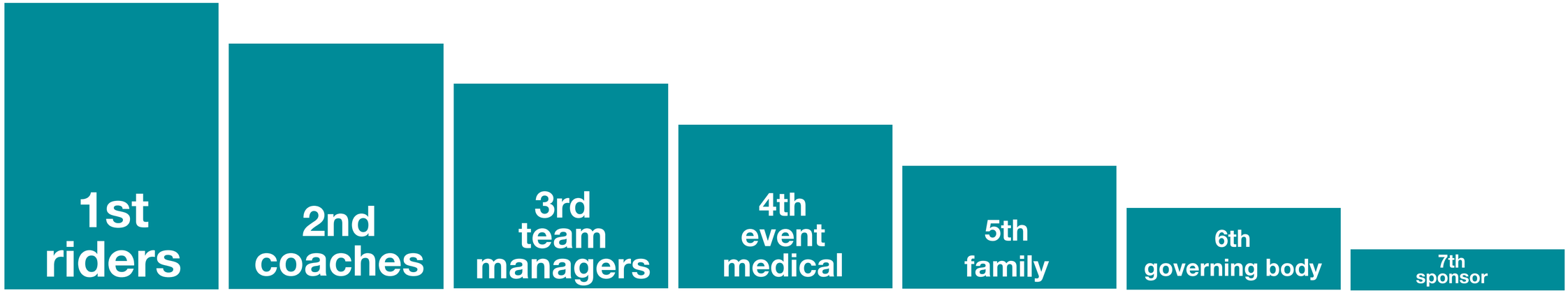


Table 14. Rank order

recommendations

Overall the rate of injury in the EWS race events was low, but targeting of specific interventions may help reduce the frequency and severity of injuries in some areas.

All riders report a substantial proportion of injuries occurring outside of Enduro race events (amateur riders in particular) and therefore education and best practice is needed at all times, including when riders are out recreationally on the trails.

- Riders should wear more protective equipment against lacerations and abrasions during steep technical race stages, and also generally when training/doing recreational riding, particularly on trails with steep rocky sections.
- Additional medical provision should be targeted by race event organisers around steep dirt and particularly rocky race stages
- Re-assessment of qualification criteria for new EWS riders/local riders who may only compete in one event.
- A rider head injury assessment protocol should be included at Enduro race events, for medical staff to use during and/or immediately after the race has been completed for those suspected of having sustained a concussion.
- Introduction of ‘red flag’ concussion education for event Marshalls to enable them to radio down to race medical staff in the event of a suspected rider concussion
- If a rider is diagnosed with a concussion injury during racing they should be withdrawn immediately from competition.
- Concussion education information should be provided around ‘red flags’ and when to stop riding, reference guidance for treating concussion including how long a rider should rest after injury, and return to play (riding) guidelines. This should be to targeted at recreational and domestic Enduro riders as well as EWS riders and their teams, for use in training/general riding and racing.
- Provision for and rider use of shoulder pre-habilitation and rehabilitation training exercises to help reduce the number, and/or severity of significant shoulder injuries.
- Guidelines and educational information should be published in key other languages in addition to English
- First Aid skills/awareness/education is needed amongst riders as the majority of injuries occur during regular riding (training) away from organised events
- The mountain bike industry should consider future development of shoulder protection products

conclusions

Injury patterns were similar across both medical reported injuries in EWS race events, and rider reported injuries across all levels. Female riders presented higher injury rates than males riders, the majority of injuries were caused by contact with the ground, and shoulder injuries were most commonly reported and also caused the greatest burden overall in terms of time lost and days needed to recover from injury.

While the rate of concussion injury was low there were some clear areas where positive changes can be made, and with concerns over longer-term health consequences of repeated concussion injuries targeted injury prevention and education strategies focussed on this area will be of benefit.

Recreational riding or training away from events presented the highest proportion of injury for all riders. As riders tend to spend more time training/doing general riding than racing it is perhaps unsurprising that more injuries occur in that environment, however it also highlights the importance of employing targeted prevention strategies in both racing and training/general riding environments, across all levels of rider.

Targeted injury prevention strategies around laceration/abrasion injuries, shoulder injuries and concussion may help to reduce the rate, severity and recurrence rates in these areas, and help to protect rider health.

study acknowledgements

A huge vote of thanks to all the EWS teams and riders for their assistance and cooperation and to the EWS race event medical staff who gave up their valuable time to complete the data collection during the two-season medical study; and to all the individual riders who took the time to complete the enduro rider reported health survey. Without whose help, time and input these projects would not have been possible.

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end notes

Ethical approval for the EWS Two-Season Medical Study and the Rider Health Study were granted through the School of Applied Sciences, Edinburgh Napier University, UK. Rider Health Study consent was implicit through a riders completion of the survey. EWS Medical Study rider consent was implicit through a riders participation in an EWS sanctioned event. Injury definitions and data collection methods during the Two-Season EWS Medical Study were aligned with the IOC injury and illness surveillance studies. Injury burden was defined as the total number of days lost from riding (needed for recovery from injury). Injury severity was defined as the average number of days lost from riding (needed for recovery), per injury. Injury severity categories were 1-3 days = minimal; 4-7 days = mild; 8-28 days = moderate; >28 days = severe.. [1] T Soligard, K Steffen, D Palmer et al. Sports injuries and illnesses in the Rio de Janeiro 2016 Olympic Summer Games. British Journal of Sports Medicine 2017; 51:1265-1271; [2] T Soligard, K Steffen, D Palmer-Green et al. Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games. British Journal of Sports Medicine 2015; 49:441-447; [3] J Brooks, C Fuller, S Kemp et al. Epidemiology of injuries in English professional rugby union: part 1 match injuries. British Journal of Sports Medicine 2005; 39:757-766.

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