Military Static Line Parachuting Injuries Seen by the Airborne Battalion Provider

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Abstract

Military static line parachuting exposes jumpers to a variety of novel methods of injury. Providers assigned to Airborne units need to develop and maintain a high index of suspicion when dealing with jump-related injuries. Understanding the incident rate and the mechanism of injury can help a provider better identify injuries based on the history of the incidence and develop that index of suspicion. Injuries can happen at almost any point during the jump process and each step has both common and unique injuries associated with it. In addition to identifying, managing, and treating the injuries involved, providing information on estimated time until return to duty can be beneficial for the commander. In the end, a provider's best tools for managing Airborne-related injuries are an understanding of Airborne operations, quality orthopedic skills, and a high index of suspicion.

Introduction

Military members have been jumping out of aircraft around the world for over 60 years, and in that time, technology has advanced in both safety and techniques. Today's paratroopers exit from fixed-wing and rotary-wing aircraft, at altitudes between 800 feet above ground level all the way up to 30,000 ft above ground level, using parachutes that range from non-steerable round parachutes deployed by static line to high performance ram-air rigs opened by the jumper after a period of freefall. Regardless of equipment type, exit altitude, location, or experience, injury is always a possibility; and despite the high level of training involved, fatalities do occur. The majority of the Airborne population performs static line jumps, and any provider assigned to such a unit should have a good working knowledge of the most common injuries, to include their history, physical exam, treatment, and expected time until they are able to return to duty.

Currently most static line operations are using round parachutes with a chest-mounted reserve. A typical proficiency jump involves a T-10 Main chute with a Soft Loop Center Pull Reserve chute, and an exit from the aircraft between 1000-1500 feet above the target drop zone. Exits are typically from a fixed wing aircraft at close to the aircraft's stall speed (approx. 135 knots for a C-130) and the parachutes are deployed by use of a static line that attaches to an anchor-line cable inside the aircraft.[1]

The military assigns Soldiers on active jump status who perform static line jumps to an Airborne or Special Operations unit. The rank structure, age, gender, and other demographics in these units is often representative of an equivalent non-Airborne unit of the same size and type. Despite their physical fitness, Soldiers in these units experience an increased likelihood of injury due to their jumping activities. Due to the nature of their assignment, these service members often perform and train to a higher level of fitness than non-jumping servicemembers.[2] The organizational and social environment of these units can cause a reporting bias in regards to injuries due to a desire to avoid the appearance of weakness. Overall, the military's training methods have limited the type and number of injuries involved with jumping. Most injuries are attributable to jumpers not complying with training standards.

Injuries associated with static line jumping include: traumatic brain injury (TBI); ankle sprains; ankle fractures; tibial and/or fibular fractures; lumbar spinal compression; distal biceps ruptures; facial laceration and abrasions (aka: "riser burn"); as well as others. A large majority of injuries are due to the jumpers' own actions or those of a jumper in their vicinity. Riser burns are often due to improper exits, distal biceps ruptures from lack of control over one's static line, lumbar compression injuries from long jumping careers, TBIs from poor landings, and leg injuries including fractures and sprains from any of the above reasons as well as fellow jumpers in the air. However, some injuries are attributable to the aircraft, weather, or drop zone, as well as other factors outside of the jumper's control.

Injury Incidence

Parachute injury surveillance drops off at the end of World War II, and without historical or current data it is difficult to pin down exact injury incidence and the data surrounding the injury.[3] This limits the accuracy of the data for less severe injuries, as Soldiers may have waited to see their primary care manager at the Battalion Aid Station or troop medical clinic (TMC). Most minor injuries, especially those associated with a stigma such as riser burn, often go unreported to an Aid Station or TMC. For this reason, any provider at an Airborne unit can expect to see higher rates than those included in this paper.

In a recent edition of the *Journal of Preventative Medicine*, parachuting was the second most common cause of acute injuries leading to hospitalization in the military, second only to falls. For the Army, parachuting was the number one cause of lower extremity fractures and the second most common cause of lower extremity and spinal sprains and strains.[4] During 1994 – 1996, there were 1,972 injuries out of the 242,949 jumps made at Fort Bragg, NC.[3] One hundred and thirty of these injuries were at altitude, which includes everything from exiting the aircraft until the jumper lands, and the remaining 1,842 injuries were related to landing, including the execution of the Parachute Landing Fall (PLF). The incident rate for injuries in general is 8.1 per 1000, but only 0.54 per 1000 for injuries at altitude, demonstrating that most injuries happen upon impact with the ground during landing.

Injury incidence in relation to age seems to be inconclusive. There is data showing that older jumpers (30-39 y/o) were more likely to be injured, while in another article by the same author the 30-39 y/o age group has half the injury rate of the younger group (17-29 y/o).[3] Craig suggests that the lower rate for older jumpers is due to experience and the ability to choose the jumps they participate in.[5] Craig did not comment on the increased injury with age in his later article; however, his sample population was over ten times the size and three times the length of his first study (242,949 over two years vs. 20,773 over eight months). Older, more experienced jumpers are more likely to pay less attention or be busy correcting less experienced jumpers during pre-jump rehearsals, and then in turn rely on their experience during actual operations. This inattentiveness may lead to simple mistakes during exit, in the air, and during landing. Many units work to maintain proficiency at the required rate of one jump per three calendar months, so despite experience gained over years it could be several months since a Soldier's last jump. For this reason, pre-jump is mandatory for all jumpers regardless of experience level.

Injuries at altitude have a different breakdown across demographics than jumping injuries as a whole. While females have a significantly higher overall incident of injury (8.0 females vs. 5.7 males), at altitude they have a slightly lower incident (0.29 female vs. 0.33 male).[3] Females also seem to have a greater incidence of fractures than their male counterparts.[6] Additionally, parachutists below age 40 have a narrow margin between incident rates with 17-29-year olds at 0.32 and 30-39 y/o at 0.31. Those above 40 have a rate of injury at 1.14, which again is significantly different then the overall incident rates by age. When viewed by rank, E-1 to E-3 are the most likely to experience injuries at altitude (0.54), O1-O9 have a rate of 0.30, junior noncommissioned officers (NCO) a rate of 0.27, and senior NCOs a rate of 0.16.[3] This is most likely attributable to jumping experience. Unfortunately, the author never states whether he adjusts these incident rates for actual population distribution since the largest portion of the unit is younger (17-22) and in the lower ranks (E1-E4).

Injuries exiting the aircraft, including aircraft strikes and static line entanglements, account for 54% of the injuries at altitude. Injuries during opening account for the remaining 46% and include minor injuries such as riser burn, strikes from unsecured equipment, up to more severe injuries such as ligament tears from lower limb entanglement in suspension lines. Overall 74% of the injuries at altitude were of a non-severe nature including lacerations, abrasions, sprains, and strains. The remaining 26% were more severe injuries including knee derangements, closed head injuries, bicipital tears, fractures, and nerve injuries. Of the 10 cases of knee derangement, five involved complete rupture of multiple ligaments. Of these severe injuries 63% involved riser/suspension line entanglements.[3]

Bricknell & Craig point out that despite most injuries being caused by ground impact, the principal hazard in the air is actually fellow jumpers.[7] It should be noted that a spectrum of injuries and severity could be involved in multiple jumper entanglements. The type of entanglements discussed by Craig & Lee all involved the jumper and their own equipment, and were often due to their own error.[3] These injuries are also possible when a jumper collides or becomes entangled with another jumper directly, or his parachute. The Army currently addresses these types of incidents during pre-jump and includes the three rules of the air: look before you turn; turn to avoid other jumpers; and "lower" jumper has the right of way. These rules are in place to prevent multi-jumper entanglements. Injuries due to collision were mostly likely not included due to a lack of occurrence.

The jump itself starts after the jumper has attached their static line to the anchor line cable in the aircraft and the jumpers are on standby to jump, and injuries can happen at any point now including the shuffle to the door. Once at the door weak exits or failure to maintain a proper body position can lead to other injuries of varying severities. In the air and under canopy jumpers experience additional chances for injury based on other jumpers around them as well as their own ability to follow the rules of the air. As the jumper executes their PLF and their body impacts the ground in the prescribed manner: balls of the feet, calf, thigh, buttock, pull-up muscle, and then rolls through, they are dissipating energy their body was forced to absorb on impact with the earth. Once complete, provided there is no injury, the paratrooper recovers their equipment and moves out concluding the jump. From here, we will cover the injuries associated with parachuting in the same sequence in which the jumper is exposed to them.

Injuries in the Air

Proximal biceps tendon ruptures, referred to as static line injuries, occur from rapid and forceful abduction of the arm due to lack of control over the static line. These are often due to the first jumper improperly handing off his static line to the Jumpmaster (JM). The subsequent jumper exits at the 1 sec interval before the JM can gain control of the static line, causing it to wrap around the arm of the second jumper on exit. If a jumper places their own static line under their shoulder instead of above, they can cause the injury to themselves. The jumper may present complaining of weakness, difficulty with supination, and/or a visual defect. Recent participation in Airborne operations should increase the provider's index of suspicion. The provider can then use their physical exam skills to identify the injury. Yergason's (Figure 1)[9] and Speed's (Figure 2)[9] tests can be helpful orthopedic exams for confirming suspicion.[8]

While physical exam is enough to determine a diagnosis, it may not be definitive enough to determine severity. MRI or ultrasound may be useful in determining severity; Kragh recommends operative repair when the rupture is 95% or higher on imaging.[10] Historically proximal ruptures were treated non-operatively in most patients, young athletes and manual laborers being the general exception.[8] With most military personnel falling in to this category of exception, operative treatment is more likely. Non-operative repair can lead to increased fatigue and associated pain with repetitive supination. Flexion may be pain free and not interfere with daily life and exercises, but strength will remain decreased when compared to the contralateral side. Operative repair of the rupture can provide the patient with full range of motion, pain-free supination, and equal bilateral flexion strength. Postoperative recovery can exceed 12 weeks

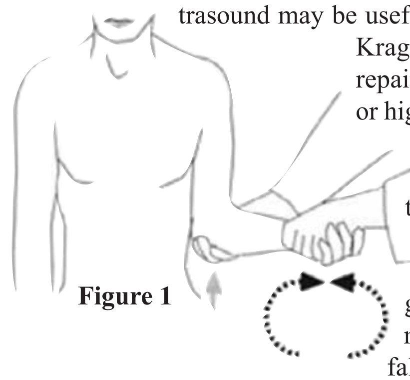
Figure 1

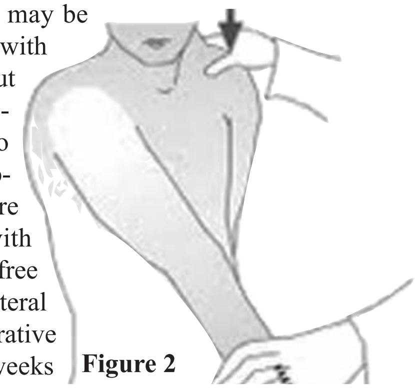
Figure 2

and requires consistent follow up and physical therapy. Units can expect the patient to return to training, parachuting, and other high impact activities when the patient is able to demonstrate sufficient strength (Kragh used pull-ups as an assessment for active duty population).[10]

Improper exit from the aircraft, also known as a weak exit, is the most common cause for a jumper to strike the side of the aircraft, or in some cases be towed by their static line and continue to impact the side of the aircraft. Various aircraft have different exit procedures, which can cause inattentive jumpers to make errors leading to a weak exit. Additionally some jumpers may struggle to get up and out due to the weight or bulkiness of their combat equipment. Aircraft strikes can be prevented or reduced by jumpers rehearsing proper exits for the planned aircraft during pre-jump, as well as maintaining attention to detail while in and when exiting the aircraft.

Striking the aircraft can lead to soft tissue contusions and TBI. TBI has been found to occur twice as often amongst Airborne Soldiers when compared to their non-airborne counterparts, and can lead to long-term effects.[11] However, with the introduction of the ACH the military has reduced the number of TBIs during Airborne operations from the levels recorded while the older Kevlar helmet was in use.[12] Despite that, head injuries still occur both during exit and more commonly when landing. There is no difference between the treatment of soft tissue contusions from this mechanism of injury (MOI) and those of any other MOI. TBI management and treatment is an area of expanding and fluctuating study and should be treated and managed in accordance with medical standard of care and local guidelines. Return to duty will be dependent on those guidelines.

In more severe cases of aircraft strikes jumpers may become towed by their static line due to their exit, rigging error, or a combination of the two. While rare, this can result in fatalities. The Army Field Manual governing Airborne operations, as well as local Airborne Standard Operating Procedures, define the JMs' responsibilities and role in dealing with a towed jumper.[1] The JM must determine the mental status of the towed jumper and ascertain the jumper's ability to understand their situation and react accordingly by pulling their reserve parachute when the JM cuts the jumper's static line. If the JM is unable to ascertain the jumper's ability to respond, or if the jumper is unconscious, then the jumper is winched back into the aircraft. Should the JM make an error in judgment and cut a jumper loose who is incapable of pulling their reserve, or should the jumper lose consciousness after being cut free, it is possible that the reserve parachute will not deploy and the jumper will impact the ground without aid of a parachute, most likely resulting in death.

Poor body position on exit can cause riser burns, which typically consist of minor abrasions and bruises to the face, neck or mastoid. These are usually due to the jumper failing to keep their chin to their chest while the canopy deploys. The rapid deployment of the parachute, which attaches to the anterior aspect of the parachute harness with nylon risers, causes the abrasions. As the parachute deploys from the rear by the static line and starts to catch air the risers rapidly pass by the lateral aspects of the head. Failing to keep chin on chest results in abrasion as the nylon quickly moves across the neck and head under the weight of the jumper and resistance of the air. Since the abrasions are minor and carry some level of stigma in the Airborne community, they often go unreported with most jumpers self-treating. In more severe cases, the jumper can experience lacerations to the face and pinna. These can be handled like any other laceration, and the pinna can be treated with bacteriostatic glue, n-Nutylcyanacrylate.[13] In addition, when conducting Joint operations with other countries, the shape and design of the helmet can affect the occurrence of these injuries. In such cases, there should be more emphasis placed on proper position. Participating countries can further reduce the incident rate by providing helmets in addition to chutes, (i.e., a British helmet when jumping a British chute).[13]

Poor body position, failing to bend at the waist on exit and maintain an "L" shaped position until the canopy deploys, and/or a weak exit from the aircraft can also lead to knee dislocations and ligament tears. As one exits the aircraft and the chute deploys the jumper's body swings below the parachute in a pendulous manner and in some cases jumpers' bodies can pass through the gap between risers before swinging back out. If a jumper does not maintain the "L" shaped position as they pass through the risers their limbs may tangle in the suspension lines. As their body weight shifts below the now-deployed parachute, the lower limb is subject to a high degree of force as it now bears the weight of the jumper and all of their equipment. This can result in dislocation of the knee and accompanying ligament tears. Knee dislocation and ligament tear can also occur due entanglement of the leg in the static line due to a combination of weak exit and improper body position. These methods are the predominant cause of major tendon rupture in parachuting.[14]

Patient presentation will depend heavily on the ligament(s) torn during the injury and the severity of the tear. Lachman's Test (Figure 3)[9] for anterior cruciate ligament (ACL), Quadriceps Active Drawer (Figure 4)[9] for posterior cruciate ligaments (PCL), and valgus/varus stress for medial collateral ligament (MCL) and the lateral collateral ligament (LCL) are quick tests to ascertain which ligaments are torn and to what degree. Treatment for all injuries involves timely diagnosis and referral to physical therapy and/or orthopedics. Depending on the degree of injury, there could be bracing or surgery in addition to the physical therapy. It is important to emphasize to patients that they need to complete physical therapy in a satisfactory manner prior to surgery becoming a viable option.[8] If there is nerve injury or vascular injury present at initial presentation or it develops at any point throughout the therapy, the patient will need an immediate referral to surgery (Detro, personal communication, 13 October 2010). This is especially true in ACL tears, where the patient should receive early assistance with stabilization to facilitate a more advantageous long-term outcome. Assessment for and treatment of meniscal tears is an impor-

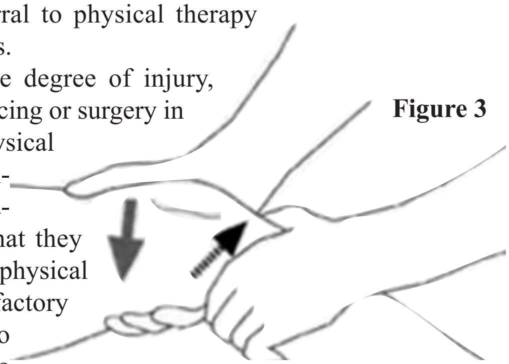

Figure 3

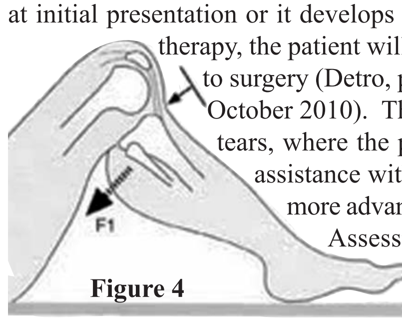

Figure 4

tant factor in reducing the chances of posttraumatic osteoarthritis.[15] Non-operative treatment can take as long as six months for a grade III MCL tear, and operative treatment with pre/post physical therapy can be even longer.[8]

Landing-related Injuries

There is very little in the way of published articles discussing incident rates of landing-related injuries. Throughout the Airborne community and across many nations it is widely accepted that the majority of jumping-related injuries are due to poor landings. Due to the wide acceptance of that fact, there are very few studies available that directly investigate the process of landing, executing a PLF, and the breakdown of related injuries. Most countries appear to have an average injury rate between five and ten per 1000.[3,5,16,17]

While landings cause most injuries on the ground, some are attributable to actions while in the air. Failure of jumpers to follow the rules of the air can result in the collapse of a jumper's parachute due to another jumper passing below them. This is usually due to the upper jumper failing to pay attention and yield right of way, of the lower jumper attempting to turn and slip away from an obstacle or yet another jumper without looking before they turn. Passing under a fellow jumper traps air in the lower parachute preventing the upper parachute from maintaining its shape and lift due to lack of air and air resistance. Jumpers call this action "stealing air". The jumper whose air is stolen often experiences a rapid descent until their parachute fully inflates again — once it is clear of the offending parachute. If this happens at higher levels of altitude the jumper might recover enough air and slow down to the point of making a normal landing; however, if this happens to close to the ground the jumper can have a much harder landing and is more prone to various injuries and severities.[17] While the following injuries are all relate to landing, they do not necessarily carry a specific mechanism of action as many of the injuries take place in the air. The landing itself and the various factors involved such as the weight of the jumper or gear, wind speed, terrain, and the type of earth all effect the chance and severity of injury leading to no specifically identifiable cause for specific injuries.

Ankle sprains are a common injury during the PLF due to inversion of the feet from improper landing technique or rough terrain. Often triage and management on the drop zone can allow the jumper to continue with the training or operation. In addition to a focused exam, inclusion of the talar tilt and anterior drawer tests assess the possibility of ligament disruption, and the squeeze and external rotation tests evaluate syndesmosis injury. When determining the need for x-ray to rule out a fracture one can use the Ottawa ankle rules, one of which includes the inability to bear weight at time of injury and at time of exam. Whether you have time and ability to do this on a drop zone is dependent upon the operation; however, the same tests will be just as useful in the clinic.

Treatment is no different from any other ankle sprain and can be managed the same with rest, ice, compression, elevation (RICE) and possibly bracing. Recovery time is dependent on the grade of sprain, with Grade I being one to two weeks, Grade II at 4-8 weeks and Grade III lasting six to twelve weeks. Physical therapy may prolong recovery. However, the strengthening and proprioception training can be useful in preventing future injuries from other activities. Chronic ankle sprains could lead to the need for surgical repair to deal with the recurrent instability.

Ankle fractures also occur and are probably the most common fracture due to parachuting.[16] The fractures occur due to the same variables as ankle sprains, though weight and descent rate could have a magnifying effect. As with ankle sprains, treatment and recovery times are dependent on the bones involved and the degree of the injury. A simple method, known as the Danis-Weber classification, uses the location of the fracture in relation to the level of syndesmosis for making a treatment decision. Treatments include closed reduction with a cast for both Danis-Weber A and Danis-Weber B as long as there is no syndesmosis involvement. Danis–Weber C requires open reduction and use of internal fixation. If the patient is determined to have a Danis-Weber B or C, one should also check for a Maisonneuve fracture. A Maisonneuve fracture is an external rotation injury that includes tearing of the majority of the tibiofibular syndosmosis; however, if the jumper executed a proper PLF, this is not likely since PLFs produce lateral force on the ankle. Treatment and the need for physical therapy dictate recovery time (Young, personal communication, 19 July 2010).[8]

Ankle injuries as whole are traditionally the most commonly injured anatomical location, and multiple articles are available discussing the parachute ankle braces (PAB) effectiveness in reducing these injuries. In the articles reviewed by Knapik the braces were found to reduce the number of sprains by a measurable amount in both studies.[6] PABs were also found to be effective in reducing ankle injuries during operational jumps in Iraq and Afghanistan. While ankle injuries in these jumps still exceed the number in training jumps, one should note that they were not the most frequent injury. In addition, Kotwal reports that there was a higher rate of ankle injuries in a study from Operation JUST CAUSE, which did not use PABs.[18] Ultimately the use of PABs is governed by the commander, though the above studies and available articles would suggest they do have a role to play in reduction of ankle injuries.

Bar-Dayan and Kragh found tibial or fibular fractures to be the second most common type of fracture, respectively.[16,2] In the Hughes study, none of the Australian Commando Battalion jumpers experienced tibial or fibular fractures, but Craig found tibial, fibular, and tibio-fibular fractures accounting for 56.7% of all fractures.[5,17] Despite the variance in incident rate, they do happen and treatment is dependent on the type and amount of displacement regardless of which bone fractures. With any tibial fracture, the provider needs to be aware of the possibility of compartment syndrome. In such a case prompt recognition and referral to orthopedic surgery is necessary.

Though uncommon, femur fractures do occur during Airborne operations. Any of the unit's medics can identify and manage the fracture on the drop zone. The drop zone party providing support for training jumps should include traction splints in their gear for this reason. There is a possibility of multisystem damage with any high-energy trauma that is significant enough to fracture the femur. Therefore, while the medics may handle the traction splint, the provider still needs to assess the patient and manage appropriately before transport to local treatment facilities.

Other high-energy fractures associated with parachuting include pelvic and lumbar. Both need quick identification and management while on the drop zone prior to movement to the local treatment facility. Spine boards prevents possible further injury and facilitates movement, and reduce the chance for damage to a nerve plexus and the associated neurological detriment. In the case of pelvic fractures, there is also concern for hemodynamic instability directly related to the fracture, as well as concomitant injuries. There are three variations of major pelvic fractures: lateral compression, anterior/posterior compression, and vertical shear. Additionally, more minor variations include single pelvic rami and avulsions. A field-expedient method for stabilizing the pelvis involves using a folded sheet to wrap and secure the pelvis there by applying circumferential force to stabilize the pelvis and limit the displacement. Some units carry commercial pelvic slings, which allow more uniform application of force and attempt to prevent over or under tightening. When dealing with a lower lumber fracture, it is important to be aware of the possibility for cauda equina; loss of urinary and anal sphincter control, which might be the only presenting symptom due to the inability to ambulate. Both of these injuries present the provider with a vascular or neurological emergency that require prompt identification and management.

Chronic Injuries

Up to this point, the jump-related injuries have proceeded from the moment the jumper exits the aircraft until the time that jumper lands and dissipates the energy through their body. Even the most experienced jumper who avoids injury often faces the chance of developing cervical or lumbar disc disease from the repetitious application of forces on the spine (Detro, personal communication, 13 October 2010). In a study involving seventy-four parachute instructors, fifty-four had various degrees of radiographic spinal changes in various levels of degeneration. T12-L1 and L2-L3 were the most common sites and severity of the degeneration increased with the number of jumps in the patients' history.[19] Isthmic spondylolysis or spondylolisthesis is described as a fatigue fracture, and patients who routinely subject the area to high stress are more likely to develop one of its forms.[8] Isthmic spondylolysis from a possible fatigue fracture in at least one case led to contralateral hypertrophy and sclerosis that led to subsequent pediculolysis. The patient continued to jump after the spondylolysis due to mild pain and the intermittent nature of his symptoms, which possibly led to increased hypertrophy and eventual stress fracture of the pedicle, culminating in spondylolithesis.[20] The authors go on to suggest that patients presenting with lower back pain who engage in activities involving repetitive axial compression should have radiographs taken and evaluated instead of taking a wait and see strategy. This would facilitate early identification and treatment of spinal disorders before further detrimental progression occurs.

Outside Factors Affecting Injuries

Numerous factors outside of the jumpers' control can affect their chances of injury as well as the severity. Increased wind speed at altitude and on the ground can dramatically change the speed with which a jumper lands as well as the jumper's ability to control their parachute and avoid other jumpers. One can logically expect an increase in injury incidence with higher wind speeds. This was supported in the review conducted by Knapik which included wind thresholds (10-15 mph) beyond which injury rates increased.[6] The composition of the drop zone, including the terrain, surrounding ground vegetation, trees, soil composition, bodies of water, and presence of structures or power lines also have effects on the injury. With experience, a provider could feasibly anticipate the injuries they will see based on the history of the drop zone. PLF method also has an effect on injury occurrence, but may be more related to the jumper's descent rate, as the jumper unconsciously attempts to compensate for the increased landing velocity. The largest effect on landing velocity is the weight of the load carried by the parachute, which includes the jumpers' own weight and any equipment weight they are carrying. The 82nd Airborne Division recently experienced a large number of injuries due to jumpers exiting the aircraft overloaded with equipment. One provider stated that using the JM's ability to hold the rucksack up during Jump Master Personnel Inspection (JMPI) may help units reduce injuries by identifying jumpers carrying too much weight. In addition, this might help reduce other injuries caused by a jumper's weak exit when carrying too much weight. (Van Winkle, personal communicaion, 7 December 2010).

Impacting the ground at any velocity carries a chance of injury, and when it comes to Airborne operations, there are numerous factors affecting that velocity. The parachutes used by militaries around are world are designed to carry specific weights, and often that includes the jumper, their combat equipment, and possibly another jumper in the event of an entanglement. With the majority of jump-related injuries happening during landing, descent velocity can become an important factor in the risk of injury. Weight has a large effect on the descent velocity and the only weight that is always present regardless of the jump type is that of the jumpers themselves. Pirson & Pirlot demonstrated that with increased weight of the jumper comes increased incident of injury. After approximately 176 pounds, the injury rate starts to increase dramatically, increasing approximately five times when weight reaches 242 pounds (the limit of the study).[21]

Aside from an individual jumper's body weight, a dramatic change in descent velocity comes with the addition of combat equipment. Jettisoning additional weight by using a hook/pile tape lowering line will somewhat reduce the weight that a jumper lands with, as well as the descent velocity just prior to landing.[21] Despite lowering combat equipment, the overall descent rate is still higher with equipment than without. This is most likely due to the length of the lowering line and the inability of the parachute to slow the jumper rapidly enough after the combat equipment has reached the ground and removed its weight from the parachute. A retrospective study of Australian Battle Group jumps found that combat equipment increased the injury rate from 10.3 per 1000 jumps to 32.6 per 1000 jumps, and went on to suggest methods for controlling the increased injury rate.[22] This supports the idea that leaders should limit the loads of jumpers to what is essential, including operational jumps in theater.[18]

As already mentioned, the drop zone itself can have a dramatic effect on the injury rate of parachutists. Various militaries around the world use different types of land and soil for drop zones in an effort to reduce injury. In Thailand, units often use fresh tilled farming fields that are fallow, similar to Fryar drop zone at the US Airborne School. The more regularly used training drop zones in the U.S. are often composed of sand, while others are simply clear ground composed of the indigenous earth. A study of Brazilian parachuting injuries found an increased injury rate when using alternate drop zones. The primary drop zone is flat and cleared of obstacles including holes, ditches, trees and bushes, while the alternate drops zones contain increased numbers of trees, including lone trees scattered across the drop zone, bushes and shrubs, fences, poles, holes, ditches and gullies. All of these obstacles contributed directly to increased injury due either to impact, or indirectly as jumpers attempted to avoid them and caused injury to themselves.[23] Many of the same obstacles on the Brazilian alternate drop zones were present on the Australian tactical drop zones - drop zones used for combat equipment and follow on training as opposed to drop zones for proficiency jumping. Maintenance of the drop zone was also a factor in Australia, where less frequent maintenance led to harder surfaces and accordingly increased injury rates.[22] While maintenance and drop zone selection are far outside the control of the provider, one should at least be aware of the drop zone's effects on chance of injury and adjust accordingly.

The primary method that jumpers have to dissipate energy when landing is the PLF. Various nations have slightly different techniques, but all employ mostly the same technique, making comparisons between techniques reasonable. For instance, Australian Defence Forces are taught to land flat-footed as they move through the PLF sequence, while U.S. forces are taught to land with the balls of their feet. After conducting a study on landing techniques at various velocities the Australians found that at higher velocities, the jumpers were unconsciously altering their PLF method to land with the balls of their feet. They postulated that this was the body's attempt to reduce lower limb loading when landing; however, this could possibly expose the jumpers' metatarsals to increased pressure and possibly destabilize the ankle.[24]

A follow-up study by the same organization looking into the effects of foot pitch on landing technique found that altering the foot pitch from flat-footed to balls of the feet led to significant changes in knee extension, plantar flexion and overall joint motion during impact. The study concludes that landing with balls of the feet provides the body with a slower rate of loading during initial impact and that landing flat-footed causes higher loading rates, thus possibly a higher risk for lower limb injuries.[25] Based on the outcome, it was recommended that the Australian Defence Forces conduct further research into and consider changing the foot pitch used in the PLF.

Conclusions

Providers for Airborne units should have a good understanding of the injuries commonly associated with jumping and the aspects involved with jumping that effect or cause those injuries. Any provider in this type of unit should have a solid understanding of orthopedic trauma and have a high index of suspicion in relation to the mechanism of injury. Splinting, especially in the case of combat jumps where the jumper may be needed to continue on the mission, is extremely important, and thus the provider needs to maintain and improve their skills as well as stay versed in field-expedient methods that can be taught to the unit's medics. While some medical equipment, such as spine boards and traction splints, may be necessary for the drop zone party on training jumps, it is not always feasible to carry these on a combat jump, especially one without a heavy drop aspect. The provider can only carry so much equipment, and the same goes for the medics throughout the unit, so in the situation where the provider is jumping with their unit their medical equipment should be limited to what they would carry in combat for the appropriate follow-on mission. (Detro, personal communication, 13 October 2010)

One of the provider's primary responsibilities is to return Paratroopers to duty, thereby increasing the unit's combat effectiveness and maintaining operational strength. Anything that improves the outcome of the jumpers' recovery or safely speeds that recovery is of benefit to both the servicemember and the commander. The key to quick and effective recovery is in prompt identification and management to include referral to orthopedic surgery if necessary. Some of the Special Operations units have organic physical therapy, which has greatly increased the recovery time and proper management of injuries in those units. For units without that organic asset, the responsibility rests on the shoulders of the provider to make the prompt and appropriate referral and manage the patient best as resources allow. In the end, a provider's best tools for dealing with Airborne-related injuries are an understanding of Airborne operations, quality orthopedic skills, and a high index of suspicion.

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