



## Risk and severity of injury in a population of BASE jumpers

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### Abstract

**Aim** To determine the frequency and severity of accidents in a population of BASE jumpers (people who jump with parachute from a fixed object such as from a cliff).

**Methods** To determine the frequency and characteristics of BASE jumping accidents, a cross-sectional survey of experienced BASE jumpers was completed.

**Results** 35 BASE jumpers enrolled in the study. Findings revealed that there were approximately 9914 jumps made and the estimated rate of injury was 0.4%. 39 accidents involving 21 (60%) BASE jumpers were found. 28 accidents (72%) predominantly involved the lower limbs, 12 (31%) involved the back/spine, 7 (18%) the upper limbs, and 1 (3%) was a head injury.

**Conclusion** BASE jumping is associated with a high risk of serious injury and appears to be significantly more dangerous than skydiving.

New Zealand has attracted an international reputation as an adventure sport destination. Worldwide adventure tourism and adventure sports are important leisure activities, of growing popularity. In this context, commercial adventure tourism has become increasingly important to the New Zealand economy. Adventure sports encompass a number of outdoor activities including rock climbing, mountaineering, skydiving, white-water rafting, mountain biking, and BASE jumping.

Recent reports in the literature have highlighted significant risk of injury and death associated with mountaineering, skydiving, white-water rafting, and mountain biking.<sup>1-5</sup>

BASE jumping is a sport that developed out of skydiving and uses specially adapted parachutes to jump from fixed objects. "BASE" is an acronym that stands for the four categories of fixed objects that one can jump off. These are: **B**uilding, **A**ntenna, **S**pan (a bridge, arch, or dome) and **E**arth (a cliff or other natural formation).

BASE jumping is an "extreme sport" and is ranked as being amongst the most dangerous adventure sports in the world (Figure 1).<sup>6</sup> As such, BASE jumping has been banned from many popular launch sites such as the Eiffel Tower in Paris and in Yosemite National Park (e.g. from El Capitan cliff where there has been fatalities) in California.

BASE jumping is considered to be significantly more dangerous than skydiving. As BASE jumps are made from lower altitudes than skydives (often less than 500 feet above ground level), BASE jumpers generally fall at lower speeds, have far less aerodynamic control, and may lose flying stability.

If the parachute is deployed while the jumper is unstable there is a high risk of entanglement or malfunction. The single canopy used may also be facing the wrong

direction. Such an off-heading opening is not problematic in skydiving, but off-heading opening that results in object strike is the leading cause of serious injury and death in BASE jumping. Also as BASE jumping takes place in close proximity to a cliff or tower which provides the jump platform, the BASE jumper may collide with the object.

**Figure 1. BASE jumping examples**



Jumper: Dr OM-D. Photo: R Topelberg.  
Location: Israel



Jumper: Dr OM-D. Photo: Red Bull Archive.  
Location: Austria

The only published study on morbidity and mortality associated with this sport examined the frequency of injuries and death associated with BASE jumping from a cliff in Norway and determined that BASE jumping is associated with a five- to eightfold risk for death or injury, compared with data on regular skydiving.<sup>7</sup> Interpretation and application of this data is limited by the absence of information on demographic characteristics or BASE jumper level of experience. Furthermore the report findings relate to the outcome of jumps from a single cliff, rather than the broad range of objects from which jumpers may launch.

The purpose of this paper is to report the demographic characteristics and morbidity findings in an international group of BASE jumpers. The degree of risk has been estimated utilising accident rates as denominator data and frequency of BASE jumps as numerator data. The data is taken from a study that has also examined the

psychological characteristics in this population (Monasterio, Mei-Dan, and Mulder in preparation).

## Method

Volunteers were recruited from BASE jump group meetings, adventure website forums, and from personal communication among the BASE jumping community. All volunteers who expressed an interest and contacted the authors were recruited into the study.

After giving written consent, participants completed several questionnaires providing demographic information and BASE jump information (estimated number of base jumps per year, how long they had been involved in the sport, whether they had had “near misses”, and whether they had suffered base jumping accidents).

The Cloninger Temperament and Character Inventory was also completed.<sup>8</sup>

Severity of accidents was rated as either:

- **Mild**—if injury required medical help, but did not lead to hospital admission and convalescence was less than 1 week;
- **Moderate**—if injury required hospital admission and/or convalescence was more than 1 week, but less than 3 months; or
- **Severe**—if injury led to risk of death, protracted convalescence (more than 3 months) and/or long-term health problems.<sup>2</sup>

## Results

**Demographics**—A total of 35 volunteers completed the questionnaires. Only one volunteer who requested inclusion into the study failed to return completed questionnaires. Thirty-four subjects (97%) were male and the median age was 34 (range 21 to 55 years.). Nineteen subjects (54%) were single/unmarried and most (27; 77%) did not have children. Fourteen participants (40%) were from the North American continent, 13 (37%) from Europe, 6 (17%) from Oceania, and 2 (6%) from Israel.

Thirty-five (100%) of the participants were involved in other adventure sports—the most common was skydiving involving all participants (35; 100%) and rock climbing/alpinism (16; 41%) participants.

*BASE jumper characteristics* are summarised in Table 1.

**Table 1. BASE jumper characteristics**

| Years BASE jumping |           | Total number of BASE jumps |          | Estimated frequency of “near misses” |           | Estimated accident frequency |             | Witnessed others dying from BASE jumping accidents |    |
|--------------------|-----------|----------------------------|----------|--------------------------------------|-----------|------------------------------|-------------|--|----|
| Med                | Range     | Med                        | Range    | Med                                  | Range     | Med                          | Range       | Yes  | No |
| 4                  | (0.25–17) | 274                        | (7–1600) | 3%                                   | (<1%–10%) | 0.5%                         | (0.01%–30%) | 26   | 9  |

Med=Median.

The median time of participation in BASE jumping was 4 years (0.25–17 years.), and the median number of jumps was 275 (7–1600). All 4 objects were used as launching platforms, without any particular object preference.

Participants estimated that the frequency of “near misses” from jumping was 3% and injury was 0.5%. Interestingly, 26 subjects (74%) had witnessed the death of at least one jumper from BASE jumping.

Accident findings are summarised in Table 2.

**Table 2. Accident characteristics of study participants**

| Mild injuries (N=10)  | Moderate injuries (N=17)   | Severe injuries (N=12)   |
|---|--|--|
| <ul style="list-style-type: none"> <li>• Tendon strain/soft tissue injury to ankle ×3</li> <li>• Contusion/soft tissue injury to lumbar spine ×2</li> <li>• Ligament damage to knee ×2</li> <li>• Laceration to arm requiring sutures</li> <li>• Contusion/soft tissue injury to lower limb ×2</li> </ul> | <ul style="list-style-type: none"> <li>• Fractured talus, 1<sup>st</sup> Metatarsal and ligament tear ×2</li> <li>• Fractured talus ×2</li> <li>• Multiple contusions/abrasions/soft tissue injury of lower limbs ×2</li> <li>• 1<sup>st</sup> metacarpal and carpal fracture ×2</li> <li>• Fracture to ankle and tear of Achilles tendon.</li> <li>• Fractured tibia and fibula ×2</li> <li>• Fractured radius and ulna—right and left side</li> <li>• Dislocation/ soft tissue injury to ankle</li> <li>• Concussion, loss of consciousness and sutures to skull</li> <li>• Fractured ankle ×2</li> <li>• Soft tissue injury to spine</li> </ul> | <ul style="list-style-type: none"> <li>• Fracture of femur</li> <li>• Fractured vertebrae (2)</li> <li>• Open fracture of tibia and fibula</li> <li>• ICU admission with fracture vertebrae (2), compression of vertebrae (4), fractured ribs (5), fractured cocchix and scapula, pneumothorax and haemothorax.</li> <li>• Spinal compression with fracture of multiple spinous processes</li> <li>• Multiple fractures to tibia/fibula with 180-degree dislocation of ankle.</li> <li>• Fracture of elbow, skull, multiple ribs with sprained ankle and pelvis</li> <li>• Multiple spinal and rib fractures with fractured tibia/fibula ×2</li> <li>• Spinal fracture with fractured tibia/fibula</li> <li>• Fractured L5 vertebra</li> <li>• Severe fracture to ankle</li> </ul> |

An estimated 9914 jumps were made; 39 accidents were reported, involving 21 (60%) of the participants. There was therefore 1 accident for every 254 jumps—a 0.4% injury rate. There were 12 severe, 17 moderate, and 10 mild accidents.

Of those who had more than one accident, nine participants were involved in two separate accidents; one each had three, four, and five accidents respectively. Twenty-eight accidents (72%) predominantly involved the lower limbs, 12 (31%) involved the back/spine, 7 (18%) the upper limbs, and 1 (3%) was a head injury.

## Discussion

To the authors' knowledge this is the first cross-sectional survey that examines the demographic, BASE jumping, and morbidity characteristics in a population of BASE jumpers. The study has captured a population of experienced BASE jumpers, who have been involved in the sport for many years.

The findings suggest that the sport attracts predominantly male participants in their mid-30s (participants become involved in the sport in their mid-20s, when they gain sufficient skydiving experience and the required maturity, and continue with the sport into their 30s), who are actively involved in a number of other adventure sport activities.

The participants generally BASE jumped from all four categories of fixed objects, without indentifying any specific object preference. Sufficient data was not collected

to determine whether accident frequency was related to particular jumping sites or objects.

The accident rate of 0.4% is exactly the same as that of a recent report by Soreide et al which examined injury rates from BASE jumping from a single site (Kjerag Massif) in Norway.<sup>7</sup> However, in contrast to the findings by Soreide et al (who found that most BASE jumping injuries were minor), 75% of injuries recorded in our study were moderate or severe.

Possible explanations for this difference include: (a) the Kjerag Massif is considered among the BASE jumping community to be a “safe” object to jump from. This is because the cliff is high (1000m) and therefore allows greater speed before parachute deployment and control by jumpers, (b) it has a clear landing area, (c) it is a legal launch site and therefore more dangerous, rushed, or night time jumps (to avoid authorities) are unlikely to occur, and (d) the site is known to attract beginner as well as experienced jumpers.

The inclusion of a high number of beginners may paradoxically decrease the risk of injury severity as they do not generally attempt “complex manoeuvres” that are more commonly associated with severe injuries.

The overall risk of non-fatal injury associated with modern skydiving has been estimated to be between 48 and 174 per 100,000 jumps.<sup>4,9</sup> Risk of injury from BASE jumping in this study is three to eight times higher (394 per 100,000 jumps). Moreover the rate of injuries requiring hospitalisation in our study was 294 per 100,000 jumps and 16 times higher than that found by Burrows et al (18 per 100,000 jumps) in their study freefall skydiving injuries.<sup>4</sup>

The BASE jumpers in this study appear to have a reasonable understanding of the rate of injury associated with the sport, as they “estimated” that the accident frequency from BASE jumping is 0.5% which is very similar to the accident frequency found in the study (0.4%).

The majority of accidents (80%) involved significant injuries to the lower limbs and spine, and the overall severity of these suggests that BASE jumping injuries are likely to present a significant burden to health services, particularly hospital accident and emergency, trauma, and rehabilitation departments. They are also likely to contribute to persisting chronic disabilities and significant loss of productivity.

Several methodological limitations need to be considered in interpreting the results of this study. The population was not a random sample. All participants who volunteered were included and the sample size was relatively small. This may have lead to selection bias as those jumpers who had experienced prior accidents may have been more motivated to share their experience and therefore more likely to participate in the study.

As the study included only active jumpers, cautious BASE jumpers, who had given up the sport following an injury or a “near-miss” experience, may have been excluded. The sample may therefore represent those with a particularly high risk-taking propensity. Alternatively the sampling process may have excluded particularly high-risk groups; as less experienced, more impulsive and higher risk-taking jumpers may

have been involved in fatal accidents at earlier stages of their BASE jumping careers and therefore were unavailable for inclusion in the study.

Of concern, Soreide et al found the death rate associated with BASE jumping from the “safe” Kjerag Massif to be 0.04%.<sup>7</sup> Given the greater severity of injuries found in our sample we are concerned that our population presents an even higher risk of mortality, and intend to undertake 2- and 5-year follow-ups of this population to determine whether this is the case.

**Competing interests:** In the past EM has worked as a mountain and jungle guide (12 years ago) and mountain cycle guide (6 years ago). OM-D is an active BASE jumper and has worked as a promotional stuntman.

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