

ORIGINAL ARTICLE

Incidence of sports injuries in elite competitive and recreational windsurfers

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Br J Sports Med 2006;40:346–350. doi: 10.1136/bjsm.2005.023077**Objective:** To investigate the incidence of injury in windsurfing and to consider methods of prevention.**Methods:** A total of 107 raceboard (RB) and wave/slalom (WS) national/international competitors and recreational (REC) windsurfers completed a questionnaire on injury incidence over two years. Recurrent injury, ability level, and any preventive measures taken were noted.**Results:** Overall the injury incidence was 1.5/person/year. The WS group suffered more injuries (2.0/person/year) than the RB (1.0) or REC (1.2) group. The most common injury was muscle strain at 35% of new injuries, much higher than in earlier studies. Overall 45% of new injuries were muscle/tendon strains (RB 55%, WS 42%, and REC 43%) and 8% were ligament sprains. In the WS group cuts and abrasions were common. The WS and REC groups reported five and one case of concussion respectively. Nearly a quarter (22%) of new lower body injuries were lower back muscular strain, with 34% of recurrent injuries. Approximately 60% of the remaining lower body soft tissue injuries involved the knee or lower leg, with the ankle/foot most often involved. The shoulder, upper arm, and elbow were the sites of 41% of new upper body soft tissue injuries. The WS group reported 250% more recurrent muscular strains than the RB group. Recurrent ligament injuries (particularly knee) were most common in the WS group. The RB group reported recurrent serious bruising to the lower leg.**Conclusion:** The injury incidence was 1.5/person/year with a high incidence of new and recurrent muscular strain. Lower back muscular strain was prevalent, indicating the need for preventive measures. Wave/slalom was associated with more new and recurrent injuries and the need for head protection.

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Accepted 1 December 2005

Windsurfing is a relatively new sport which has become very popular at both recreational and competitive levels with millions of participants world wide.^{1,2} There are six recognised disciplines, but, on the basis of differences in equipment and type of activity, these can be grouped into two major divisions: (a) raceboarding, in which a standard course is completed as fast as possible; (b) wave/slalom, in which competitors perform freestyle acrobatic and aerial manoeuvres. The former group use large and heavy boards, and the latter use short boards and are reliant on foot straps to assist in aerial activities.

The Olympic form of the raceboard event is highly demanding not only in terms of the whole body strength and endurance needed to control the sail and boom relative to the wind strength and direction requirements, but also when working to maintain speed with little wind. In light to moderate winds, a forced movement of the sail away from and towards the body (termed pumping) is used to promote sailboard progression by catching and enhancing the effect of any existing wind. Pumping was first allowed in the 1996 Olympics, thus increasing the physical and muscular demands³ in both training and competition. There are no general regulations relating to clothing or equipment, although at Olympic level sailboards and sailing rig may be designated. McCormick and Davis⁴ reported in 1988 that recreational sailboarding in the United States was a relatively safe sport; the most serious injuries reported in 73 athletes were lacerations (29%), jellyfish stings (26%), abrasions (23%), and muscular strains (19%). The overall injury rate was 0.22 per 1000 participation hours. Nathanson and Reinert⁵ reported an injury incidence of 1 per 1000 days in a study conducted in 1994. Sprains (26%), lacerations (21%), contusions (16%), and fractures (14%) were the most common. Aerial manoeuvres such as jumping and high falls

were common causes. Pryma *et al*⁶ reported one injury per 174 windsurfing days for a group of 44 fun-board elite windsurfers; a catapult crash, resulting from jumping manoeuvres, was the most common type of accident. A later study⁷ of 49 elite competitors identified one-handed jumps and loops with high injury risk.

An internet survey⁸ of German windsurfers during the 2000 season revealed a rate of 1.92 injuries per participant, with bruising (contusions) the most common injury and fractures comprising 11% of the injuries. The source of the higher incidence was thought to be the rising popularity of the short board events, with the attendant range of aerial manoeuvres. In the year before the Greek Olympic games, 50% of 22 severe accidents in the Aegean Sea were fractures, and 23% were anterior dislocations of the shoulder.⁹

The aims of this study were to investigate in different forms of windsurfing the relative injury incidence from a broader perspective. Incidence of soft tissue injuries such as muscular strain and ligament sprains were considered as well as acute injuries such as fractures and contusions. The information is considered in relation to the incidence of recurrent injury with the aim of identifying potential preventive measures and safety considerations.

METHODS

A windsurfing specific questionnaire was developed after comments on preliminary versions had been received from groups of 20 experienced sailors. The ethics committee sanctioned the study. After receiving an explanation of the study and an information sheet, each windsurfer provided written consent before participation. The 107 respondents fall into three groups: competitive national/international raceboarders (RB; n = 36), competitive national/international wave slalom surfers (WS; n = 43), and recreational (REC; n = 28).

Table 1 Windsurfing ability rank levels

| Level | Examples of skill at each level |
|-------|--|
| 1 | Learning to windsurf Basic tacking and gybing Sailing up, down, and across the wind |
| 2 | Basic harness techniques Faster tacking and gybing |
| 3 | Introduction to beach starting Introduction to planing techniques Use of foot straps and harness Flare gybing in light and strong winds |
| 4 | Beginning to carve gybe Water starting Launching and landing in waves |
| 5 | Advanced planing techniques Carve, slam, duck, slalom gybing Wave riding and jumping |
| 6 | Advanced aerial and freestyle manoeuvres Forward loop, backward loop, tabletop, etc |

Details of windsurfing related injuries were collected under the classifications of fracture, muscle strain, tendon strain, ligament sprain, dislocation, serious cut/abrasion, serious bruising, concussion, and other. Both closed and open questions were used to assist in data verification and aid in distinguishing between muscle and tendon strains and ligament sprains. Participants were required to list the number of injuries in specific body areas occurring over a two year period during training or racing for each classification. Twenty four main areas were specified: head, face, neck, shoulder, biceps, triceps, elbow, forearm, wrist, hand, fingers, chest, abdomen, upper back, lower back, hip, groin, thigh (front), thigh (rear), knee, shin, calf, ankle, foot, and toes. In addition, details were requested of any persistent pain, the number of repeated episodes, if medical treatment was needed, and, if so, the type of medical practitioner consulted. Each participant gave details of their windsurfing ability for ranking and comparison purposes (table 1).

Details of the wind and sea conditions at the time of injury were noted, with activity details and whether during competition, training, or recreational activity. Any perceived involvement of equipment in the injury or poor physical condition was recorded. Participants also gave details of alternative equipment, clothing, or technique adopted in an attempt to prevent or reduce injury. Responses were anonymous, with questionnaires coded at the event distribution sites in 1999/2000 to enable security of personal data. The response rate was about 89%, with most collected by hand.

RESULTS AND DISCUSSION

Nineteen of the 107 respondents were women (RB = 12, WS = 5, REC = 2), reflecting the generally higher participation rate of men. After initial screening, the data for both sexes were combined as the injury patterns appeared similar in each group at each level. The mean (SD) ages of the groups differed: RB = 31.8 (16.6), WS = 28.5 (10.0), REC = 30.1 (13.6) years. The windsurfing ability levels were similar for the RB (4.6 (0.9)) and REC (4.5 (0.9)) groups. The higher ranking of the WS group (5.5 (0.5)) reflected the involvement of aerial manoeuvres. The participation rates, expressed as hours per year, were similar for the RB (466 (229)) and WS (429 (237)) groups, but significantly ($p < 0.05$) less for the REC group (322 (226)). In windsurfing, the limitations of using participation hours as a basis for injury incidence comparisons should be recognised. In field sports, time on the pitch and game duration can be regarded as good indicators of participation, whereas in windsurfing,

Table 2 Injury incidence in competitive and recreational windsurfers over two years, excluding recurrent and ongoing injuries

| Injury | RB | WS | REC |
|---------------------|------|------|------|
| Fracture | 4 | 9 | 1 |
| Cut/graze | 11 | 36 | 8 |
| Serious bruising | 12 | 18 | 10 |
| Muscle strain | 34 | 56 | 20 |
| Tendon strain | 8 | 16 | 9 |
| Ligament sprain | 3 | 11 | 12 |
| Dislocation | 0 | 2 | 4 |
| Concussion | 0 | 5 | 1 |
| Other | 4 | 20 | 2 |
| Total | 76 | 173 | 67 |
| Average/person/year | 1.05 | 2.01 | 1.20 |

Other includes perforated eardrums, nerve trap, sciatica, shin splints, etc. RB, Raceboard group; WS, wave/slalom group; REC, recreational windsurfing group.

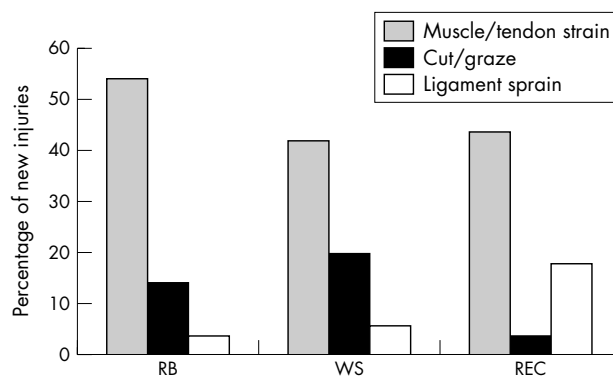


Figure 1 New muscle and tendon strains, cuts and grazes, and ligament sprains expressed as a percentage of the total number of new annual average injuries in the raceboard (RB), wave/slalom (WS), and recreational (REC) windsurfing groups.

participation can mean presence at the venue, not active windsurfing because of the dependence on wind and water conditions.

Injury is a problem in both elite and recreational windsurfers, with most participants experiencing an injury within the two years, and an overall average incidence rate of 1.5/ person/year, which is lower than that in the German internet based study.⁸ Table 2 shows that the average injury incidence/ person/year in the WS group was almost twice that experienced by the RB group.

Concussion was reported in five of the WS group and one of the REC group (in wave/slalom activity), and three of these cases were accompanied by eardrum perforation. Reports indicated that at the time of injury no one wore a helmet. The wearing of a helmet in wave and slalom activities would seem to be a sensible precaution, especially when the potential outcomes, including the risk of drowning, are considered. Rosenbaum and Dietz¹ recommended that helmets be worn by experienced windsurfers sailing in crowded areas or when performing high speed or aerial manoeuvres, and also by beginners in case of collision with the sailing rig. Gosheger *et al*⁷ and Petersen *et al*⁸ made similar recommendations.

The chest ribs were most at risk of fracture, with three in both the RB and WS groups and one in the REC group. One in the RB group reported fracture in the lower back. The WS group reported other fractures: two facial, two finger, one ankle, and one toe. The generation of higher forces in the wave/slalom event may have contributed to the greater

Table 3 Lower body soft tissue injuries reported over two years

| | Muscle | | | Tendon | | | Ligament | | | Bruising | | | Cut/graze | | | Total |
|-------------|--------|----|-----|--------|----|-----|----------|----|-----|----------|----|-----|-----------|----|-----|-------|
| | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | |
| Low back | 10 | 12 | 6 | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 30 |
| Abdomen | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 2 |
| Hip | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Groin | - | 1 | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | 3 |
| Thigh front | 1 | 2 | - | - | - | - | - | - | - | 1 | 1 | 2 | - | 1 | - | 8 |
| Thigh back | 1 | 3 | - | - | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | - | 10 |
| Knee | - | - | - | - | 1 | - | 1 | 4 | 1 | 2 | - | 1 | 1 | - | - | 11 |
| Shin | - | 4 | - | - | - | - | - | - | - | 2 | 1 | 1 | 4 | 4 | - | 16 |
| Calf | - | 2 | 4 | - | - | - | - | - | - | - | - | - | 1 | 3 | - | 10 |
| Ankle | 1 | 2 | 1 | - | 1 | 2 | - | 4 | 7 | 1 | - | 1 | - | 2 | - | 22 |
| Foot | 2 | 1 | - | - | 1 | 1 | 1 | - | 3 | 1 | 1 | - | 1 | 6 | 1 | 19 |
| Toes | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| Total | 16 | 27 | 11 | 1 | 5 | 4 | 2 | 8 | 11 | 8 | 6 | 6 | 7 | 20 | 1 | 133 |

RB, Raceboard group; WS, wave/slalom group; REC, recreational windsurfing group.

fracture incidence in this group. The only dislocations reported were in the fingers, with two in the WS group and four in the REC group. Most "other injuries" at unidentified sites occurred in the WS group. These were neurological injuries arising from sciatica, whiplash, and carpal tunnel syndrome. Shin splint pain was also reported in this category.

In each group, the most common injury was muscle strain, which represented 35% of all injuries, much higher than reported in earlier studies.^{4 10 11} The larger size and weight of the long board may have contributed to the incidence of muscular strain in the RB group. Considering muscle and tendon strains together, the proportion of all injuries was 55% for the competitive RB group, 43% for the REC group, and 42% in the WS competitors. Figure 1 shows the high incidence of muscle and tendon strain in relation to other common types of injury. In previous recent studies, although ligament sprains have been identified as a potential issue of concern, a high incidence of muscular strain has not been revealed. A higher incidence of serious bruising and cuts and abrasions was evident in the competitive groups, with a much higher incidence of cuts/abrasions (21%) in the WS group and hospital treatment more likely.

Collision with equipment when overpowered by wind and waves was the major contributory factor to injury occurrence in the WS group (in accord with reports made by Pryma *et al*⁶ and Petersen *et al*⁸). The respondents also identified specific equipment faults—for example, ineffective foot strap release in two cases and harness release in one—as causes of injury. Subsequent preventive measures reported include the wearing of new personal gear—for example, wet suit boots,

lumbar back support belt, and a helmet. New equipment adopted included a smaller diameter boom and an alternative harness. Attention has been drawn previously to the importance of ensuring a fast mechanism of foot strap release,^{9 11 12} which is particularly important because of the fracture risk.

Reports indicated that encountering novel weather conditions, along with the inherent uncertainty, was a predisposing factor to injury occurrence. In the REC group, 31% identified collision with equipment as a contributory factor, with the adoption of subsequent preventive measures—for example, changing equipment involved in the injury incident: raising the boom, changing a harness, or wearing a back support or a helmet. However, modifying technique was considered to be the most effective way of minimising or preventing injury. Such modifications include better warm up, improving stretching procedures, increased lower body strength and body posture to aid optimal sailing technique, and the development of greater upper body strength to cope with the demands of pumping in light winds, with uphauling particularly borne in mind. Physiotherapy was the most common form of remedial treatment, with hospital attendance required for head injuries, fractures, and lacerations.

Table 3 reveals that in the lower body, 22% of all lower body soft tissue injuries involved muscular strain in the lower back and was more common in both competitive groups. In the WS group, lower leg muscle strains occurred and cuts and grazes, notably to the feet. The REC group indicated most ligament sprains in the ankle and foot, whereas in the WS group the knee and ankle ligaments were injured possibly

Table 4 Upper body soft tissue injuries over two years

| | Muscle | | | Tendon | | | Ligament | | | Bruising | | | Cut/graze | | | Total |
|------------|--------|----|-----|--------|----|-----|----------|----|-----|----------|----|-----|-----------|----|-----|-------|
| | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | |
| Head | - | - | - | - | - | - | - | - | - | 1 | 2 | 1 | - | 2 | 2 | 8 |
| Face | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 6 | 2 | 10 |
| Neck | 3 | 4 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 8 |
| Shoulder | 7 | 1 | 4 | 1 | - | 3 | 1 | - | 1 | 1 | 3 | - | - | 1 | - | 23 |
| Biceps | - | 5 | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - | 7 |
| Triceps | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Elbow | - | 4 | - | 4 | 9 | 2 | - | - | - | - | 1 | - | - | 2 | - | 22 |
| Forearm | 1 | 3 | 4 | - | - | - | - | - | - | - | 1 | - | - | 2 | 1 | 12 |
| Wrist | 2 | 2 | - | 1 | - | - | - | 1 | - | - | - | 1 | - | - | - | 7 |
| Hand | - | - | - | - | 1 | - | - | 2 | - | - | - | - | 2 | 1 | 2 | 8 |
| Fingers | - | 1 | - | - | 1 | - | - | - | - | - | - | 1 | 1 | 1 | - | 5 |
| Chest | - | 1 | - | - | - | - | - | - | - | 1 | 1 | 1 | - | 1 | - | 5 |
| Upper back | 5 | 6 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 12 |
| Total | 18 | 29 | 9 | 7 | 11 | 5 | 1 | 3 | 1 | 4 | 10 | 4 | 4 | 16 | 7 | 129 |

RB, Raceboard group; WS, wave/slalom group; REC, recreational windsurfing group.

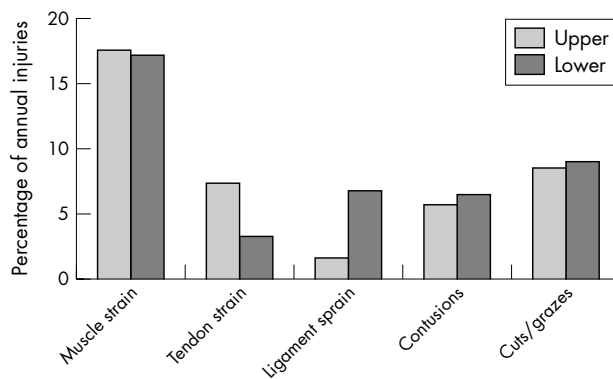


Figure 2 Distributions of new injuries to the upper and lower body for selected categories relative to total injuries for all windsurfing groups.

because of the stress during take off for aerial flight and high forces on landing. These findings differ from those of Gosheger *et al.*,⁷ who identified ankle sprain as the most common injury in World cup competitors.

Table 4 shows that the shoulder, upper arms, and elbow complex were the sites of 41% of upper body soft tissue injuries, and muscle and tendon strains in the WS group accounted for 30%. The incidence of cuts and grazes in the WS group was high, notably involving the head and face.

The injury incidence was similar in the lower and upper body (tables 3 and 4, fig 2). However, most of the muscle and tendon strains occurred in the upper body, whereas most ligament sprains occurred in the lower body.

All groups reported recurrent and ongoing injuries in the lower back (table 5). Two competitors had adopted wearing a harness with a back support to prevent and minimise injury problems. The problem of the incidence of lower back pain

reported by Ullis and Anno¹³ and Allen and Locke¹⁴ attracted attention and stimulated smaller case study investigations,^{15,16} which confirmed the notable incidence of the problem in the eighties.

In this study, a very high incidence of new and recurrent lower back muscle strain was evident: 28% of all lower body soft tissue injuries (or 14% of all new and recurrent injury). This was not identified in other studies of the period possibly because of a narrower focus on more acute injuries. It indicates that, for windsurfers, specific muscular training and flexibility exercises focused on the trunk and back muscles are needed, with particular consideration of muscles acting at the hip and shoulder joints. The use of a neoprene waist and lower back support could be beneficial in the protection of the novice recreational and competitive windsurfer. Such a support could provide protection during initial shore based lifting activities when the back muscles may not be fully

Table 5 Recurrent lower body soft tissue injuries over two years

| | Muscle | | | Ligament | | | Bruising | | | Cut/graze | | | Total |
|----------|-----------|-----------|----------|----------|-----------|----------|----------|----|-----|-----------|----|-----|-------|
| | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | |
| Low back | 11 | 28 | 6 | - | - | - | - | - | - | - | - | - | 45 |
| Thigh | - | 2 | - | - | - | - | - | 4 | - | - | - | - | 6 |
| Knee | - | - | - | - | 12 | 2 | 10 | 2 | - | 3 | - | - | 29 |
| Shin | - | 8 | - | - | - | - | 10 | - | - | 5 | - | - | 23 |
| Calf | - | 1 | 4 | - | - | - | - | - | - | - | - | - | 5 |
| Ankle | - | 4 | - | - | 1 | 1 | 10 | - | - | - | - | - | 16 |
| Foot | - | 1 | - | 2 | - | - | - | 2 | - | 3 | 1 | - | 9 |
| Total | 11 | 44 | 10 | 2 | 13 | 3 | 30 | 8 | - | 11 | 1 | - | 133 |

Note: values in bold indicate ongoing injury.
RB, Raceboard group; WS, wave/slalom group; REC, recreational windsurfing group.

Table 6 Recurrent upper body soft tissue injuries over two years

| | Muscle | | | Tendon | | | Ligament | | | Bruising | | | Cut/graze | | | Total |
|------------|----------|-----------|----------|--------|----|----------|----------|----|-----|----------|----|-----|-----------|----|-----|-------|
| | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | RB | WS | REC | |
| Head | 8 | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 10 |
| Neck | 3 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | 9 |
| Upper back | 1 | 12 | - | - | - | - | - | - | - | - | - | - | - | - | - | 13 |
| Shoulder | 2 | 1 | 4 | 2 | - | 4 | - | - | 2 | - | - | - | - | - | - | 15 |
| Biceps | 1 | 1 | - | - | - | - | - | - | - | 4 | - | - | - | - | - | 6 |
| Triceps | 1 | 1 | - | - | 7 | - | - | - | - | - | - | - | - | - | - | 9 |
| Elbow | - | 3 | - | 10 | 2 | 5 | - | - | - | - | - | - | - | - | - | 20 |
| Forearm | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Wrist | - | 1 | - | 5 | - | - | - | - | - | - | - | - | - | - | - | 6 |
| Hand | 1 | - | - | - | 2 | - | - | - | - | - | - | - | 3 | - | - | 6 |
| Total | 17 | 26 | 5 | 17 | 11 | 9 | - | - | 2 | 2 | 4 | - | 3 | - | - | 96 |

Note: values in bold indicate ongoing injury.
RB, Raceboard group; WS, wave/slalom group; REC, recreational windsurfing group.

What is already known on this topic

- Development of competitive windsurfing over the last decade or so has changed the physical demands and thus one would expect the injury profile
- Recent studies have identified ligament sprain, fractures, and contusions as the most common injuries and the need for head protection when performing aerial manoeuvres

warmed up. It would also provide additional core stability during demanding tasks such as uphauling, which has been identified as a time of particular injury risk for long board sailors.¹ The use of a harness with a good release system to reduce longer term muscular strain should be considered.

The WS group reported about 250% more recurrent muscular strains to the body than the RB group. Ligament injuries and ongoing problems (particularly to the knee) were much more common in the WS group, which mirrors observations of Pryma *et al.*,⁶ who found ligament injury to be most common (33%). The RB group reported much serious bruising to the lower leg, which was due, in part, to problems when going aground.

Comparison of tables 5 and 6 reveals that overall there were more recurrent injuries in the lower than the upper body, with the WS group reporting injury to the lower back twice as often as to the upper back. Within the upper body, recurrent muscular and tendon strain in the neck to elbow region was a particular problem in all groups, although the recurrent incidence was much higher in the WS and RB groups.

CONCLUSION

The injury incidence was 1.5/person/year with a high incidence of new and recurrent muscular strain. Lower back muscular strain was prevalent, indicating the need for preventive measures. Comparison of the elite windsurfers reveals that participation in wave/slalom events was associated with more new and recurrent injuries, and the need for head protection.

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What this study adds

- The overall injury incidence was 1.5/person/year; elite wave/slalom competitors had a higher incidence (2.0/person/year) than elite raceboarders (1.0/person/year) and mixed activity recreational participants (1.2/person/year)
- Muscle/tendon strains formed 45% of new injuries with many recurrent, indicating the need for preventive measures such as body conditioning and supportive and protective equipment and clothing

Competing interests: none declared

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