ORIGINAL ARTICLE

Epidemiology of injuries in adventure racing athletes

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Objectives: To assess the demographics and training characteristics of adventure racing athletes in the United Kingdom, the prevalence and anatomical distribution of hazardous encounter, and overuse injury in this population, and the effects these injuries have on training.

Methods: A retrospective training and injury questionnaire for the previous 18 months was distributed to 300 adventure racing athletes at two national race meetings. The definition of an injury was "any musculoskeletal problem causing a stop in training for at least one day, reduction in training mileage, taking of medicine, or seeking of medical aid."

Results: The data were derived from the responses of 223 athletes. Advanced level athletes did 11 (4) sessions and 17 (8) hours of training a week (mean (SD)). An injury was reported in the previous 18 months by 73% of the respondents. The most common site of acute injury was the ankle (23%) and of chronic/overuse injury, the knee (30%), followed by the lower back, shin, and Achilles tendon (12% each). There were significant correlations ($p<0.01$) between the hours spent cycling per week and number of acute injuries, and between the number of days off per week and number of chronic/overuse injuries. Injuries resulted in an average of 23 days training cessation or reduction.

Conclusions: Acute injuries were sustained mainly as a result of the nature of the terrain over which athletes train and compete. In overuse injuries lack of adequate rest days was a significant contributing factor. Only a small proportion of training time was spent developing flexibility and core stability.

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Adventure racing is a fast growing endurance sport combining the disciplines of orienteering, mountain biking, and canoeing.

In the United Kingdom, 2002 marked the first year of a UK national adventure racing championships, and there is now a well developed national race programme with participants racing for periods ranging between two and 10 days. In a typical two day competition there may be five or six stages involving the three core disciplines. Each stage may last between two and seven hours and these would be undertaken consecutively over a 36 hour period. Longer national and international races exist, with continuous competition for up to 10 days, and in these races additional stages can involve mountaineering, horse riding, swimming, or other sporting activities. The participants in such events are mainly elite sponsored teams.

In order to perform at a high level in the sport the physical demands are extreme. Teams are required to reach as many checkpoints as possible within the allowed stage times and in this way competitors have to cover large distances at speed, often over unforgiving terrain. Considerable skill is needed in the individual sports and also in efficient map reading and navigation.

The course location and stage structure for each race is unique and only released to competitors in the fortnight before the start. This makes it difficult to prepare specifically for a particular event and as a result training would be expected to focus on maximising aerobic capacity in each core activity. Both acute/traumatic and overuse injuries can be anticipated as a result.

Training and injury data in the individual sports of orienteering,[1–7] mountain biking,[8–13] and canoeing[14–17] have been described in varying quality and quantity over the past 20 years. More recently, in line with its increasing popularity, the sport of triathlon has been the focus of research studies.[18–26] There are currently no published reports on training patterns or injury profiles in this group of multisport athletes.

Our aims in this study were therefore to assess three main areas: the demographics and training characteristics of advanced, intermediate, and beginner level adventure racing athletes in the United Kingdom; the prevalence and the anatomical distribution of hazardous encounter and overuse injury in this population; and the effects on training of these injuries.

METHODS

At two 48 hour British adventure racing championship qualifying events, three weeks apart, 300 competitors were given a retrospective training and injury questionnaire while attending the registration desk. The questionnaires were filled in and returned the same evening.

Questionnaire details

During the development of the questionnaire, a pilot was distributed to 15 athletes of varying ability. The questionnaire was subsequently changed according to observed responses and comments from the athletes. The final questionnaire was divided into three sections: demographics, training, and injuries.

Demographics

The age, sex, height, and weight of the subjects were recorded. Athletes were asked to classify themselves into beginner, intermediate, or advanced level.

Training

The questionnaire pertained to the previous 18 months of training. This time span was chosen to cover one complete competitive season (September 2000–2001) and the 2001–2002 training periods before attendance at the races where the study was conducted. Athletes were asked to indicate their training habits during a typical week of hard training, without taper, during the race season. For athletes using periodisation schedules, this aimed to correspond to their most strenuous period. Both the number of workouts and the

Table 1 Population demographics for United Kingdom adventure racing athletes

Variable	All athletes	Advanced	Intermediate	Beginner
Age (years)	33.9 (7.3) (20 to 62)	36.6 (7.4) (24 to 54)*	33.6 (7.4) (20 to 62)	32.7 (6.3) (23 to 54)*
Mass (kg)	72.8 (9.6) (49 to 107)	72.3 (9.2) (52 to 95)	72.9 (9.2) (49 to 96)	72.9 (10.7) (50 to 107)
Height (m)	1.77 (0.07) (147 to 193)	1.76 (0.04) (147 to 193)	1.77 (0.07) (149 to 191)	1.78 (0.09) (147 to 191)
Sex	172 M (76%)	32 M (82%)	101 M (76%)	39 M (72%)
	54 F (24%)	7 F (18%)	32 F (24%)	15 F (28%)

Values are mean (SD) and range, or n (%).
*p<0.05, advanced *v* beginner.
F, female; M, male.

total hours were recorded for the following disciplines: running, cycling, swimming, rowing ergometer, canoeing, weight training, and circuit training. The number of hours of stretching/flexibility was reported and, in view of current sports medicine practice, athletes were asked about the number of hours of specific core stability (or Pilates) exercise they performed. The number of rest days was noted.

Injuries

An injury was defined as ''any musculoskeletal problem causing cessation of training for at least one day, reduction in training mileage, taking of medicine, or seeking of medical aid.''[19 20 24] Chronic/stress or overuse injuries, resulting from gradual accumulation of physical stress during training, were reported separately from acute or traumatic injuries, occurring in a brief moment of time or accident. The absolute number of injuries in each category over the previous 18 months was recorded. Separate sections were completed for each individual acute and chronic injury sustained. Information on the anatomical site, the discipline to which the injury was attributed, the number of days of training cessation/reduction, and the seeking of medical help was derived from the athletes' report. The anatomical sites were neck, shoulder, arm (including elbow/wrist/hand), upper back, lower back, groin, front of thigh, hamstrings, knee, calf, shin, Achilles tendon, ankle, foot, other.

Statistics

The questionnaire results were coded and analysed using SPSS v11 for Windows. A one way analysis of variance (ANOVA) test with post hoc Scheffé analysis was used to determine significant differences in the training data between the three groups. Pearson's correlation coefficient was calculated to measure associations between training data and injury rates. Probability values less than 0.05 were considered significant.

RESULTS

Demographics

The response rate for the survey was 75%. The population demographics are given in table 1. The mean age of advanced athletes was significantly greater than of those at beginner level (p<0.05). A training diary was kept by 59% of the advanced athletes but by only 22% of intermediate and 18% of beginners.

Training

Overall weekly training values are presented in table 2, and the time spent training in individual disciplines in table 3.

Injuries

One or more injuries were reported by 73% of all athletes in the 18 months before the survey. Acute injuries were sustained by 44% of advanced, 35% of intermediate, and 19% of beginners; chronic injuries were sustained by 59% of advanced, 54% of intermediate, and 56% of beginners. The mean number of injuries per athlete surveyed is shown in table 4.

The most common site of acute injury was the ankle (23.0%), followed by arm/shoulder (16%), then the knee and lower back (11% each). Sixty one per cent of these injuries were attributed to running and 22% to cycling. In chronic injuries the knee was most often affected (30.6%), followed by the shin, lower back, and Achilles tendon (12.1% each). Athletes attributed 74% of these injuries to running and 9% to cycling.

Acute injuries caused a mean reduction in training of 22.0 (28) days (range 1 to 120), and chronic/overuse injuries caused a reduction of 24 (34) days (range 12 to 180). There were no statistically significant differences between the three levels. Medical help was sought in only 44% of all injuries, in 52% of the advanced category, 41% of the intermediate category, and 42% of the beginners.

The total number of hours spent training per week was correlated with the total number of injuries sustained over the 18 month period (p<0.01). There was a significant correlation between the hours spent cycling per week and acute and total numbers of injuries (p<0.01). The relative amount of training in other modes did not have any effect on the number of injuries. A negative correlation was observed between the number of chronic/overuse injuries and the number of days off per week (p<0.01). There were no other significant correlations.

DISCUSSION

The response rate to the survey of 75% is considerably higher than in many previous studies and this presumably reflects the sampling method used. The limitations of collecting retrospective data in this way must be remembered, including the possible bias because injured or ill athletes may not actually be attending the races, which would underestimate the true injury rate. The data from this research can be

Table 2 Mean number of weekly sessions and hours spent training (SD)(range)

	All athletes	Advanced	Intermediate	Beginner
Sessions	8.8 (3.9) (2 to 20)	11.5 (3.9) (4 to 20)*†	8.4 (3.7) (2 to 17)*	7.6 (3.7) (2 to 12)†
Hours	10.7 (5.8) (2 to 37)	16.6 (7.8) (8 to 37)*†	9.8 (4.6) (3 to 37)*	8.4 (4.6) (2 to 18)†

Values are mean (SD) and range.
*p<0.05, advanced *v* intermediate.
†p<0.05, advanced *v* beginner.

Table 3 Mean number of training hours per week spent in each discipline (SD)(range)

Discipline	All athletes	Advanced	Intermediate	Beginner
Running (hours)	3.8 (2.1) (1 to 10)	5.5 (2.3) (2 to 10)*†	3.5 (1.8) (1 to 9)*	3.1(2.0) (1 to 9)†
Cycling (hours)	3.3 (2.6) (1 to 12)	5.2 (2.7) (1 to 12)*†	3.1 (2.5) (1 to 11)*	2.1 (2.0) (1 to 9)†
Swimming (hours)	0.5 (1.0) (0 to 3.5)	0.9 (1.5) (1 to 7.5)*	0.5 (0.8) (0 to 3.5)	0.4 (0.8) (0 to 3.5)*
Rowing ergometer (hours)	0.3 (0.6) (0 to 2.5)	0.5 (1.1) (0 to 2.5)	0.3 (0.6) (0 to 2.5)	0.3 (0.4) (0 to 2.5)
Canoeing (hours)	0.4 (1.0) (0 to 5.5)	1.1 (1.3) (1 to 3.5)*†	0.3 (0.8) (0 to 5.5)*	0.3 (0.9) (0 to 4.5)†
Weight training (hours)	0.9 (1.3) (0 to 7.5)	1.4 (1.8) (0 to 7.5)	0.7 (0.1) (0 to 5.5)	0.9 (1.2) (0 to 4.5)
Circuit training (hours)	0.4 (0.7) (0 to 3.5)	0.3 (0.6) (0 to 1.5)	0.3 (0.7) (0 to 3)	0.4 (0.8) (0 to 3.5)
Flexibility (hours)	0.8 (1.3) (0 to 7)	1.3 (1.7) (0 to 7)	0.7 (1.3) (0 to 7)	0.7 (0.9) (0 to 3)
Core stability (hours)	0.3 (0.8) (0 to 8)	0.3 (0.7) (0 to 7)	0.3 (0.8) (0 to 8)	0.2 (0.7) (0 to 3.5)
Days off per week	2.3 (1.3) (0 to 5)	1.3 (1.0) (0 to 4)‡§	1.6 (0.9) (0 to 4)‡	2.3 (1.3) (0 to 5)§

Values are mean (SD) and range, number of training hours per week.
*$p<0.01$, advanced *v* intermediate.
†$p<0.01$, advanced *v* beginner.
‡$p<0.05$, advanced *v* intermediate.
§$p<0.05$, advanced *v* beginner.

interpreted only as indicative of the subgroup of athletes sampled at the two races attended.

Demographics

The age, height, and weight distribution of athletes is similar to that seen in triathletes.[18–21] Because of the logistics of the sport, and partly owing to its recent development, there are no nationally recognised competition levels. The absence of a fixed race distance or time makes grouping of athletes beyond self classification difficult. The final race position could be recorded, but inter-race comparison would be difficult owing to varying numbers of competitors and scoring systems. It must also be remembered that any classification based solely on training input would be biased because of the large skill component involved.

Training

The volume of training undertaken is large. Advanced athletes complete a similar mean number of hours a week as the elite triathletes surveyed by Vleck *et al* in 2001.[24] Approximately two thirds of the training time is devoted to cycling and running. This reflects the contribution of the lower body during a typical race. Upper body training is split between rowing ergometer, swimming, and canoeing. Advanced athletes do a greater proportion of this training specifically on the water (canoeing). More detailed training session information (that is, intensity, terrain) was not obtained in this study and would be a suggestion for further research.

Injuries

We aimed to determine the occurrence and anatomical distribution of injuries in adventure racing athletes. The number of athletes reporting an injury over the study period (73.1%) is comparable with other studies involving orienteers and triathletes, although some—particularly of ultraendurance triathletes—have shown injury rates of up to 90%.[12 18 19] The results confirmed that chronic/overuse injuries were more common than acute/traumatic injuries. The distribution of injuries is difficult to compare with other studies owing to variation in the methods of defining and grouping anatomical areas.

The incidence of acute injuries is considerably higher than has been observed in triathletes. The distribution reflects a combination of the injuries seen in orienteering and mountain biking. Lower limb involvement (mainly ankle) is most common, reflecting the orienteering component of the sport and the unstable terrain over which athletes train and compete. It would have been useful to obtain information about whether acute injuries were sustained during training or while racing. The second most common area for injuries was the arm/shoulder; this is comparable with the distribution seen in mountain biking, being consistent anatomically with falling from a bicycle both on, and more commonly, off road.[7–13]

The most common chronic/overuse injury sites were the knee, Achilles tendon, shin, and lower back. As in the 1998 study in triathletes by Vleck *et al*, the Achilles tendon was one of the most frequently injured sites. This is in contrast to previous reports where injury to the Achilles tendon has either been overlooked or has not been reported from the data obtained.[24–26] It may be that the similar injury definition and anatomical grouping between this study and that of Vleck *et al* influenced this result. It is important that research of this kind in future uses similar consistent methodology in order that comparisons can be made. It is well documented that ''extrinsic'' training errors (such as shoe wear and bike set up) and biomechanical abnormalities are involved in the causation of many lower limb injuries.[23] While we did not set out to determine such causative factors in adventure racing athletes, it can be anticipated that these play a major part. In addition, the time devoted to flexibility training was small and only 16% of athletes reported doing any specific core stability training. The number of hours of this type of training may have been underestimated here because of some core stability derived from weight training. With 12.1% of injuries

Table 4 Mean number of total (acute + chronic), acute, and chronic injuries per athlete surveyed

	All athletes	Advanced	Intermediate	Beginner
Total injuries	1.1 (1.0)	1.5 (1.4)*	1.1 (0.9)	0.9 (0.9)*
Acute injuries	0.4 (0.7) (0 to 4)	0.6 (0.9) (0 to 4)*	0.5 (0.7) (0 to 3)	0.2 (0.5) (0 to 2)*
Chronic injuries	0.7 (0.8) (0 to 3)	0.9 (0.9)(0 to 3)	0.7 (0.7) (0 to 2)	0.7 (0.8) (0 to 3)

Values are mean (SD) and range.
*$p<0.05$, advanced *v* beginner.

Take home message

Adventure racing is a new, exciting and fast growing endurance sport. Athletes do a large amount of training and present with a unique pattern of acute and chronic injury.

being to the lower back in this study, and a growing body of evidence now linking poor core stability and back pain, athletes should be advised to focus more on this area.

Very few studies have shown a significant correlation between the amount of training and the occurrence of injury in triathletes or multisport athletes, which is in contrast to running studies.[5 6] The data presented here show a correlation between the total number of hours training and the total number of injuries ($p<0.01$), and this would be expected given the considerable number of weekly training hours. It would be interesting to determine whether certain types or intensities of training session are associated with specific injuries. The number of acute injuries was correlated ($p<0.01$) with the number of hours spent cycling per week, and this could be explained by the high frequency of traumatic injury in off-road biking. Unfortunately we do not know the proportion of cycle training performed off-road in these athletes; however, it would be expected to be greater than training on-road. With chronic injuries, the correlation between injury number and days off per week has not been reported before in multisport athletes. It may be that by having less than one day of complete rest per week allows a gradual accumulation of physical stresses predisposing to injury. The pathophysiology of these injuries remains to be proven. There may, of course, be further associations between various training factors that have not been detected by this study, either because of the inherent problems with retrospective recall or because they were not part of the questionnaire (for example, sudden increases in training load).

It is clear that there is a considerable impact on training by injury in this population, across all levels, and that the lost time can have a detrimental effect on race performance. This is especially true for advanced competitors, for whom the margins between winning and losing are narrow. The number of athletes seeking medical help for their injuries is small, which may in part be a reflection of the availability and standard of NHS musculoskeletal medicine services in some areas.

Directions for future research

The population of adventure racing athletes represents a growing pool of sportsmen and women who could provide data for many areas of sports medicine research. The problems of retrospective analysis could be overcome by doing prospective injury surveys. The intensity and types of training workout, incremental training load, and on/off road distribution are all areas that need to be assessed in order to determine the aetiology of injury and how to modify training to prevent injuries. In addition to this, the effects of nutrition and sleep deprivation in longer races add to the wealth of useful information these athletes can provide.

Conclusions

Adventure racing athletes, especially at advanced level, are performing at comparable levels of training to triathletes at Olympic level, and in some cases at ultraendurance level. The acute injuries sustained are similar in their overall anatomical distribution to those seen in orienteering and mountain biking, and overuse injuries occur in areas consistent with previous studies of triathletes. From a clinical perspective the proportion of training focusing on core stability could be improved. This may not only be of benefit in terms of back injury but may also help improve bike handling and stability over rough ground. It is not clear how training should be modified to reduce injury. Despite the variable number of days off per week reported by these athletes, it appears that adequate rest is required to minimise the risk of overuse injury. The threshold for this is yet to be determined.

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