Tournament water skiing trauma

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Abstract
Tournament water skiing is an increasingly popular and internationally successful sport in Great Britain, despite the climate. The kinematics and injury patterns of the three disciplines will be unfamiliar to most clinicians and are described, with estimation of the stresses. Advances in equipment over the last 15 years have reduced the risk of severe injury in the tricks event, while high speed impacts are responsible for the majority of trauma in slalom and jump. There is a surprisingly high incidence of injury to the lumbar spine during the high impact jump event. Comparison with findings in other sports suggests that the spine may be damaged by overuse, particularly before skeletal maturity.

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Key terms: sports injuries; water skiing

Tournament water skiing is an increasingly popular and internationally successful sport in Great Britain, and is attracting financial support which allows for full time participation by over a dozen athletes in this country alone. Very little has been published about injuries sustained by these elite sportsmen, descriptions in the majority of textbooks being largely confined to gynaecological injuries and trauma caused by collision with other objects and by the disastrous but rare propeller injuries which have little to do with the sport itself.

Competitive water skiing
Competitive water skiing has four completely separate groups: tournament, barefoot, racing, and the newly introduced show skiing (fig 1). Tournament water skiing has three disciplines, slalom, tricks, and jump, which may be entered individually or combined to give an overall winner.

In all three disciplines of tournament water skiing, the boat is driven at constant speed in a straight line down the middle of the course. In the slalom event, skiers have to ski outside six buoys – three on either side, equidistant (11-5 metres) from the boat’s path. If they are successful, the boat turns round and returns back through the course for the skiers to negotiate the same buoys (the first buoy always being on the right hand side), but this time at higher speed until the competitor fails. When the maximum permissible speed has been completed (58 kph for men and 55 kph for women), the line is sequentially shortened until

Figure 1  Show skiing.
the skier fails to round a buoy. At international level, the first pass through the course is already with a line shorter than the standard 18.25 metres, and the world record is currently at a line length of over a metre shorter than the distance from the line of the boat to the line of the buoys, meaning that the skier must not only swing out to be level with the boat at the side (figs 2 and 3), but also lean inwards using the length of the body to push the ski wider.

In the tricks (or figures) event, the boat speed is at the competitor's choice and the clock starts with the start of the first manoeuvre. Skiers then have 20 seconds or until they fall to do as many "tricks" as possible - the harder the trick, the more points are awarded, so a combination of speed and difficulty is essential. Tricks may be performed on the surface or in the air over the boat's wake, and may be with the tow line attached to the foot (fig 4). Jumping over the rope (like skipping) while turning, and somersaults (fig 5) are particularly high scoring.

Like the other two disciplines, jumping has no style points; in this case it is purely the distance covered between the ramp and landing that counts (provided that the skier is able to regain balance and ski away after landing) (fig 6). The boat speed is 57 kph for men and 54 kph for women and the jump heights 1.80 metres and 1.50 metres respectively. The jump is 6.4 metres long and usually
made of a steel frame with a flat waxed fibre-glass ramp surface (giving an angle of wedge of about 16 degrees for men). The distance jumped is increased by maximising speed through pulling out wide on the opposite side of the boat from the ramp and swinging back across as late, hard, and fast as the skier dares and then timing the kick off the ramp (fig 7). Clearly, the later and harder the "cut" the more speed and distance. The world record is a distance of 67-9 metres, and top skiers will strike the ramp at over 100 kph.

Traditionally, jumping has been regarded as the most dangerous activity, but higher speeds with twisting falls and sharp jerks from slack rope are common in slalom, where there are very rapid changes in speed and direction. This has been found to be a particular problem in early season, when skiers may not yet have progressed to "all-out" jumping while already slaloming to their limit. Until a few years ago when safety releases were developed and improved, there were several cases of knee ligament injury and femoral fracture during "toe-hold tricks", where the rope is held by the foot, skiers often being quite unable reliably to release themselves from the tow rope following a fall.

Types of injury
Injuries in elite tournament water skiers are different from those described in recreational participants\(^1\) in that they ski in a highly controlled environment from which natural hazards such as poor driving and dangers on the shore are largely eliminated. Although competitors are fitter, the stresses are much higher and less predictable.

The best data have been produced by the American Water Ski Association who, in sanctioning a tournament, insist that all injuries seen by the medical officer are reported to them on a standard proforma with a follow up questionnaire for the definitive diagnosis. In our survey of 87 of the best international competitors in the world, just over two thirds of the injuries were sustained during training and would therefore not be reported in America. The spectrum of injuries was also slightly different.

Of the acute injuries, those in the lower limb are largely as a result of skis catching in the water at high speed, particularly while jumping. Grades 1 and 2 collateral ligament injuries of the knee are common, with less cruciate and meniscal injuries than expected. Ankle injuries are uncommon, perhaps because of the high boots worn by elite competitors.

The upper limb (especially the shoulder) was injured as slack was taken up in the tow rope – largely during the slalom event. Blisters and callosities are troublesome in early season but self limiting.

Chronic low back pain is very common in elite tournament water skiers, as has previously been reported.\(^1\) Of 87 such competitors, 18 had had to miss training or competition within a 12 month period due to low back pain although none had any neurological symptoms.

Spinal pathology has been described in a number of sports,\(^6\) particularly in water skiing where participation at a young age is necessary to achieve excellence. Horne et al described the radiological changes found by screening competitors in the national water ski tournament in Canada, and correlated these with the number of years exposure to the jump event, especially before skeletal maturity.\(^6\) We have found that slalom is as high risk an activity as jumping, at least in unmasking symptoms in the presence of pre-existing pathology, but this is largely seen in early season – often when skiers were up to near their best in slalom but before full speed jumping had begun, and was associated with the sudden "snatch" of slack rope being taken up.

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**Figure 6** Jump – at the ramp.

**Figure 7** Jump – in the air.
The speeds and forces in water ski jumping have been estimated both by calculation and measurement (Smith G, unpublished data), and are thought to be 5–9 g both on striking the jump and landing, over a period of 95 ms. Intra-abdominal pressures have been measured at 120–192 mm Hg even in jumps of approximately half world record length. Elite competitors achieve speeds of up to twice that of the boat by cutting hard across the wakes — the later the cut is left, the more speed needed and the most severe injuries have occurred through leaving this cut too late and hitting the steep side of the ramp, sustaining a direct blow which, while uncommon, has resulted in fatalities.

The ability of binders to stabilise the ankle yet release only in the event of a fall is a source of concern. Elite athletes will often use the highest and tightest binders which will transmit forces most readily to the ski, but may not release in a fall, and the newly designed snow-ski type of boots, which release off the ski rather than foot, have yet to make a significant impact. Heel pads are worn routinely for jumping and need to be changed regularly to retain their function.

Prophylactic and therapeutic knee and lumbar spine support braces are being used increasingly and indeed many manufacturers include stiff bands along the sides of the knees in their jump wet suits. While these with protect the knee from a direct blow, the only possible support they may give is by cutaneous proprioceptive enhancement.

It is difficult to imagine a functional shoulder support which would do any more good than the knee braces, although “arm slings” (belts passing round the waist with a loop around the distal humerus, holding the shoulder in full adduction) are in wide use. No elbow injuries were reported as a consequence of these in this study, though it is a recognised hazard.

Conclusion
Tournament water skiing is an increasingly popular and competitive sport. Two areas cause concern: first, the high incidence of low back pain enforcing rest from the sport, and especially the possibility of an effect of high level competition on the immature spine; and second, knee injuries associated with the inability of binders to provide optimal support and release the foot when necessary. We suggest that tournament skiers should slalom below their maximum level in early season until they are fully “match fit” to avoid back injuries; and the development of safe bindings should be continued. More data are needed, but it has already been suggested that long distance jumping is an inappropriate event for children.

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