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Injury Patterns and Wilderness Medical Preparedness in BASE Jumping

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SUMMARY

Background. The risks of BASE jumping are due both to its high inherent risk and the austere locations in which jumpers are often injured. Despite this, emergency management education and resources are lacking for BASE jumpers. We seek to highlight a category of treatable incidents whose outcomes could be improved through emergency medical education and training.

Methods. The available literature on BASE jumping injury profiles and wilderness medical education were reviewed. Based on these data, experts on BASE jumping injuries and austere rescue provide medical training and equipment suggestions for BASE jumpers operating in remote environments.

Results. Orthopedic injuries, particularly of the lower limbs and spine, predominate in BASE jumping. Almost no medical or training resources exist that have been developed for, or in partnership with, the BASE jumping population. Group preparedness may be significantly aided through a combination of equipment carried on each person and equipment that can be quickly accessed.

Conclusions. Emergency preparedness is multifactorial and context-dependent, but jumpers' ability to respond to both injury and rescue situations is crucial in the BASE environment. A proactive approach from the wilderness medicine community can address the problem of BASE jumping injuries from medical and pre-hospital perspectives.

KEY WORDS
Improvisation; parachutist; trauma; injury; BASE; Wingsuit

INTRODUCTION

Fixed object parachuting, also known as BASE (Building, Antennae, Span, Earth) jumping, is an extreme sport known to entail risk to life and limb (1,2,3). Regardless, the sport continues to grow quickly. Unfortunately, this growth is paralleled by an increasing number of BASE-related injuries and fatalities (3,4,5). To better remember and learn from these incidents, members of the BASE jumping community maintain a running list of information on all known BASE-related fatalities, known as the 'BASE Fatality List' (BFL) (4). The BFL contains information on each incident and clearly shows the upward trend in annual fatalities since the first known fatal incident in 1981 (**figure 1**). Even when accounting for the upward fatality trend, driven by the sport's growth and the increased popularity of wingsuit BASE jumping, significant variation in year-to-year fatality rates does exist and its causes are yet to be thoroughly understood (3,5).

The potential influence of social media, while not yet rigorously documented, appears anecdotally to be a driving force in riskier BASE practices. Recent advances in both the technology and popularity of wingsuiting, a discipline of skydiving/BASE involving a suit worn along with a parachute to increase glide, have accompanied this growth. Since 2000, wingsuit-related fatalities have gone from being sporadic to accounting for the majority of BASE-related fatalities (3,6).

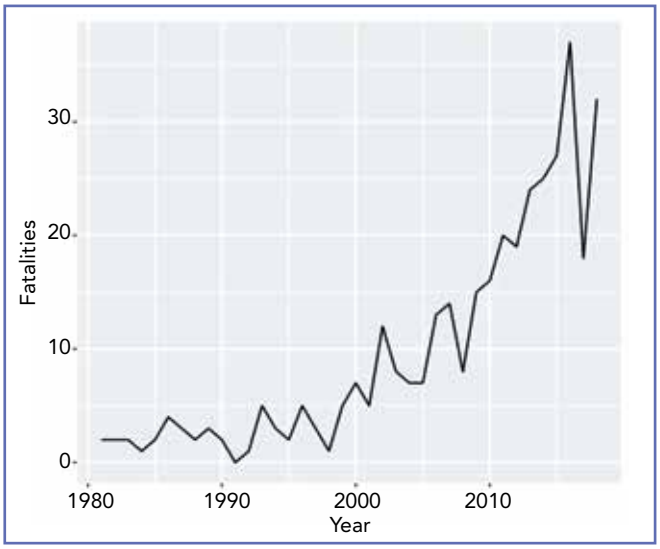

Figure 1. BASE Fatalities 1981-2018 (4).

Although not a formal rule, most BASE instructors recommend that aspiring jumpers have at least 150-200 skydives as a foundation of experience before beginning BASE training (7). This skydiving background helps develop a number of skills such as freefall and parachute piloting skills, planning, risk management, and emergency management.

A common assumption is that when one BASE jumps, only one of two outcomes is possible: either the jumper will be completely uninjured or immediately dead. However, many types of malfunctions are possible (7). Similarly, not all injured jumpers are either stable and ambulatory or dead on scene (2,5,6,9). It is possible that belief in this false dichotomy may itself be part of the reason that so little medical research exists regarding BASE injuries. Non-fatal injuries needing management do exist (2,5,6,9). Acknowledging the existence, and understanding the nature of treatable injuries is necessary to begin developing medical solutions.

With the growing participation and fatality rates in this sport, more research is required to understand the mechanism of risks associated with the sport and to better prepare participants and first responders (3). By evaluating the injuries and factors which lead to them in BASE jumping, standards can be established for the equipment needs of participants and medical responders.

METHODS

Review

A narrative review was performed through PubMed, Google Scholar and Google. Additional references were sought among citations within the articles. Search terms included "expedition", "skydive", "base", "jumping", "parachute", "injury", "wilderness", "medicine", "first aid", "training", "emergency", and "wingsuit". Articles identified in this search were included according to their level of discussion of wilderness medicine topics in the context of parachuting, focus on parachuting sports or parachute gear, and English language publication. Articles not focused on parachuting sports or on non-BASE parachuting were not considered for inclusion.

Suggestion development

Suggestions presented herein are representative of the consensus judgment of an expert panel based on injury profile data, evidence on wilderness medical kit contents and experience in field rescue with the guiding priority of minimalism. More specifically, the suggestions are crafted to solve the largest number of relevant problems with as little dedicated equipment as possible.

The experts consulted include the following: a US emergency medicine physician with 10+ years of BASE jumping experience who has worked as the expedition physician for many remote BASE expeditions, a US emergency medicine physician with 10 years of BASE jumping experience and 5+ years of experience as a remote expedition physician, a US military combat medic with 5+ years of experience in BASE jumping, a US military combat medic with 5+ years of experience in BASE jumping and wilderness EMS, and a professional BASE jumping instructors with 20+ years of BASE jumping experience. In addition to the listed qualifications, all experts have provided medical care and overseen rescues in the BASE environment.

Standardized questionnaires were given to every consultant and any additional information provided beyond the original questions was tracked and reported. The standard questions were the following.

- "What do you consider the bare minimum training and equipment for BASE jumper medical preparedness?"
- "What experience do you have in BASE medical emergency management?"
- "What has been your experience with using parachutes and other existing relevant equipment as improvisational tools?"
- "What do you see as a responsible way to provide medical training to jumpers?" The experts' various recommendations were recorded and grouped to develop the included suggestions as ideas for emergency preparedness equipment.

Results: expert panel

Each expert answered every question and their responses are summarized here with description of individual responses, when relevant.

Question 1: "What do you consider the bare minimum training and equipment for BASE jumper medical preparedness?" Regarding formal medical training, each of the following was mentioned as a recommended medical training pathway: Wilderness First Aid (WFA), Wilderness First Responder (WFR), Acute Trauma Life Support (ATLS), and Tactical Combat Casualty Care-All Combatants (TCCC-AC). None of these were mentioned more frequently than another.

Having enough experience in the BASE environment to anticipate and avoid accidents was consistently emphasized as being more important than medical training. Aspects of situational awareness, such as familiarity with local rescue vehicle access, how to activate local emergency and rescue resources, and the practice of agreeing on emergency plans prior to BASE activities, were similarly emphasized over individual medical training. The ability of a jumper to lower themselves from a suspended position, referred to as "self-belay", is considered a mandatory skill for BASE jumpers by one expert.

Regarding equipment for medical preparedness, the experts consistently emphasized the importance of considering context (location, weather, team size, time of day) of any given jump or expedition. The most commonly suggested items to be carried were tape, multitools, dental floss, knives, methods for locating a team member (GPS locator or whistle), tourniquets, and water. Other items mentioned include SAM (Structural Aluminum Malleable) splints, traction splints, blankets and safety pins. Multiple experts noted that there is an important difference in what equipment needs to be 1) carried on each individual jumper, 2) carried on at least one person in the team, 3) quickly accessible by the team, and 4) accessible through external resource activation, such as rescue teams. Small items and those regarding improvisation and self-rescue, such as water, dental floss, tape, and multitools, were recommended to be carried by each jumper. Larger sets of equipment, such as climbing equipment for vertical rescue, traction splints and backboards, simply need to be reasonably accessible by the team.

Question 2: "What experience do you have in BASE medical emergency management?" BASE jumping-related incidents in pre-jump activities, jumping activities and post-jump activities were described. Injuries before or after BASE jumping activities were typically related to hiking and climbing while approaching or climbing down from the exit point or landing areas. BASE jumping incidents managed by, witnessed by, or otherwise involving the consulted experts include the following: cliff and building strikes, some resulting in vertical entrapment on the object's vertical face; hypothermia, frostnip, and frostbite; heat stroke and dehydration; fractures of the wrist, radius, ulna, fingers, nose, vertebrae, ribs, femur, tibia, and ankle; dislocations of the shoulder, knee, patella, and ankle; improvised high-angle rescues from cliffs; the placement of backboards with and without BASE jumping rigs and helmets; water rescues; and placement of femoral traction splints.

Question 3: "What has been your experience with using parachutes and other existing relevant equipment as improvisational tools?" Experts' experience with developing splints for orthopedic injury of the tibia, ankle and wrist were described using common protective gear (such as shin pads), parachute lines and extra clothing. Slings were developed from jumpers' clothing using safety pins that one expert regularly keeps in their BASE jumping equipment. Dental floss carried by a jumper has been used in an incident managed by one expert to lift water and climbing equipment to a vertically-entrapped jumper. One expert has used a piece of rigid cloth from the parachute deployment system known as the 'bridle' to develop a tourniquet and used their multitool as a windlass for tightening the tourniquet. The use of parachute equipment in marking landing areas for a rescue helicopter was also mentioned.

Question 4: "What do you see as a responsible way to provide medical training to jumpers?" All consulted experts agreed that providing small amounts of medical training to individuals otherwise lacking medical training may be harmful. This risk may exist in the form of partially-trained individuals failing to activate emergency resources out of the assumption that their limited training will be adequate to manage a given emergency or improperly applying their skills. This possibility also may introduce liability concerns for those offering the training. Most experts recommended that any medical training provided must be as simple and limited as possible with the priority placed on timely activation of emergency resources and patient assessment. Encouraging jumpers to seek medical training through some type of established formal training (WFA, WFR, TTTC, etc.) was broadly considered the most responsible approach by the consulted experts. No particular training pathway or program was mentioned with more consistency than another.

DISCUSSION

Accident rates

BASE jumping environments are quite heterogeneous, so a jump's absolute risk is unpredictable. Factors like exit altitude, the landing area, changing weather, and social pres-

sures provide meaningful stressors and distractors that intensify the variability in risk between jumps, while variability in (changing) technical challenges has direct impact on the jump's outcome. Despite this diversity, the injury rate has been predicted independently by various authors at 0.4% per jump (1 injury per ~250 jumps).[1,9] Severe injuries, defined in the study by the time needed to recover, occur at a rate of 0.2%, or 1 severe injury per 500 jumps (6).

One popular BASE jumping location, Norway's Kjerag Massif, has tracked the number of jumps made since 1994 resulting in a fatality risk of 0.04%, or 1 in ~2500 jumps at this object (1). Kjerag Massif is generally considered a "safe" object due to the forgiving cliff angle, ample freefall altitude, legality, and landing areas. Other BASE jumping locations are therefore likely to be at least as dangerous, if not more dangerous, in terms of fatality risk per jump. These accidents, fatal and non-fatal, provide an ongoing challenge for medical providers and search-and-rescue resources in popular jumping locations: Italy, Switzerland, Norway, Australia and the Western United States currently most notable.

Injury profiles

Injuries with all varietiesy of intensity occur within BASE jumping. **Table I** stratifies a sample of reported BASE jumping injuries by representative injury type and severity, as determined by time to recovery, risk of death and level of medical care required in managing the injury (9).

Regarding anatomic injury profiles, lower limb injuries are the most commonly reported—present in 61-72% of BASE accidents due to being the first body part to "hit the ground" and slow down the flying jumper upon impact (6,8). Of the other injuries documented, 20-31% included back and spine injuries, occurring when the legs do not absorb all the energy of an impact; 18% included chest wall injuries, often related to hitting vertical objects under canopy or on landing; 18% included upper limb injuries, commonly from landing on an outstretched hand; and 3-13% included head trauma from landing or object strikes. Many subjects reported multiple injury categories per incident. Søriede and colleagues indicate that severe head trauma was the most prevalent fatal injury in their sample from the Kjerag Massif jump records (1). These studies' injury data are presented in **figure 2** and represent the relative rates of body region inclusion, meaning that more than one may be marked for any given jumper or injury, leading to a cumulative rate appearing to exceed 100%.

Table I. BASE Jumping Injury Severity Diversity (9).

Mild (25.6%)	Moderate (43.6%)	Severe (30.8%)
Contusions Small lacerations Strains and Sprains	Small bone fractures Joint dislocations Blunt thoracic trauma	Femoral fractures Open fractures Multiple moderate injuries

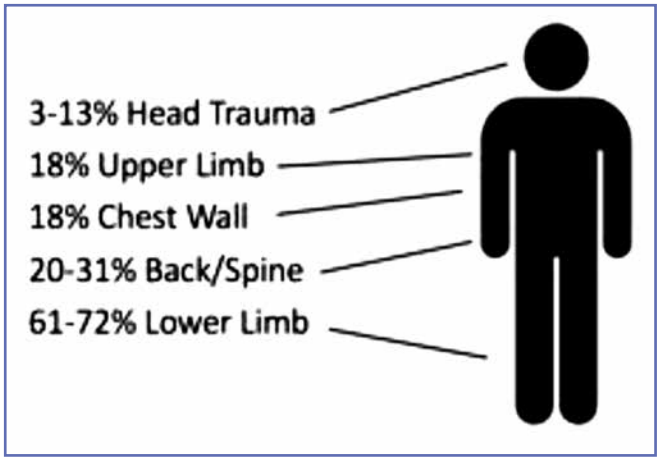

Figure 2. Dispersion of Injury Regions in BASE Jumpers (6,9).

Research on BASE jumping injuries using emergency department records gives further resolution to the data. From 2010-2014, BASE jumping injuries treated in United States emergency rooms were diagnosed with injuries in multiple body regions in 55% of cases, 38% with isolated extremity injuries, 5% with isolated head or neck injury, 2% with isolated chest injury, and 1% with isolated abdominal injury (10). It is worth noting that in analysis of BASE jumping injuries in this study, all patients that reached an emergency room ultimately survived their injuries, whether they were discharged directly from the emergency room or escalated to inpatient or surgical care.

The jumpers' experiences and mindset

Safe practices, conservative risk assessment and humility are considered by the consulted experts to be capable of preventing many of these accidents. However, of BASE jumpers surveyed in Mei-Dan and colleagues' 2012 work, 43% had experienced a significant injury in the sport, 72% had witnessed the death or serious injury of a fellow jumper, and 76% had had what they considered to be a 'near-miss' incident (6). Only 6% of jumpers surveyed had never been injured, seen a fatality or had a 'near-miss.' In addition, based on Mei-Dan and colleagues' analysis of the known fatalities and their data-driven estimate of the number of active BASE jumpers, it was estimated that there is approximately a 10% lifetime fatality risk associated with BASE jumping (3).

Even among other extreme sports, BASE is a uniquely risky environment (11). For this reason, the psychology of BASE jumpers has also been the subject of research. Understanding their motivations for becoming involved in the sport may contain insights for how to motivate them in pursuing further training in related topics like emergency management. Scientific personality assessments among BASE jumpers have identified high levels of novelty-seeking and self-directedness with low levels of harm avoidance, social reward dependence and self-transcendence, when compared to controls (12). However, no narrowly-defined personality profile encompasses all jumpers. Individual variance in personality traits does not significantly correlate with a history of BASE-related injuries or jumpers' gender identity (12,13). Significantly, 40% of BASE jumpers were found to have extremely low harm avoidance scores, while only 5% of controls had comparably low scores.[14] These low harm avoidance scores may confer resilience to psychological stress and are edified by high levels of persistence and self-directedness (14).

Analyses considering these personality traits alongside neuro-endocrine stress markers have identified latent subgroups of stress reactivity patterns and distinct personality profiles among BASE jumpers (14). Stress reactivity trajectories surrounding BASE jumps correlated significantly with these multidimensional personality profiles and individual personality measures. Jumpers' experience, personalities and mindset do concretely affect the stress their body undergoes and the way they experience the jump.

The colloquial assumption is often that BASE jumpers have little regard for their own lives and enjoy risk itself. However, their motivations are far more complex. Wingsuit BASE jumpers in a particularly risky discipline called terrain proximity flight—intentional flight close to the object—have been the subject of qualitative psychological assessment (15). BASE jumping was found for these individuals to be an extremely personal pursuit. It was their way to understand and process the world, grow as individuals and discover their authentic selves. They described it as instilling confidence, a sense of purpose, emotional regulatory capacity, and the ability to manage fear and anxiety in all facets of their lives. They saw wingsuit BASE jumping not a risk taken just for the thrill, but a mechanism of growth and self-realization (15).

These data help show not just what kind of people are drawn to become BASE jumpers, but also how their training and experience interact with and contribute to who they become and how they handle the physical and psychological stresses of BASE jumping. This may serve as an important context for the development and promotion of BASE-related training programs, such as an emergency management course.

Wilderness medicine considerations and training resources

While new jumpers (skydivers and/or BASE jumpers) are typically encouraged to seek some sort of first aid training, it is not known whether this training is obtained with any regularity. Based on the authors' experience and personal communications with many BASE jumping course instructors, as of this writing, it is not common practice to offer medical training as a formal component of BASE training programs, if it happens at all. BASE jumpers are often insufficiently trained and ill-outfitted for medical emergencies. Integrating medical and emergency management training components to first BASE jump training courses could be a way to systematically address this gap among jumpers entering the sport.

No research articles were identified that involved the documentation, development, effectiveness, or necessity of any wilderness or improvisational medical interventions aimed specifically at skydivers, wingsuiters or BASE jumpers. One article mentioned a parachute as a potential improvisational tool, but did not demonstrate gear-specific knowledge or application (16). Case reports about injured jumpers also exist, but offer little in terms of solutions (17, 18). A book on extreme sports injuries mentioned some preliminary considerations for treating injured BASE jumpers and skydivers, but was not intended to meaningfully prepare the jumpers themselves (2). The only identified resource developed specifically for jumpers is an extended post on a popular BASE jumping social media forum covering the absolute basics of emergency assessment, shock, blood loss, long bone injuries, and joint injuries for BASE jumpers (19). *The Great Book of BASE,* the popular training guide for the basics on BASE jumping, lacks specific advice other than the blanket advice to seek first aid training.[20] Neither an overview nor recommendations on what medical equipment should be carried on BASE jumping expeditions was identified in the authors' search.

Existing work does acknowledge the question of which items belong in a medical kit, but often focuses broadly on what items have been carried on expeditions in the past (21-23). Some authors have curated their recommendations to the problems faced by a specific group of athletes, such as mountain climbers, adventure race participants and backcountry snowboarders (24-30). These medical kits tend to focus on managing soft tissue injuries, minor orthopedic injuries and repetitive use injuries. Articles on sports practiced in less accessible locations did have a stronger focus on tools that would aid evacuation or rescue, such as whistles and GPS, and improvisation, such as binding materials like wire and tape (27,28).

Jumpers are not likely to be searching for their training solutions in the medical literature, so these limited academic results are unsurprising. Currently, new jumpers only have informal stories about managing injuries, very limited first aid training, and potential career medical training to inform the dangers they may face in the sport. Discussion and action within the medical community could very realistically lead to the development of tools, resources, or training that affect real progress in BASE jumper emergency preparedness.

Even among those who do not survive their BASE jumping injuries, about 12% of fatally injured jumpers were alive on site when rescuers arrived.[8] While this does not mean that any individual case certainly could have been affected through improved interventions, it indicates the existence of potentially treatable cases. Details of the 'golden hour' are controversial in the scientific literature, but simple actions that can be taken in-field or training that can be given to expedite rescue and escalation of medical care are likely to be beneficial (31,32).

It has been shown that with adequate initiative, a sport's cultural push for safety can lead to concrete outcomes. For example, avalanche survival courses have recently become very popular among alpine and backcountry skiers. Even without regulatory compulsion, those athletes have taken their safety into their own hands, with preparation such as first aid courses being pre-requisite for many professional avalanche training courses. Similar educational resources do not exist for skydivers and BASE jumpers. Improvisational medicine based on parachute equipment appears entirely unaddressed in the civilian literature on wilderness medicine. Although the authors are aware of the military literature on improvised medical uses of parachute equipment, further work needs to be done adapting these principles to civilian BASE jumping activities (33).

Medical kit suggestions and preparedness recommendations

Based on the injury profiles developed in this previous research (**figure 2**), it is clear that injuries of the lower limb predominate in BASE jumping, followed by back and spinal injury, chest wall injury, and upper limb injury. The treatment of orthopedic injuries is therefore of highest priority for equipment and training selection purposes. Existing data on the contents of professional medical rescue kits indicate a prioritization of equipment for splinting, resuscitation, oxygenation, wound dressing, and heat management—a higher level of care than can be reasonably achieved in an individual emergency kit (23,25,34). The following suggestions do not represent an exhaustive or ideal list. Self-management of medical problems should only be considered in the absence of accessible rescue care as a measure of last resort. A 'fully prepared' jumper would need to have dedicated training and bring additional equipment, similar to skiers or climbers heading to remote unknown dangerous projects, but simplicity drives adherence. It is important that each and every person in the jumping group agrees on a concrete, current plan on which emergency resources to contact and how they will be contacted for every jump location, known as "exit points", and region. Jumpers must consider that intervening circumstances can make emergency access impossible. For example, rescue helicopters often will not fly in fog. This means that even with a perfect plan for rescue, there are instances where some degree of self-management is necessary. It is wise for BASE jumpers and anyone recreating in remote environments to seek some degree of training in first aid and wilderness emergency management.

No data were identified regarding what medical gear best supplements standard BASE equipment for the management of medical emergencies. The authors and consultants therefore share their personal clinical practices. A data-based approach is categorically superior to a compilation of opinions, so the available data on wilderness medical kit contents were incorporated whenever possible, but the unique practicalities of and severity of injuries in BASE jumping limited these resources' contributions (23,35-37).

The consultants' experience indicated that BASE jumpers deciding on medical kit contents should consider both Primary equipment, carried redundantly by each jumper, and Secondary equipment that should be available for use, but does not need to be carried on each person. The treatment of orthopedic injuries, enabling improvisation with minimal equipment, and aiding cliff/building rescue were considered the top priorities based on the presented data and the consultants' experience. Items that are highly recommended as Primary equipment include an emergency whistle and/or a GPS beacon, a small roll of tape, a multitool, dental floss, and extra water (**table II**). These represent items with important roles not just through their intended functions, but also the improvisational and rescue techniques that become possible through them. The whistle is to aid in locating the injured jumper, tape and a multitool can have a wide number of improvisational and survival roles, dental floss can be lowered to retrieve the end of a heavier rope or light supplies in rescues where the victim is vertically suspended (stuck in tree, hung up on a cliff), and extra water is a survival aid in any situation where prolonged rescues are a possibility. Depending on situational context, a GPS locator such as Garmin InReach should be considered for inclusion in the Primary equipment. It is reasonable to

substitute a lightweight utility cord for dental floss, if kit size permits, but jumpers must be strictly cautioned against the likely severe or fatal outcome of suspending their own body weight on any unsuitable type of cord.

Secondary equipment is usually kept in a nearby camp or vehicle and typically includes items such as SAM splints, femoral traction splints, blankets, and extra water, in addition to equipment for other location-specific concerns like cliff and tree rescues. Some consultants recommend the inclusion of a pelvic binder if members of the group are trained on its proper use. In any discussion of wilderness medical care, it is important to address the idea that treating a potential future patient beyond the scope of one's training can be just as dangerous as not acting. Adequate training is key to the responsible and effective practice of wilderness medical care. Unique needs presented by environmental and personal contexts should absolutely be considered by all jumpers when making equipment decisions.

Improvised solutions like carrying techniques, slings, splints, and rescue techniques are all made much more viable with even minimal equipment such as these. While it may seem counterintuitive, rigid supplies and classic tools (i.e., SAM splints) are not necessary to make an effective splint. Padding materials, such as a parachute or wingsuit arm foam, are quite rigid when adequately compressed. For this reason, rigid splinting and support materials like sticks or hiking poles are not strictly necessary for field injury management of common BASE-related orthopedic injuries. No matter the supplies, each environment presents different challenges. Just to name a few examples, jumpers in cliff and forest environments would be well-served to learn rappelling techniques; in the afternoon, bringing a headlamp is a must, given the long duration of some rescues or paths off the object if conditions deteriorate; and extra water is more crucial in desert environments where water is unavailable or where filtering may not be feasible. In any location, having a long-term mindset with one's contingency plans is advantageous.

Anecdotally, recent incidents have highlighted the importance of bringing equipment that can aid in locating an injured jumper. One in particular involved a wingsuit pilot who survived terrain impact without deploying a parachute. The jumper was severely injured but was not located for many hours until hikers heard them yelling. Simple emergency whistles carry better than the human voice over distance and a carried GPS beacon could have called for rescue. Either may have significantly expedited rescue for this jumper or another in their situation.

Table II. Suggested equipment.

Primary Equipment	Secondary Equipment
Emergency Whistle	SAM Splint
Tape Roll	Femoral Traction Splint
Multitool	Blankets
Dental Floss	Extra Water
Extra Water	Pelvic Binder
GPS Locator (per context)	Vertical Rescue Equipment

LIMITATIONS

The primary limitation of these suggestions is the lack of identified experimental data on what constitutes the optimized BASE medical kit. Unfortunately, identified data on medical kits in other wilderness and sport environments are difficult to generalize to BASE because of its unique weight/volume considerations, injury profiles, and improvisational tools in the BASE environment. To mitigate this, many consultants with broad experience in BASE expedition medicine, injury management, and search and rescue were consulted.

CONCLUSIONS

Best practices in wilderness medical emergencies depend heavily on the medical background of the jumpers, the severity of the situation, and location. Despite these nuances, with modest preparations, many BASE emergency situations could be made more manageable and lives can ultimately be saved. Orthopedic injuries, particularly of the lower limbs, are the most likely in BASE jumping. Limited equipment with both medical and rescue-oriented purpose carried by each jumper may help improve BASE jumping accident outcomes, in the opinion of consulted experts. The suggested equipment includes primary equipment carried redundantly on each person and secondary equipment that is accessible to the team, but is not practical or helpful to carry on the person.

Care must be taken to provide and develop training in a 'do no harm' fashion, avoiding improper application of only the most memorable techniques in damaging ways by partially-trained individuals. The potential liability concerns associated with any medical training must be acknowledged, but can be mitigated and should not stand as an unquestionable barrier.

The development of curricular materials for teaching emergency management educational sessions at BASE jumping holidays ("Bridge Day" in West Virginia, for example), skydiving events, BASE first jump courses, and BASE advanced jump courses therefore may represent opportunities to affect injury outcomes in the entire parachuting community. Resources should be developed for audiences with and without formal medical training.

BASE jumping carries significant risk, but the BASE community as a whole also demonstrates a dedication

to safety. A population-centered approach to determine jumpers' needs will aid in designing effective solutions and curricula. There are significant challenges presented by the wilderness environments in which BASE jumpers are often injured, but creating links between the BASE and wilderness medicine communities could lead to changes with concrete impact on injury and fatality outcomes. This work serves only as an early step in establishing best practices for jumper preparedness.

CONTRIBUTIONS

Study concept and design (JS, GV); Acquisition and analysis of data (JS, MS); Drafting of the manuscript (JS); Critical revision of the manuscript (JS, MS, GV, OM); Approval of final manuscript (JS, MS, GV, OM).

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests (38).

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