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J Bone Joint Surg Am. 1944;26:547-557.

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Publisher Information

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www.jbjs.org

A STUDY OF TYPICAL PARACHUTE INJURIES OCCURRING IN TWO HUNDRED AND FIFTY THOUSAND JUMPS AT THE PARACHUTE SCHOOL

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Parachute jumps at The Parachute School have increased progressively from their inception in 1941 to the time of this writing. Parachute injuries at The Parachute School have proportionately decreased progressively, until at the present time a "jumper" has roughly only a one per cent. chance of being injured in any way in any one parachute descent. This remarkable increase in parachute activities, in spite of the decrease in the rate of injury, establishes a wealth of clinical material for study. This clinical material has been used in preparing this report.

Certain types of training injuries and fractures from jumping have occurred repeatedly, until there now exist several clinical entities recognized as typical parachute injuries. These will be discussed subsequently.

In this report, the writers have analyzed the material at hand according to:

1. The type of injury most common to each of the four training stages, and the anatomy, physiology, and, where possible, the mechanics involved in producing the injury.
2. The immediate and follow-up care of the injured provided at The Parachute School.
3. New training techniques and apparatus accounting for the diminishing rate of injury.
4. New methods of selection employed in choosing parachute personnel.

An "injury" has been arbitrarily defined as a condition directly resulting from training, which causes the student to lose one day or more from duty. Minor sprains, lacerations, contusions, or exhaustive states in students who can be rehabilitated at The Parachute Medical Unit and returned to duty within a few hours are not considered statistically as "injuries".

The parachute course of training consists of four stages briefly described for the purpose of orientation as follows:

1. *A Stage*: calisthenics, rope-climbing, running, and jumping from low four-foot to six-foot platforms into sawdust pits.
2. *B Stage*: tumbling, trainasium, landing trainer, jumps from mock doors (four to six feet), jumps from mock towers (thirty to thirty-five feet), and suspended-harness drill.
3. *C Stage*: daily jumping from the 250-foot towers (free and controlled), and landing by parachute on sawdust. Tumbling is reviewed, and parachute control is practised.
4. *D Stage*: The applicant makes the necessary number of plane jumps to qualify as a parachutist; the jumps are made from a plane in flight, and the landing is made on level and uneven terrain.

The physical hardening accomplished through A-Stage training puts most applicants at something near physical perfection. It has been found that in men physically at their best, fear phenomena in the apparatus of the next three stages are less prone to develop.

The strain or tear of the right rectus muscle has proved to be the most frequent cause of disability in A-Stage training, and the most interesting clinically, since it closely simulates acute appendicitis. This occurs in rope-climbing, presumably when the lower extremities are raised at right angles to the body, and the legs grasp the rope, as shown in Figure 1.

It is believed that in the attempt to reach the top of the rope, an unusually strong

effort is made, in some cases causing a definite sharp pain in the abdomen and resulting in the following clinical syndrome: The patient appears at The Parachute Medical Unit, complaining of pain in the abdomen, and walking with the hips slightly flexed. The simple process of getting on the examining table is difficult because of the pain. With the patient standing, the abdomen appears relaxed, there being no effort to "hold in the abdomen". In those cases with hematoma formation, a definite bulge can be seen along the course of the rectus muscle. Inspection further reveals some subcutaneous ecchymosis (after four to seven days have elapsed), extending downward from the point of maximum tenderness. The muscle is exquisitely tender on light palpation, and the patient resists any sort of deep pressure. When asked to raise the body from the prone position, keeping the lower extremities flat on the table, severe pain is experienced. These cases occur in the right rectus in 90 per cent., and in the left in 10 per cent. It is believed that this is due to the greater effort which is exerted on the right side in the majority of cases. A white blood count of 9,000 to 11,000 occurs the day following the injury, with polymorphonuclear leukocytes ranging from 70 to 80 per cent. Now that the cause has been determined, the diagnosis can readily be made, but many patients have been hospitalized for observation for appendicitis. One patient was operated upon. A hematoma below the rectus was found. The wound was closed and the appendix was not removed.

Since the act of tumbling has proved effective in disseminating the shock of landing, the proper technique of tumbling is drilled into the applicants over and over again daily, until a smooth, properly executed tumble automatically follows contact with the ground from any height. This emphasis on tumbling leads to the typical injury of Stage B,—the acromioclavicular contusion and the acromioclavicular separation. Figures 2 and 3



Photograph by the United States Army Signal Corps

FIG. 1

Illustrating the mechanism of the "right rectus strain or tear".



FIG. 2 Photograph by the United States Army Signal Corps

Tumbling from the "landing trainer". If the tumbling is improperly executed, the point of the shoulder strikes the ground with greatest force, resulting in acromioclavicular injury.

show two training situations, involving tumbles which are being properly executed.

The shoulder tip should not touch the ground; the forearm, held rigidly by the triceps, acts as a bar over which the body rolls. When the triceps is relaxed, the shoulder comes in direct contact with the ground, and the acromioclavicular injury occurs. Separation of the acromioclavicular joint in these injuries involves only the tearing of the articular capsule in some cases; the coracoclavicular ligaments remain intact and prevent the scapula and acromion from being displaced downward.

In the more severe cases, the capsule and the coracoclavicular ligaments are torn,



FIG. 3 Photograph by the United States Army Signal Corps

Illustrating in greater detail the mechanism of acromioclavicular injury.

and the acromion, being completely separated from the clavicle, is displaced downward by the weight of the upper extremity. In Figure 4, the acromioclavicular separation is marked, but the scapula and the acromion are depressed only slightly.

In one case it was felt that the coracoclavicular ligaments had been stretched, but that the connection to the clavicle had been maintained. This case was treated by placing a block in the axilla and strapping it to the body; an additional strap extended up over the lateral end of the clavicle and the shoulder, and down posteriorly, and was attached to the block behind the axilla. The elbow was raised by means of a sling. This patient returned to full jump duty after five months, has now qualified as a parachutist,



Photograph by the United States Army Signal Corps

FIG. 4

Roentgenogram illustrating typical acromioclavicular separation.

and has no symptoms referable to the shoulder.

The less severe injury—namely, the simple acromioclavicular separation with slight, if any, tearing of the capsule—responds to immobilization of the upper arm and shoulder for from two to four weeks. These students are ready for full parachute duty in this length of time, with no other treatment than physiotherapy and rest.

In C and D Stages, the injuries have a common cause,—namely, landing by parachute. The injuries, while more frequent in D Stage, involve the same mechanism, and both will be described together. There are two typical parachute leg injuries. The first, resulting from a parachute jump, is the double fracture, involving the lower third of the fibula and the posterior lip of the tibia. The mechanism of this fracture is explained on the basis of a double force. It is thought that when this fracture occurs, the foot is rotated externally and is forced posteriorly on contact with the ground. When the foot is rotated externally, the anterior portion of the body of the talus (astragalus) presses against the anterior border of the inner surface of the external malleolus, forcing it outward and backward. If the force is sufficient, and if the inferior tibiofibular ligament remains intact, this force tends to cause an oblique fracture of the lower end of the fibula, usually about two inches above the tip. The posterior force is the result of the forward motion of the foot as it strikes the ground. The impact is transmitted up the metatarsals, through the tarsus, and forces off the posterior tibial lip. In the presence of a ground wind, and with oscillation at the time of landing, a more violent eversion of the ankle may occur, resulting in the trimalleolar fracture described by Lewin in his study of the foot and ankle. In these cases, fracture of the internal and external malleoli and the posterior tibial lip occurs. This trimalleolar fracture, however, is considerably less frequent than that involving the fibula and posterior tibial lip alone.

Figure 5 shows the position of the feet and legs and the landing attitude as the parachutist approaches the ground. Figure 6 shows a fracture of the ankle involving not only the usual lower end of the fibula and posterior tibial lip, but also the internal malleolus, which occurs in the more violent eversions of the ankle on landing.

These fractures were common prior to some recent changes in landing attitudes. The "original parachute fracture" just described has recently begun to be replaced by a fracture of the upper third of the fibula or dislocation of the fibular head. This is due to the fact that greater support is given to the ankle by having both feet held firmly together at the moment of striking the ground. However, coincident with the decrease in the

fracture just described, there has been an increase in fractures of the upper third of the fibula and also in dislocation of the fibular head. Since the latter situation is simpler to handle surgically, and since the convalescent time is substantially less, this is considered a favorable change.

This second "typical parachute injury" we have called the "silent fracture", since so frequently the upper third of the fibula will be fractured and the patient will exhibit few, if any, symptoms. It is not unusual for the fracture to occur in C Stage and the soldier proceed with the actual plane jumps of D Stage before reporting for medical care. Figure 7 shows a fractured fibula which occurred on Friday of one week, although the student did not appear at the Medical Unit until Tuesday of the next week, when he complained of "a little" pain. It is our belief that a fracture of the upper third of the fibula could very frequently be misdiagnosed as a sprained muscle, if the possibility of this "silent fracture" were not kept in mind.

Such relatively *painless pathology* can undoubtedly occur only because the fibula does not enter into weight-bearing. In a series of thirty-five cases diagnosed recently, only ten students reported for treatment at the time of the fracture. The other twenty-five reported for "slight pain" in the upper outer aspect of the leg seven to thirty days after the injury. Many showed marked callus formation in the original roentgenogram. It is felt that some cases of fracture in the upper third of the fibula are never diagnosed as fractures. These fractures have become more frequent in our series as fractures of the lower fibula have decreased, as a result of the ankle support afforded by landing with the feet and ankles held firmly together.

Dislocations of the fibular head have occurred in a small series of cases, but are becoming more frequent as the ankle injuries diminish in frequency. Figure 8 shows the fibular head in a dislocated position.

It is felt that the sideward landings, which occur in oscillations, result in a tendency to "spring" the fibular head from its position, or fracture it in the upper third.

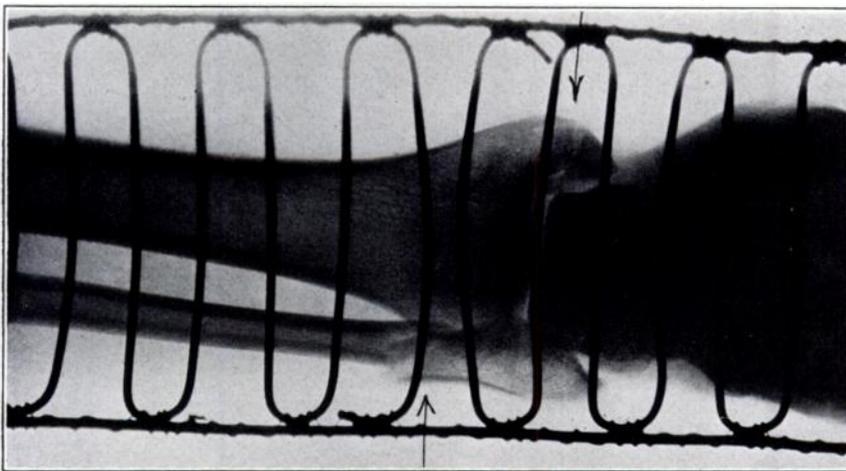
Key and Conwell mention the possibility of backward, forward, outward, or upward dislocation of the fibular head. The dislocations of the fibular head occurring in parachute landings are primarily lateral dislocations, resulting from the "springing" action described. The attachment of the tendon of the biceps femoris would tend to dislocate it posteriorly and upward, but this type of dislocation has not occurred in our series. The diagnosis is not difficult, since the bone is subcutaneous and can be readily palpated. These dislocations are sometimes reduced on the jump field by the ambulance surgeon or



Photograph by the United States Army Signal Corps

FIG. 5

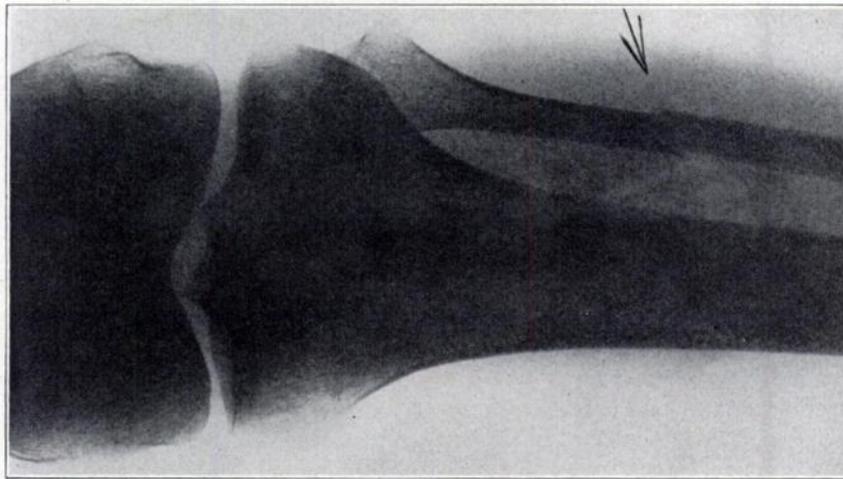
Parachutists in descent. Preparation for ground contact has been properly made.



Official photograph by the United States Army Air Forces

FIG. 6

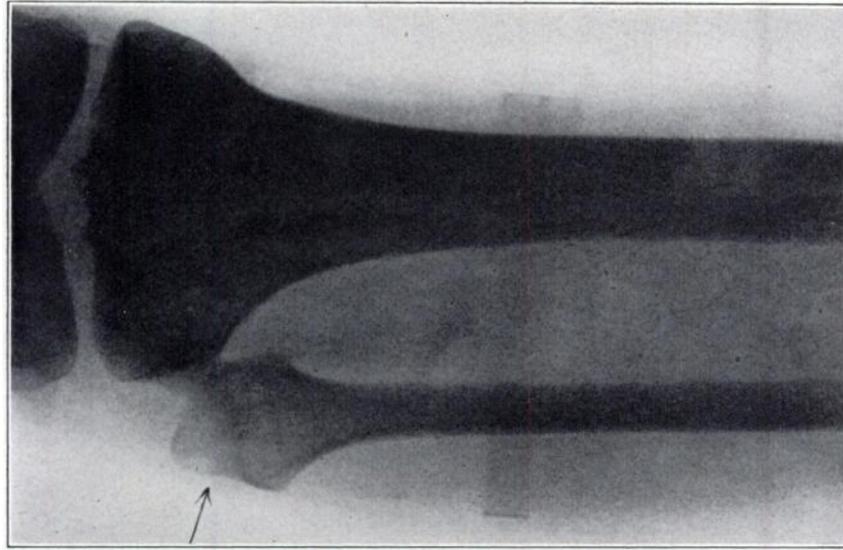
Typical parachute fracture of the ankle, involving both tibia and fibula.



Official photograph by the United States Army Air Forces

FIG. 7

Illustrating the so-called "silent fracture" of the upper fibula. The term "silent fracture" has been coined to indicate the relatively painless nature of this fracture.



Official photograph by the United States Army Air Forces

FIG. 8

Typical dislocation of the fibular head. Here, as in the "silent fracture", there is a minimum of symptomatology. These are infrequent.

at The Parachute Medical Unit after roentgenographic examination. The procedure is strong inversion of the foot and direct pressure over the fibular head. An elastic bandage is applied, and the patient is given crutches and is kept ambulatory. We have seen no evidence of peroneal-nerve involvement yet. One medical officer in parachute training, having a dislocated fibular head, reported a numbness of the foot, lasting several days after the accident. There was no tendency to muscle weakness, or "foot-drop". We are of the opinion that the relation of the peroneal nerve to the fibular head is such that with slight or moderate dislocation of the fibular head no pressure is exerted on the nerve. Furthermore, reduction is accomplished very early in these cases, and, if pressure on the nerve does occur, it is relieved promptly.

These two clinical syndromes, one involving the ankle, the other involving the upper fibula, have occurred so frequently that they are now considered classical parachute entities.

With the opening shock of the parachute, while the soldier is falling freely, any type of fracture or injury may occur, if the body position is incorrect. The most unusual, recently, has been a deep laceration of the perineum, extending from the scrotum to and involving the sphincter ani, and extending deeply enough to expose the lower segment of the rectum.

This was caused by the parachutist doing a forward somersault in the air with his legs apart before the parachute opened. The suspension lines went between his legs. When the parachute opened in the propeller blast, the great force of the taut suspension lines was exerted on the perineum causing the deep laceration. When the body position is normal, this great opening force is directed to the body harness from the suspension lines. It is thought that this accident occurred because the parachutist "dived" rather than "jumped" from the plane in flight; and because he neglected to keep his feet and legs together at the exit. Such cases are rare, but are of great clinical interest because they show the hazards involved when the "rules" are not followed.

THE IMMEDIATE AND FOLLOW-UP PROVISIONS FOR CARE OF THE INJURED

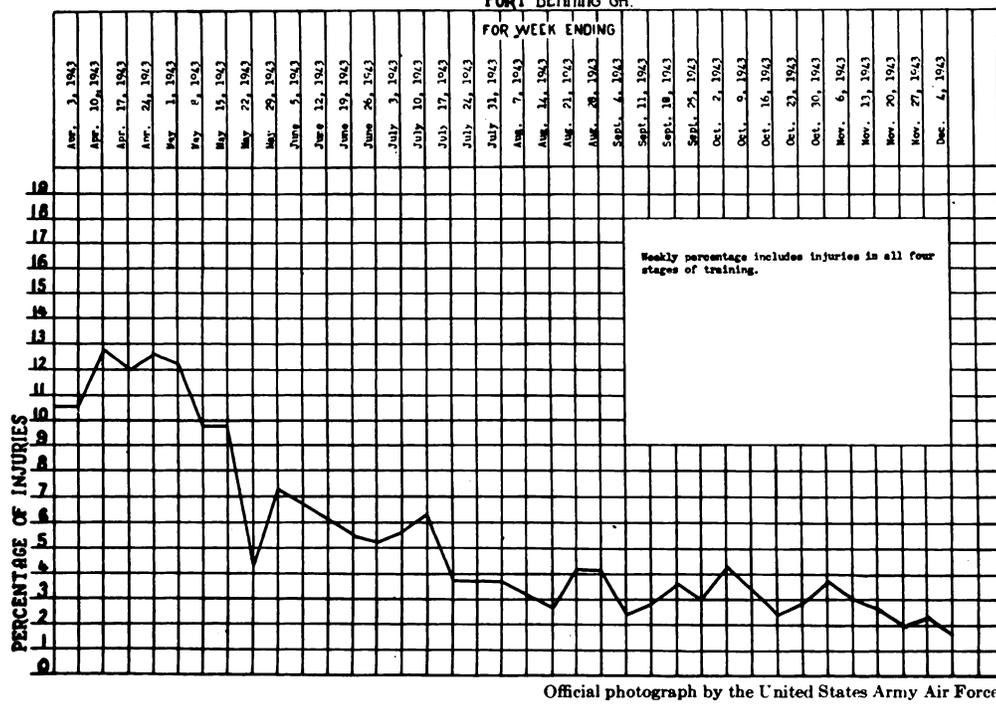
The fractures discussed in this article are seen long before swelling has had time to occur, because of the preparedness which exists in The Parachute School for immediate handling of injuries. Very frequently fractures can be palpated by the examining physician, before the obscuring action of oedema has intervened.

Students with injuries occurring in A Stage, B Stage, and C Stage are picked up by the ambulance from The Parachute Medical Unit within a very few minutes from the time of the injury. Jumping injuries occurring in D Stage are handled as follows:

On the jumping field there is an aid man assigned to watch the descent of every parachutist. He is within six feet of the parachutist when the latter lands. If there is any evidence whatever of injury, the aid man unfolds his red flag. Two ambulances and doctors are assigned daily to the field. One responds immediately to a waving red flag. The diagnosis is made within a matter of two minutes, as a rule, from the time of injury. The injured member is splinted, and the patient is transported to The Parachute Medical Unit where roentgenograms are taken. Wherever possible, if no fracture exists, ambulatory treatment is encouraged. Patients with fractures are admitted to the Hospital; those with sprains, regardless of their severity, contusions, and the like, are supplied with crutches, and are kept ambulatory.

On two occasions The Parachute Medical Unit has conducted a series of studies to determine the advisability of novocain injection of sprains. The immediate relief of discomfort by this method cannot be disputed. However, with early icing, tight binders, and the use of crutches for twenty-four hours, the pain is not a troublesome problem. It is believed that novocain injection has definite value in selected cases, where the pain is severe, or for those patients who must walk immediately. The great majority of pa-

COMBINED WEEKLY INJURY REPORT FOR ALL STAGES
THE PARACHUTE SCHOOL
FORT BENNING GA.



Official photograph by the United States Army Air Forces

FIG. 9

Graphic representation of how all injuries, both in the jumping stage and the prejump training stages, have been markedly decreased.

tients, however, receive no injections of novocain under our present method of treatment. The length of disability is not shortened by novocain injection, possibly because almost complete healing is required before a soldier is permitted to return to jumping status.

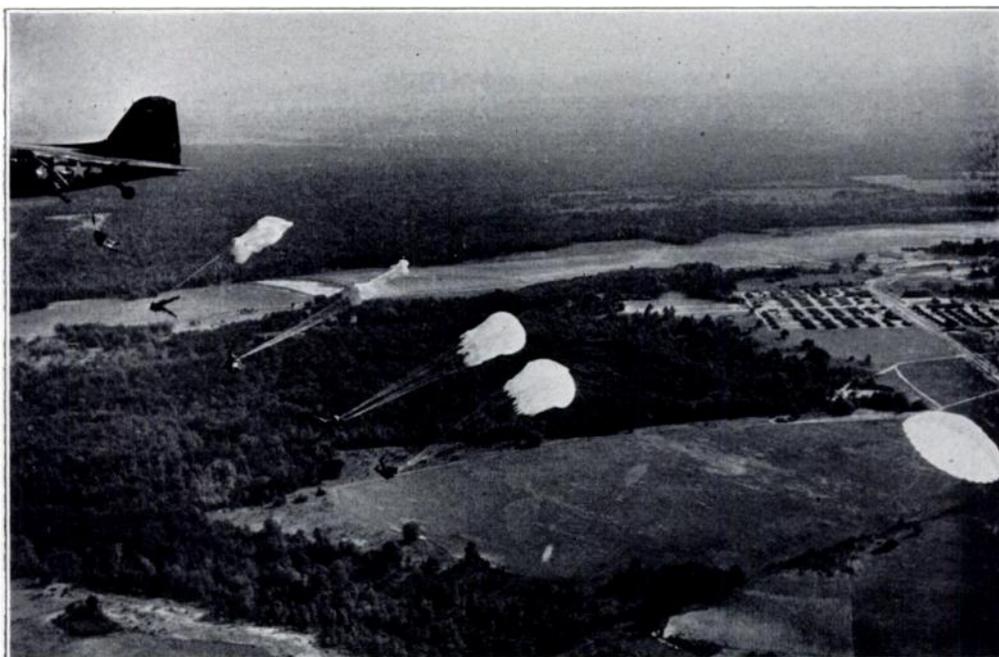
In the first twenty-four hours, tight bands, icing, and immobilization is the treatment of choice. After the first twenty-four hours, warm applications, gentle massage, and early active motion is the course followed. The Physiotherapy Department in The Parachute Medical Unit handles hundreds of men daily, using infra-red or ultra-violet lamps, whirlpool baths, alternating hot and cold baths, and massage.

**NEW TRAINING TECHNIQUES AND APPARATUS ACCOUNTING FOR THE DIMINISHING
 RATE OF INJURY**

It is believed that certain revisions of the landing method taught at The Parachute School are in some measure responsible for a distinctly diminishing rate of injury. This decrease was accomplished in spite of an increase in the training load of The Parachute School since July 1943. A revision of technique entailed:

1. Landing with the feet together, legs bent slightly at the knees, and the weight of the body slightly forward over the feet. Legs are held so that the knees are together. The muscles are not tensed, yet not relaxed. The leg muscles are alert to take up the landing shock.

2. A variation of the previously taught tumbling technique, so that proper landing can be made during ground approaches that are angular to the line of drift during a parachute descent. It was discovered that, although the desired approach was a forward drift when landing (See Figure 5), in a large percentage of instances, backward or oblique landings occurred.



Official photograph by the United States Army Air Forces

FIG. 10

Parachutists in various stages of the plane exit. It is at this moment that occasional "freak" accidents occur.

Further diminution of the rate of injury was accomplished by exacting supervision of each student during this period of training before entering D Stage. Careful attention to the maintenance of all equipment and training aids was found also to have some value.

A study of the parachutists in Figures 3 and 5 shows the value of the training in Stages A, B, and C. Figure 5 indicates lessons in landing technique that were properly learned. In the early days of parachute training, when the student load on the School was small, the Assistant Commandant was able to select the most favorable weather, when allowing his novices to jump for qualification. However, when it became necessary for The Parachute School to increase its output, it became increasingly difficult to pick ideal jumping weather for the novice. The directive to "qualify the men" made it impossible to limit their jumping to ideal weather conditions, as in the past. The decreased injury percentage appears all the more remarkable in view of these conditions.

Strong ground winds frequently set up a pendulum-like motion of the parachutist, in which the apex of the parachute is the fixed and the parachutist himself the moving end of the pendulum. This swinging motion, or oscillation as it is termed, can materially reduce the parachutist's opportunity for making a landing, uninjured. When the old method of landing was taught, the novice's feet were approximately the width of the hips apart. It is apparent that a sideward oscillation would bring the landing shock of all the body's weight upon one or the other foot. This increased the possibility of sprain or fracture. The new method of landing—that is, with the feet together—distributes the shock of an oscillating landing with almost perfect equality to both feet and legs. Careful records maintained at The Medical Unit of The Parachute School, covering thousands of injuries, have permitted the preparation of Figure 9.

The new method of landing was inaugurated in the A Stage on June 12, 1943. It will be noted that since that time there has been a marked decline in the weekly percentages of combined injuries. This average was not subjected to the violent fluctuations which

had previously characterized it. Comparison of the 1943 seasonal averages with those of 1942 reveals that in each case the percentage of combined injuries is lower.

SELECTION METHODS EMPLOYED IN CHOOSING PARACHUTE PERSONNEL

The selection of parachute personnel is done with utmost care. All incoming applicants to the School have first been examined by their Unit Medical Officer, who is supplied with a copy of the physical requirements for parachute admission. This serves as a gross screening process in weeding out obviously poor material. On admission to the Receiving Battalion at The Parachute School, all men are subjected to an examination system at The Parachute Medical Unit, which rules out anatomically and psychologically poor material. The men are passed through a series of rooms and individually examined from a psychiatric viewpoint, with stress being laid on various phobias for the detection of any lack of desire for training of this severity. They then proceed through the various stages of the physical examination, with particular stress being placed on anything which is symptomatic at present,—such as old lumbosacral sprains, old fractures still painful, old retracting scars, and any history of symptoms referable to the head (dizziness, blackouts, fainting spells, *et cetera*). Men with potential hernias are ruled out, for fear of exaggeration of the hernia during training. All applicants with heart murmurs are ruled out, unless the murmurs can be definitely proved to be functional. All those with questionable visual acuity without glasses are ruled out, unless their vision is 20/40 or better bilaterally. Venereal disease disqualifies a man on the original examination. If venereal disease is contracted during the course of training, the soldier is immediately removed from parachute training and is disqualified. Luetics who have had what is considered adequate treatment, and whose blood and spinal-fluid serology are negative, are acceptable. These applicants are not considered as having venereal disease. The elimination of these conditions results in rejections of between 10 and 15 per cent. of all applicants reaching The Parachute School at Fort Benning, for training.

Further selection is accomplished through the observations of the Stage Leaders in noting hesitancy or actual inability to perform some of the preliminary low-jumping procedures.

Such selection standards result in the acceptance of the best men available. We are convinced that men physically perfect are less prone to injury in training than those with any physical impairment, and, therefore, credit some of the diminishing rate of injury to the increasing severity of standards of selection.

The four types of physical injuries which have been discussed are parachute entities, proved by their repeated occurrence in soldiers taking this course. Their frequency, it is felt, has been markedly reduced in the past six months, and those occurring now are recognized as unavoidable (at present) in the production of qualified parachutists.

CONCLUSIONS

1. This survey covers in excess of 250,000 parachute descents at The Parachute School.
2. Statistically, any parachutist has only a one per cent. chance of injury in any one parachute descent, and this figure is decreasing.
3. Some typical medical parachute entities have now been established.
 - a. Strain of the right rectus muscle.
 - b. Contusions and separations of the acromioclavicular joint.
 - c. Fracture of the lower third of the fibula, associated with fracture of the posterior tibial lip.
 - d. The "silent fracture" of the upper third of the fibula, and less frequently a dislocation of the fibular head. The fibula may be fractured in its upper third and be relatively asymptomatic; hence, the designation "silent fracture".

4. Holding the feet together on contact with the ground, replacing the old method of holding the feet eighteen inches apart on landing, has markedly reduced ankle fractures.

The authors wish to acknowledge the active cooperation of the X-Ray and Orthopaedic Services at Station Hospital, Fort Benning, Georgia. The photographs were reproduced through the courtesy of the Post Signal Photographic Laboratory, Fort Benning, Georgia, and Base Photographic Section, Lawson Field, Georgia. The figures quoted were obtained from the official records of The Parachute School.

Both authors are qualified parachutists.

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FATIGUE FRACTURES

BY MAJOR PERCIVAL A. ROBIN AND MAJOR SAMUEL B. THOMPSON

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In a period of sixteen months, fifteen cases of insufficiency fractures occurring in bones other than the metatarsals have been treated in this Hospital. They have been classified in this category, because of the absence of a history of trauma sufficient to produce a true fracture. Of the fifteen cases considered, thirteen were in the tibia, one in the femur, and one in the pubic bone. Of the tibial fractures, two were bilateral and one of these was multiple.

CLINICAL FEATURES

The usual history elicited on admission was that a generalized aching pain had developed in the involved extremity. The pain had come on during or shortly after an extended march and had continued to grow steadily worse with increased activity. Finally, the pain had become localized at the site of the fracture. The patient frequently noted swelling of the extremity, occurring early in the course of this condition.

On physical examination, localized tenderness was found at or near the fracture site, associated with swelling in this region and generalized oedema of the involved extremity. If the patients were admitted in a later stage, a palpable mass, produced by exuberant callus, was found. It was discovered, through clinical experience with fatigue fractures, that these clinical manifestations were sufficient to make one suspect the presence of this entity. Any one of the findings occurring singly also warranted roentgenographic investigation.

ROENTGENOGRAPHIC FEATURES

If the roentgenographic examination was made in the initial phase of the fracture, the earliest manifestation noted was an infraction involving the cortex. The tibia was the bone most commonly involved, and the fracture, as a rule, could be seen either medially or