U.S. Army Center for Health Promotion and Preventive Medicine

USCHPPM

THE PARACHUTE ANKLE BRACE: ENTANGLEMENTS AND INJURIES AFTER CONTROLLING FOR EXTRINSIC RISK FACTORS

USACHPPM REPORT NO. 12-MA01Q2-07

U.S. Army Center for Health Promotion and Preventive Medicine
Aberdeen Proving Ground, MD

U.S. Army Research Institute of Environmental Medicine
Natick, MA

Approved for public release; distribution is unlimited

Readiness Thru Health

U.S. Army Center for Health Promotion and Preventive Medicine

The lineage of the U.S. Army Center for Health Promotion and Preventive Medicine (USCHPPM) can be traced back over 50 years. This organization began as the U.S. Army Industrial Hygiene Laboratory, established during the industrial buildup for World War II, under the direct supervision of the Army Surgeon General. Its original location was at the Johns Hopkins School of Hygiene and Public Health. Its mission was to conduct occupational health surveys and investigations within the Department of Defense's (DOD's) industrial production base. It was staffed with three personnel and had a limited annual operating budget of three thousand dollars.

Most recently, it became internationally known as the U.S. Army Environmental Hygiene Agency (AEHA). Its mission expanded to support worldwide preventive medicine programs of the Army, DOD, and other Federal agencies, as directed by the Army Medical Command or the Office of The Surgeon General, through consultations, support services, investigations, on-site visits, and training.

On 1 August 1994, AEHA was redesignated the U.S. Army Center for Health Promotion and Preventive Medicine with a provisional status and a commanding general officer. On 1 October 1995, the nonprovisional status was approved with a mission of providing preventive medicine and health promotion leadership, direction, and services for America's Army.

The organization's quest has always been one of excellence and the provision of quality service. Today, its goal is to be an established world-class center of excellence for achieving and maintaining a fit, healthy, and ready force. To achieve that end, the CHPPM holds firmly to its values which are steeped in rich military heritage:

- ★ *Integrity is the foundation*
- ★ *Excellence is the standard*
- ★ *Customer satisfaction is the focus*
- ★ *Its people are the most valued resource*
- ★ *Continuous quality improvement is the pathway*

This organization stands on the threshold of even greater challenges and responsibilities. It has been reorganized and reengineered to support the Army of the future. The CHPPM now has three direct support activities located in Fort Meade, Maryland; Fort McPherson, Georgia; and Fitzsimons Army Medical Center, Aurora, Colorado; to provide responsive regional health promotion and preventive medicine support across the U.S. There are also two CHPPM overseas commands in Landstuhl, Germany, and Camp Zama, Japan, which contribute to the success of CHPPM's increasing global mission. As CHPPM moves into the 21st Century, new programs relating to fitness, health promotion, wellness, and disease surveillance are being added. As always, CHPPM stands firm in its commitment to Army readiness. It is an organization proud of its fine history, yet equally excited about its challenging future.

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
03-10-2007	FINAL	APR 05 – DEC 06

4. TITLE AND SUBTITLE	**5a. CONTRACT NUMBER**
The Parachute Ankle Brace: Entanglements and Injuries after Controlling for Extrinsic Risk Factors	**5b. GRANT NUMBER**
	5c. PORGRAM ELEMENT NUMBER
6. AUTHOR(S)	**5d. PROJECT NUMBER**
Joseph J Knapik, Salima Darakjy, David Swedler, Fred Manning, Keith G Hauret, Paul Amoroso, Bruce H Jones	**5e. TASK NUMBER**
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	**8. PERFORMING ORGANIZATION REPORT NUMBER**
U.S. Army Center for Health Promotion and Preventive Medicine Aberdeen Proving Ground, MD U.S. Army Research Institute of Environmental Medicine Natick, MA	12-MA01Q2-07

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	**10. SPONSOR/MONITOR'S ACRONYM(S)**
Defense Safety Oversight Council, Military Training Task Force, Pentagon, Washington DC	DSOC MTTF
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Previous studies have demonstrated that the parachute ankle brace (PAB) reduces ankle injuries during military airborne operations. This investigation reevaluated the PAB controlling for extrinsic risk factors. Injury incidence among airborne students wearing the PAB was compared to those not wearing the PAB. Covariate data were collected on extrinsic risk factors including wind speed, type of jump (administrative-nontactical versus combat load) and time of day (day versus night). A total of 596 injuries occurred in 102,784 jumps. After controlling for covariates in a multivariate model, students who did not wear the brace were 1.90 (95%CI=1.24-2.90) times more likely to experience an ankle sprain, 1.47 (95%CI=0.82-2.63) times more likely to experience an ankle fracture, and 1.75 (95%CI=1.25-2.48) times more likely to experience an ankle injury of any type. Injuries to other parts of the lower body (exclusive of the ankle) were not significantly influenced by the brace. The incidences of parachute entanglements were similar among students wearing and not wearing the PAB. Thus, after controlling for covariates known to effect injury rates, the PAB protected against ankle injuries and especially ankle sprains while not influencing parachute entanglements and other lower body injuries exclusive of the ankle.

15. SUBJECT TERMS

wind, combat load, night, entanglements, risk factors, epidemiology, Airborne, military personnel

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESONSIBLE PERSON**
					Dr. Joseph Knapik
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified			410-436-1328

Standard Form 298 (Rev.8/98)
Prescribed by ANSI Std. Z39.18

Table of Contents

1. REFERENCES 1
2. PURPOSE 1
3. AUTHORITY 1
4. BACKGROUND 1
5. METHODS 2
   (1) Injury Data 3
   (2) Jump Closure Reports 3
   (3) Brace Wear Data 4
   (4) Data Processing and Analysis 4
6. RESULTS 5
7. DISCUSSION 9
   (1) Comparison of Parachute Ankle Brace Investigations 9
   (2) Injury Incidence 10
   (3) Risk Factors for Parachute Injuries 10
   (4) Risk Factors for Specific Injuries 11
   (5) Limitations 12
8. CONCLUSIONS 12
9. RECOMMENDATIONS 12
APPENDIX A. References A-1
APPENDIX B. Documents Related to MTTF/DSOC Initiatives on the Parachute Ankle Brace B-1
APPENDIX C. Acknowledgements C-1

DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND MD 21010-5403

MCHB-TS-DI

EXECUTIVE SUMMARY
USACHPPM REPORT NUMBER 12-MA-01Q2-07
THE PARACHUTE ANKLE BRACE: ENTANGLEMENTS AND INJURIES AFTER CONTROLLING FOR EXTRINSIC RISK FACTORS

1. INTRODUCTION.

a. Previous studies have shown that the parachute ankle brace (PAB) reduces injuries in airborne training and in United States (US) Army Rangers during airborne operations. Despite this, use of the brace was discontinued in 2000 because of the costs of maintenance and anecdotal reports that the brace increased injuries in other parts of the lower body and complicated parachute entanglements. A study of students at the US Army Airborne School (USAAS) compared the period of PAB use (1994-2000) to the period after the PAB was discontinued (2000-2002) and showed that the risk of an ankle injury hospitalization was 1.7 times higher after the PAB was discontinued.

b. In 2004, the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) worked with the US Army Research Institute of Environmental Medicine (USARIEM) and the Military Training Task Force (MTTF) of the Defense Safety Oversight Council (DSOC) to reinstitute use of the PAB in military airborne operations. The DSOC required information to demonstrate that the PAB was still effective in light of changes to military equipment and uniforms (primarily boots). PABs were purchased for the USAAS and they were evaluated over a 21-month period. The major purpose of this paper is to report on the results of the reevaluation of the PAB while it was phased into USAAS training. The focus of the reevaluation was an examination the effectiveness of the PAB in reducing the incidence of ankle injuries while controlling for extrinsic risk factors. Secondary purposes were to 1) examine the influence of the PAB on lower body injuries exclusive of the ankle, 2) examine the influence of the PAB on parachute entanglements, and 3) more fully explore the association between specific types of parachute injuries and extrinsic risk factors.

2. METHODS.

a. Batches of PABs were purchased for the USAAS from April 2005 to December 2006. While these PABs were being phased into Airborne School training the Quality Assurance Office at Fort Benning, Georgia provided investigators with three items: 1) an anonymized list of injuries, 2) a list that indicated whether or not braces were worn by each class, and 3) Jump Closure Reports (JCR) for each airborne operation. The injury list included the date of the injury, class number, jump number (1 through 5), and the type/anatomical location of the injury. Class lists contained class number, jump dates, number of students and whether or not PAB were worn by a particular class. JCRs contained the date of the jump, class number, jump number, number of students who jumped, wind speed, type of jump, time of day, and entanglements. Wind speeds were continuously collected on the drop zone using a Davis Weather Wizard device and averaged for the period of jump operations. The type of jump was either 1) administrative-nontactical in which the student jumped without any equipment other than their uniform, parachute, and Kevlar helmet, or 2) combat load in which a service member jumped with uniform, parachute, Kevlar helmet, load-carrying equipment, weapons container, and rucksack. Time of day was either day or night. Entanglements involved two or more jumpers who made physical contact that interfered with their normal descent.

b. Based on the date, class number, and jump number, which were reported in all three data sources, injury cases were matched to aggregated information from class lists and JCRs, including brace status, wind speed, type of jump, time of day and entanglements. To analyze the information, a new database was constructed with one line for each student in a class who executed a jump on each jump operation. If an injury occurred on a particular jump operation, the type of injury and anatomical location were listed on one of the case lines for that jump operation. Comparisons were made between those who wore the PAB and those who did not. Overall injury incidence was examined, as well as incidence of ankle sprains, ankle fractures, overall ankle injuries and concussions. Because of concern that the PAB may be transmitting forces up the leg and increasing injury incidence in the legs or lower body, injuries were additionally grouped into 1) lower body injuries exclusive of the ankle, 2) lower body fractures exclusive of the ankle, and 3) lower body strains and sprains exclusive of the ankle.

3. RESULTS.

a. A total of 596 injuries occurred during 102,784 jumps for an overall cumulative injury incidence of 58 injuries/10,000 jumps. Compared with students who wore the brace, students not wearing the brace were 2.00 (95% confidence interval (95%CI)=1.32-3.02) times more likely to experience an ankle sprain, 1.83 (95%CI=1.04-3.24) times more likely to experience an ankle fracture, and 1.92 (95%CI=1.38-2.67) times more likely to experience an ankle injury of any type. There were only minor differences between brace wearers and non-wearers for lower body injuries exclusive of the ankle (risk ratio (RR) (no brace/brace)= 0.92, 95%CI=0.65-1.30), lower body fractures exclusive of the ankle (RR (no brace/brace)=0.99, 95%CI=0.59-1.67) and lower body strains and sprains exclusive of the ankle (RR (no brace/brace)=1.45, 95%CI=0.73-1.27).

b. In univariate analysis overall injury incidence was associated with higher wind speed (RR (10-13 knots/1-0 knots)=1.86, 95%CI=1.35-2.56), night operations (RR (night/day)=2.25, 95%CI=1.81-2.81) and combat load jumps (RR (combat load/administrative-nontactical)=1.65, 95%CI=1.38-1.97). Ankle sprains were not associated with higher wind speed (RR (10-13 knots/1-0 knots)=0.79, 95%CI=0.28-2.04), but were associated with night operations (RR (night/day)=2.99, 95%CI=1.98-4.05) and combat load jumps (RR (combat load/administrative-nontactical)=1.71, 95%CI=1.19-

2.45). Likewise, ankle fractures were not associated with higher wind speeds (RR (10-13 knots/1-0 knots)=1.28, 95%CI=0.45-3.40), but were associated with night operations (RR (night/day)=3.50, 95%CI=2.00-6.10) and combat load jumps (RR (combat load/administrative-nontactical)=2.79, 95%CI=1.72-4.50). As might be expected, overall ankle injury risk was not associated with higher wind speeds (RR (10-13 knots/1-0 knots)=0.97, 95%CI=0.48-1.91), but was associated with night operations (RR (night/day)=3.18, 95%CI=2.30-4.42) and combat load jumps (RR (combat load/administrative-nontactical)=1.98, 95%CI=1.49-2.63).

c. Multivariate analysis showed that use of the PAB independently reduced risk of ankle injuries and ankle sprains when wind speed, night operations, and combat loads were considered. With these factors considered, students not wearing the brace were 1.90 (95%CI=1.24-2.90) times more likely to experience an ankle sprain and 1.75 (95%CI=1.25-2.48) times more likely to experience an ankle injury of any type when compared those wearing the brace. The association of ankle fractures and brace status was reduced in the multivariate model (RR (no brace/brace)=1.47, 95%CI=0.82-2.63).

d. Multivariate analysis also showed that overall injury incidence was associated with high wind speeds (RR (10-13 knots/1-0 knots)=2.13, 95%CI=1.55-2.92), night operations (RR (night/day)=2.24, 95%CI=1.70-2.96), and combat load jumps (RR (combat load/administrative-nontactical)=1.26, 95%CI=1.01-1.57). Ankle sprains were associated with night operations (RR (night/day)=2.62, 95%CI=1.70-4.03), but less with combat load jumps (RR (combat load/administrative-nontactical)=1.38, 95%CI=0.95-2.01). Ankle fractures were more strongly associated with night operations (RR (night/day)=2.51, 95%CI=1.37-4.60) and combat load jumps (RR (combat load/administrative-nontactical)=2.34, 95%CI=1.42-3.85). All ankle injuries were associated with night operations (RR (night/day)=2.57, 95%CI=1.80-3.65) and combat load jumps (RR (combat load/administrative-nontactical)=1.65, 95%CI=1.22-2.22).

e. Use of the PAB was not associated with increased incidence of entanglements. There were a total of 89 parachute entanglements of which 51 involved entanglements that persisted until the jumpers reached the ground. Entanglement incidence in the PAB and no-PAB groups were 9.6/10,000 jumps and 7.5/10,000 jumps, respectively (p=0.33). The incidence of entanglement that persisted until the jumpers reached the ground in the PAB and no-PAB groups was 4.2/10,000 jumps and 4.9/10,000 jumps, respectively (p=0.73). There were only 2 injuries among entangled jumpers; both of these were entanglements to the ground and both were among those not wearing the brace.

5. DISCUSSION.

a. The present investigation found that the PAB protected against ankle injuries, especially ankle sprains, during military parachute training. This protective effect was manifest even after considering wind speed, time of day, and jump type, covariates shown to affect injury rates in this and other studies. Injuries to other parts of the lower body (exclusive of the ankle) were not significantly influenced by the brace. Entanglement incidence was similar among brace wearers and non-wearers.

b. Overall injury risk increased with higher wind speeds, night jumps, and combat loads in agreement with previous studies. This study is the first to examine the association of these extrinsic risk factors with specific injuries, finding that risk factors differed depending on the type of injury. Ankle sprains, ankle fractures, and overall ankle injuries were associated with night operations and combat load jumps but not with higher wind speeds.

c. The protective effect of the PAB for ankle fractures decreased when considered in a multivariate model with night jumps and combat loads (the risk ratio (no brace/brace) decreased from 1.89 to 1.47). Jumps with combat loads were associated with almost twice the risk of an ankle fracture when compared with the risk for any type of injury or for an ankle sprain. Combat loads probably increased the descent rate, resulting in higher ground impact forces. Rucksacks (the largest single portion of the combat load) were attached to the jumper by a quick release strap that the jumper was instructed to activate just before impact with the ground. If this was done with proper timing, the load hit the ground before the jumper. However, this process altered the descent rate and could have affected the "timing" of the jumper's ground impact, thereby inhibiting the proper execution of a parachute landing fall. Additionally, the load represented a drop zone hazard in that a jumper could land on top of it, also resulting in an improper parachute landing fall. Parachutists were in training and generally performed only two combat load jumps.

8. CONCLUSIONS. This investigation confirmed previous work that showed that the PABs were effective in reducing the incidence of ankle sprains and ankle injuries during military parachuting. It expanded on previous work by showing that this protective effect remained even when other known extrinsic parachute injury risk factors were taken into account. The PAB did not increase the incidence of other lower body injuries or parachute entanglements.

9. RECOMMENDATIONS. The PAB should be used during military parachute training to reduce injuries. Studies in operational units should be conducted with experienced parachutists to see if the PAB can increase operational combat capability through injury reduction.

USACHPPM REPORT NUMBER 12-MA-01Q2A
THE PARACHUTE ANKLE BRACE: ENTANGLEMENTS AND INJURIES AFTER CONTROLLING FOR EXTRINSIC RISK FACTORS

1. REFERENCES. Appendix A contains the scientific/technical references used in this report.

2. PURPOSE. To reevaluate the parachute ankle brace (PAB) with regard to its effectiveness in reducing the incidence of injury during military parachute training while controlling for extrinsic risk factors known to influence injury rates in military airborne operations. Secondary purposes were to 1) examine the influence of the PAB on other lower body injuries, 2) examine the influence of the PAB on parachute entanglements, and 3) more fully explore the association between specific types of parachute injuries and extrinsic risk factors.

3. AUTHORITY. Under Army Regulation 40-5 (3), the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) is responsible for providing epidemiological consultation services upon request. This project was initiated by the Military Training Task Force (MTTF) of the Defense Safety Oversight Council (DSOC). The Army Center for Health Promotion and Preventive Medicine (USACHPPM) agreed to the project in coordination with the United States Army Research Institute of Environmental Medicine (USARIEM). USARIEM had responsibility for both the ground-based (on-site) data collection and database analysis. However, when the principal USARIEM investigator departed, USACHPPM assumed responsibility for the ground-based data collection and analysis, which is the topic of this report. Documents related to the project appear in Appendix B.

4. BACKGROUND.

a. Since World War II, military airborne operations have delivered troops to key areas of the battlefield, altering the tactical and strategic aspects of warfare. The idea of tactical military airborne operations was first proposed in 1919 by William (Billy) Mitchell and approved by General John J Pershing. However, with the quick end of World War I the idea was never realized. In 1928 the United States (US) Army Air Corps staged a number of airborne demonstration jumps in Texas that were observed by foreign army representatives, but the Soviet Union was the first country to develop military airborne units in the 1930s. This was quickly followed by developments in Germany culminating in the first combat jumps, which spearheaded the German invasion into the Netherlands in May 1940. The US Army formed a platoon of airborne troops in July 1940 and initiated the first jump school at Fort Benning, Georgia, in April 1941 (10, 14).

b. While military parachuting techniques were being developed, studies indicated that injury incidences were 210 to 240/10,000 descents (9, 28). As parachute design and jump procedures improved, injury rates declined to about 60 injuries/10,000 descents (6).

The ankle was shown to be the most common anatomical site of injury, accounting for 21% to 43% of all injuries (1, 2, 8, 12, 15).

c. Stemming from the high rates of ankle injuries and from promising studies showing a reduction in ankle injuries in sports activities (22, 26, 27), the US Army worked with Aircast® Corporation (subsequently purchased by DjOrtho® in 2006) to develop an outside-the-boot ankle brace for military airborne operations. This device, known as the PAB, was tested at the US Army Airborne School (USAAS) in 1993 and was shown to effectively reduce the incidence of inversion ankle sprains (2). In 1994, the US Army adopted use of the brace for all airborne operations (4). A subsequent evaluation among US Army Airborne Rangers showed a 57% reduction in ankle injuries when the brace was employed (25). Despite these positive outcomes, PAB use was discontinued in 2000 because of the costs of maintaining the brace and anecdotal reports that the brace increased injuries in other parts of the lower body and complicated parachute entanglements. A study of students at the USAAS compared the period of PAB use (1994-2000) to the period after the PAB was discontinued (2000-2002) and showed that the risk of an ankle injury hospitalization was 1.7 times higher after the PAB was no longer used (24).

d. In 2004, USACHPPM worked with USARIEM and the DSOC MTTF to reinstitute use of the PAB in military airborne operations. The DSOC required information to demonstrate that the PAB was still effective in light of changes in military equipment and uniforms (primarily boots). PABs were purchased for the USAAS and they were evaluated over a 21-month period. The major purpose of the investigation reported here was to re-evaluate PAB with regard to its effectiveness in reducing the incidence of injury during military parachute training while controlling for extrinsic risk factors known to influence injury rates in military airborne operations. Secondary purposes were to 1) examine the influence of the PAB on other lower body injuries, 2) examine the influence of the PAB on parachute entanglements, and 3) more fully explore the association between specific types of parachute injuries and extrinsic risk factors.

5. METHODS.

a. The USAAS at Ft Benning Georgia has the responsibility for training all Soldiers, Marines, Sailors and Airmen, in the practical aspects of military parachuting. Students must successfully complete a three-week training course. The first two weeks involve training on aircraft exit and ground landing techniques. The third week involves actual parachute descents. To graduate from Airborne School students must complete five parachute jumps from C-17 or C-130 aircraft from altitudes of 1,000 to 1,250 feet. The first jump is an individual effort with one second between jumpers and 10 jumpers exiting from each side of the aircraft. The other jumps are mass exits with 15 jumpers exiting in quick succession from each side of the aircraft.

b. Batches of PABs were purchased for the USAAS from April 2005 to December 2006. Students who wore the PAB during parachute descents were instructed on proper fitting and wear and familiarized with the PAB during the first two weeks of training. While the PAB was being phased into the parachute training, the Quality Assurance Office at Fort Benning periodically provided investigators with an anonymized list of injuries, Jump Status Reports (JSR), and a list of classes wearing and not wearing the PAB, as described below.

(1) <u>Injury Data.</u>

(a) During all USAAS parachute training operations, three medics were on the drop zone and two medics were in an ambulance just off the drop zone. A senior non-commissioned officer (NCO) known as Jump-2 routinely traveled with one of the medics and recorded injury information. If a student was injured on the drop zone, Jump-2 completed a "Report of Injury/Incidence" in consultation with the medics. Jump-2 reported the injury by radio to another NCO, known as the Master Trainer, who was located in the airborne operations office. The Master Trainer then completed an initial "Operations Report" based on information from Jump-2. The Operations Report was subsequently updated by an NCO or officer in the injured student's training class. Information for the update could have come from a number of sources. Generally, the NCO or officer spoke to the injured student or (in more serious cases) went to the hospital and questioned the casualty and/or any available medical staff. If additional information was required to determine the specific injury type, the radiology or orthopedics departments in the hospital were contacted. The Operations Report was continually updated based on information from these sources.

(b) The Quality Assurance Office at Fort Benning abstracted a list of injuries from the USAAS Operations Reports. The anonymized list provided to the investigators included the date of the injury, jump number (1 through 5), class number, and type/ anatomical location of the injury, as well as the age and sex of the injured jumper.

(2) <u>Jump Closure Reports.</u>

(a) The Master Trainer completed a Jump Closure Report (JCR) each time there was a USAAS jump operation. The JCR contained the date of the jump, class number, jump number, number of students who jumped, wind speed, type of jump, time of day and parachute entanglements (if any). Wind speeds were continuously collected on the drop zone using a Davis Instruments Weather Wizard device and averaged for the period of the jump operation. The type of jump was either 1) administrative-nontactical, in which students jumped without any equipment other than their uniform, parachute, and Kevlar helmet, or 2) combat load, in which the students jumped with their uniform, parachute, Kevlar helmet, load carrying equipment, weapons container and rucksack. The rucksack and weapons container were attached to quick release straps that service members were instructed to activate just before impact with the ground. The quick release served to drop the load downward about 15 feet from the student's body, but it remained attached. Combat load jumps were performed once during training. Time of day was listed as either day or night. Night jumps were generally conducted after 1900 hours in the winter and after 2200 hours in the summer months.

(b) Parachute entanglements were listed in the narrative section of the JCR. An entanglement was defined as a physical contact between two or more jumpers that interfered with a normal parachute descent. Two types of entanglements were derived from the narrative description in the JCR. The first type was an entanglement of any kind. The second type was an entanglement in which the jumpers remained in physical contact until they impacted the ground. Entanglement information included whether or not an injury had occurred but not the type of injury.

(3) Brace Wear Data. The Quality Assurance Office at Fort Benning, Georgia, compiled a list of USAAS classes from April 2005 to December 2006. Investigators extracted the following information from the list: class number, jump dates, number of students and whether or not the class wore PABs.

(4) Data Processing and Analysis.

(a) Based on the date, class number, and jump number, which were universally reported in all three data sources, injury cases were matched to aggregated information from class lists and JCRs to include brace wear status, wind speed, type of jump, time of day, and entanglements. To analyze the information, a new database was constructed with one line for each student in a class who executed a particular jump on a particular jump operation. If an injury occurred on a particular jump operation, the type of injury, anatomical location, and the age and sex of the injured jumper were listed on one of the case lines for that operation. Injuries were separated into type and anatomical location. Types included sprains, strains, fractures, concussion, dislocation, abrasion/laceration, contusion and environmental (primarily heat related). Often the injury was just listed by anatomical location with a non-specific injury type (e.g., "ankle injury," "knee injury"). In these cases, the injury type was listed as "pain."

(b) Because of the DSOC concern that the PAB might be transmitting forces up the leg and increasing injury incidence in the legs or lower body, injuries were placed into "groups" involving the lower body. These groups included lower body injuries, leg injuries, lower body musculoskeletal injuries, lower body fractures, and lower body strains and sprains. Lower body injuries included all injuries with an anatomical location of pelvis, hip, thigh, knee, calf, shin, foot/toe, but did not include injuries to the ankle. Leg injuries included the same areas but did not include the ankle or foot/toe. Lower body musculoskeletal injuries included the same anatomical sites as lower body injuries with an injury type of fracture, sprain, strain, contusion, or pain (but not abrasions/lacerations or environmental). Lower body fractures included the same anatomical sites as lower body injuries with an injury type of fracture. Lower body strains and sprains included the same anatomical sites as lower body injuries plus an injury type of strain or sprain.

(c) Data analyses were performed using SPSS version 15.0. Injury incidence was calculated as the sum of all injuries, injury anatomic location/type combinations (e.g., ankle sprains, ankle fractures), injury groups or injury types divided by the total number of jumps times 10,000 (injuries/10,000 jumps). Denominator data consisted of the number of jumps from the JCRs. Covariates included PAB wear status (brace or no brace), wind speed (0-1 knot, 2-5 knots, 6-9 knots, or 10-13 knots), time of day (day or night) and jump type (administrative-nontactical or combat load). The chi square test of proportions was used to assess the association between the covariates and all injuries, various injury anatomic locations/types, injury groups, and injury types. Risk ratios and 95% confidence intervals (95%CI) were calculated. Covariates that were significantly ($p<0.10$) associated with injury incidence in the univariate (chi square) analysis were included in a multivariate logistic regression. In the multivariate analysis, simple contrasts with a baseline variable (defined with a risk ratio of 1.00) were used. Outcomes in the logistic regression were the presence or absence of all injuries, a particular injury anatomic location/type, or an injury type. Entanglements among the braced and not braced groups were compared using the chi square test of proportions.

6. RESULTS.

a. A total of 596 injuries occurred during 102,784 jumps for an overall cumulative injury incidence of 58 injuries/10,000 jumps. Table 1 shows the injuries by type and Table 2 shows the injuries by anatomical location. There were 11 multiple injuries, but only the more serious type is listed in Tables 1 and 2. The most common anatomic location/type combinations were ankle sprains (n=144), ankle fractures (n=74), shin fractures (n=41), shoulder dislocations (n=25), knee sprains (n=17), foot fractures (n=15), and face abrasions/lacerations (n=14).

Table 1. Airborne Injuries by Type

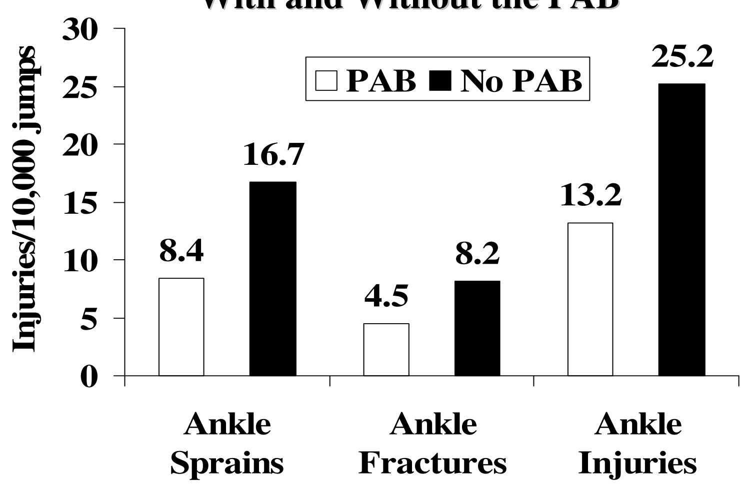
Type	N	Proportion (%)
Sprain	194	32.6
Fracture	148	24.8
Concussion	96	16.1
Pain	66	11.1
Dislocation	28	4.7
Abrasion/Laceration	28	4.7
Contusion	17	2.9
Strain	9	1.5
Environmental	10	1.7

b. A total of 33,461 jumps were made with the PAB and 69,323 jumps without the PAB. Figure 1 shows the influence of the PAB on ankle sprains, ankle fractures and all ankle injuries. Compared with students who wore the brace, students who did not wear the brace were 2.00 (95%CI=1.32-3.02) times more likely to experience an ankle sprain, 1.83 (95%CI=1.04-3.24) times more likely to experience an ankle fracture, and 1.92 (95%CI=1.38-2.67) times more likely to experience an ankle injury of any type.

Table 2. Airborne Injuries by Anatomical Location

Anatomic Location	N	Proportion (%)
Head	102	17.1
Face	19	3.2
Neck	7	1.2
Chest	7	1.2
Shoulders	41	6.9
Elbow	5	0.8
Arm	20	3.4
Hand	1	0.2
Back	23	3.9
Pelvis (including coccyx)	21	3.5
Hip	7	1.2
Thigh	1	0.2
Knee	20	3.4
Calf	3	0.5
Shin	50	8.4
Ankle	219	36.7
Foot/Toe	37	6.2
Location Not Specified	3	0.5
Environmental	10	1.7

Figure 1. Cumulative Injury Incidence With and Without the PAB



c. Table 3 shows the cumulative injury incidence for various injury types and groups. In all cases, there are only small differences between the brace wearers and non-wearers.

Table 3. Incidence for Various Injury Types and Groups by Parachute Ankle Brace Wear

Injury Group or Type	Injury Incidence (injuries/10,000 jumps)		Risk Ratio (No Brace/Brace) and 95% Confidence Interval	Chi Square p-Value
	Brace	No Brace		
All Injuries	52.60	60.59	1.15 (0.97-1.37)	0.11
Lower Body Injuries (exclusive of ankle)	14.35	13.14	0.92 (0.65-1.30)	0.62
Leg Injuries (exclusive of ankle)	11.06	9.38	0.85 (0.57-1.27)	0.42
Lower Body Musculoskeletal (exclusive of ankle)	14.34	13.42	0.94 (0.66-1.33)	0.71
Lower Body Fractures (exclusive of ankle)	6.27	6.20	0.99 (0.59-1.67)	0.97
Lower Body Strains/Sprains (exclusive of ankle)	3.29	4.76	1.45 (0.73-2.87)	0.29
Concussions	10.46	8.80	0.84 (0.56-1.27)	0.41

d. Table 4 shows the univariate associations between three covariates (wind speed, time of day, jump type) and all injuries, ankle sprains, ankle fractures, ankle injuries, and concussions. All injuries were associated with each of the covariates. Ankle sprains, ankle fractures, and ankle injuries were associated with time of day and jump type, but not with wind speed. Concussion risk was markedly elevated at higher wind speeds, but concussions were not associated with time of day or jump type.

Table 4. Univariate Associations between Risk Factors and Airborne Injury Incidence

Injury Type	**Variable**	**Level of Variable**	**Injury Incidence (cases/10,000 jumps)**	**Risk Ratio (95%CI)**	**Chi Square p-Value**
All Injury	Wind Speed	0-1 knot	44.1	1.00	
		2-5 knots	37.3	0.85 (0.65-1.11)	<0.01
		6-9 knots	59.1	1.34 (1.06-1.70)	
		10-13 knots	82.2	1.86 (1.35-2.56)	
	Time of Day	Day	52.6	1.00	<0.01
		Night	118.6	2.25 (1.81-2.81)	
	Jump Type	Admin/Nontactical	50.4	1.00	<0.01
		Combat Load	83.1	1.65 (1.38-1.97)	
Ankle Sprain	Wind Speed	1-0 knots	11.1	1.00	
		2-5 knots	10.0	0.90 (0.52-1.54)	0.69
		6-9 knots	13.7	1.24 (0.74-2.05)	
		10-13 knots	8.7	0.79 (0.28-2.04)	
	Time of Day	Day	12.1	1.00	<0.01
		Night	36.1	2.99 (1.98-4.50)	
	Jump Type	Admin/Nontactical	12.2	1.00	<0.01
		Combat Load	20.9	1.71 (1.19-2.45)	
Ankle Fracture	Wind Speed	0-1 knot	6.8	1.00	
		2-5 knots	4.2	0.62 (0.27-1.37)	0.19
		6-9 knots	3.1	0.46 (0.16-1.21)	
		10-13 knots	8.7	1.28 (0.45-3.40)	
	Time of Day	Day	5.9	1.00	<0.01
		Night	20.6	3.50 (2.00-6.10)	
	Jump Type	Admin/Nontactical	5.0	1.00	<0.01
		Combat Load	13.9	2.79 (1.72-4.50)	
Any Ankle Injury	Wind Speed	0-1 knot	18.1	1.00	
		2-5 knots	14.2	0.79 (0.50-1.22)	0.73
		6-9 knots	18.0	1.00 (0.65-1.53)	
		10-13 knots	17.5	0.97 (0.48-1.91)	
	Time of Day	Day	18.2	1.00	<0.01
		Night	58.0	3.18 (2.30-4.42)	
	Jump Type	Admin/Nontactical	17.6	1.00	<0.01
		Combat Load	34.8	1.98 (1.49-2.63)	
Concussion	Wind Speed	0-1 knot	5.1	1.00	
		2-5 knots	3.2	0.62 (0.23-1.55)	<0.01
		6-9 knots	18.0	3.53 (2.06-6.05)	
		10-13 knots	28.0	5.48 (2.86-10.39)	
	Time of Day	Day	9.6	1.00	0.39
		Night	6.4	0.67 (0.27-1.66)	
	Jump Type	Admin/Nontactical	9.4	1.00	0.98
		Combat Load	9.5	1.01 (0.61-1.66)	

e. Table 5 shows the multivariate associations of the covariates with all injuries, ankle sprains, ankle fractures, and ankle injuries (from the multivariate logistic regression). Brace wear was associated with fewer ankle sprains and ankle injuries even when time of day and jump type were considered in the analysis. While brace wear was still protective for ankle fractures, the effect was considerably reduced when time of day and jump status were included in the multivariate model.

Table 5. Multivariate Association Between Risk Factors and Airborne Injury Incidence (Multivariate Logistic Regression)

Injury Type	Variable	Level of Variable	Odds Ratio (95%CI)	Wald Statistic p-value
All Injury	Brace Status	Brace	1.00	-----
		No Brace	1.15 (0.93-1.42)	0.18
	Wind Speed	0-1 knot	1.00	-----
		2-5 knots	1.01 (0.77-1.32)	0.97
		6-9 knots	1.53 (1.20-1.97)	<0.01
		10-13 knots	2.13 (1.55-2.92)	<0.01
	Time of Day	Day	1.00	-----
		Night	2.24 (1.70-2.96)	<0.01
	Jump Type	Admin/Nontactical	1.00	-----
		Combat Load	1.26 (1.01-1.57)	0.04
Ankle Sprain	Brace Status	Brace	1.00	-----
		No Brace	1.90 (1.24-2.90)	<0.01
	Time of Day	Day	1.00	-----
		Night	2.62 (1.70-4.03)	<0.01
	Jump Type	Admin/Nontactical	1.00	-----
		Combat Load	1.38 (0.95-2.01)	0.09
Ankle Fracture	Brace Status	Brace	1.00	-----
		No Brace	1.47 (0.82-2.63)	0.19
	Time of Day	Day	1.00	-----
		Night	2.51 (1.37-4.60)	<0.01
	Jump Type	Admin/Nontactical	1.00	-----
		Combat Load	2.34 (1.42-3.85)	<0.01
Any Ankle Injury	Brace Status	Brace	1.00	-----
		No Brace	1.75 (1.25-2.48)	<0.01
	Time of Day	Day	1.00	-----
		Night	2.57 (1.80-3.65)	<0.01
	Jump Type	Admin/Nontactical	1.00	-----
		Combat Load	1.65 (1.22-2.22)	<0.01

f. Of the injured jumpers, 29% of men wore the brace and 31% of women wore the brace (chi square p=0.80). The average (±SD) age of injured brace wearers was 825±6 years while the average (±SD) age of injured brace non-wearers was 24±5 years (t-test p=0.11).

g. A total of 89 parachute entanglements occurred, of which 51 involved entanglements that persisted until the jumpers reached the ground. Only one entanglement involved 3 jumpers; none involved more than 3 jumpers. The overall entanglement incidence was 8.7/10,000 jumps and the incidence of entanglements to the ground was 5.0/10,000 jumps. Table 6 compares entanglements between those who wore the brace and those who did not wear the brace. Overall entanglements were slightly higher among those wearing the brace but entanglements that persisted until the jumpers reached the ground were slightly lower among those wearing the brace. Only 2 injuries occurred among entangled jumpers: both of these were entanglements to the ground and both involved jumpers not wearing the brace.

Table 6. Entanglements in the Braced and Not Braced Groups

	Incidence (%)		Risk Ratio (Brace/No Brace) and 95% CI	p-value
	Brace	No Brace		
Entanglements	9.6	7.5	0.76 (0.50-1.25)	0.33
Entanglements to Ground	4.2	4.9	1.17 (0.61-2.29)	0.73

7. DISCUSSION. The present investigation found that the PAB protected against ankle injuries, especially ankle sprains, during military parachute training. This protective effect was manifest even after considering wind speed, night jumps, and combat loads, covariates known to affect injury rates in this and other studies (9, 12, 18, 19, 21). Injuries to other parts of the lower body (exclusive of the ankle) were not significantly influenced by the brace. The age and gender distribution of injured jumpers did not differ between brace wearers or non-wearers indicating these potential intrinsic risk factors (1, 7, 8, 23) were similar across the two groups. The incidence of entanglements was similar in the braced and not braced groups.

(1) Comparison of Parachute Ankle Brace Investigations.

(a) The PAB reduced the risk of ankle sprains and ankle injuries in the present investigation and these findings are in consonance with other studies examining the PAB (2, 24, 25), as shown in Table 7. Most studies have been conducted with students attending the USAAS with the exception of the study by Schumacher et al. (25) that examined US Army Rangers. Only Amoroso et al. (2) performed a randomized intervention trial; other investigations (including the present one) were ecological/observational in design. Amoroso et al. (2) had few cases of ankle injuries and ankle sprains because of the relatively small number of descents but the ankle sprains in the non-PAB group were more serious than those in the PAB group. In general, these studies support the results of the current investigation, indicating that individuals who wear the PAB have about half the risk of an ankle injury compared with those not wearing the PAB.

Table 7. Comparison of Results from Investigations of the PAB

Investigation	Descents	Outcome Measure	Outcomes (injuries)	Injury Incidence (Injuries/10,000 jumps)		Risk Ratio (95%CI)
				PAB	No PAB	
Amoroso et al. 1998 (2)	3,674	Ankle Injury[a]	15	27.4	54.1	2.0 (0.6-6.6)
		Inversion Ankle Sprains	8	5.5	37.9	6.9 (0.9-56.1)
		All Ankle Sprains[a]	12	16.4	48.7	3.0 (0.7-13.8)
Schumacher et al. 2000 (25)	13,782	Ankle Injury	44	15.1	44.5	2.9 (1.4-6.1)
		Ankle Fracture[a]	12[b]	5.1	11.5	2.3 (0.6-8.4)
Schmidt et al. 2005 (24)[c]	973,715[d]	Hospitalized Ankle Injury	526	3.0	6.7	2.2 (1.8-2.8)
Present Investigation	102,784	Ankle Injury	219	13.2	25.2	1.9 (1.4-2.7)
		Ankle Sprains	144	8.4	16.7	2.0 (1.3-3.0)
		Ankle Fractures	74	4.5	8.2	1.8 (1.0-3.2)

[a]Derived from data in article
[b]Estimated from incidence reported in article
[c]Compared only pre-brace period to brace period
[d]Estimated from sample sizes assuming 5 jumps per service member

(b) In the Schmidt et al. study (24), there was little change in the magnitude of the ankle injury risk reduction after controlling for intrinsic risk factors (age, gender, race, rank, service duration). The present study was not able to specifically examine intrinsic risk factors because while age and gender were available on injured jumpers, this information was not available for uninjured jumpers. On the other hand, the present study was the first PAB investigation to control for extrinsic risk factors, those relating to the external environment. Even after controlling for night jumps and extra equipment in the multivariate model, there was little change in the magnitude of the risk ratio (no brace/brace) for ankle sprains and ankle injury. Wind speed was not considered in the multivariate model because it had no univariate association with ankle injury.

(2) <u>Injury Incidence.</u> The general findings of the current study are in accord with the literature with regard to injury incidence. The overall parachute injury rate of 58 cases/10,000 jumps agrees very well with the estimate of 56 cases/10,000 jumps calculated by Bricknell and Craig (6) based on their literature review of 13 post-1946 studies. Ankles were the site of 37% of the injuries in the present investigation and the literature reports that the ankles are involved in 21% to 43% of all injuries (2, 5, 8, 12, 15, 17, 25). Ankle sprains comprised 24% of all injuries in the present project and they account for 9% to 33% of all jump injuries reported in the literature (5, 8, 12, 15). Ankle fractures were 12% of all injuries in the current investigation and previous studies reported that 7% to 23% of all jump injuries were ankle fractures (5, 8, 12, 15).

(3) <u>Risk Factors for Parachute Injuries.</u>

(a) A number of previous studies of military parachute injuries have examined associations between overall injury incidence and various extrinsic risk factors (7-9, 11, 12, 18-21). Injury definitions have varied widely, as previously discussed (16), but the overall results have been relatively consistent in identifying specific factors associated with injury. In agreement with previous studies, the present investigation found that overall injury risk was elevated by higher wind speeds, night jumps, and additional equipment (9, 12, 18, 19, 21). Past studies have reported minor elevations in injury risk at wind speeds 6 (9) to 9 (19) knots, with higher risk when wind speeds exceed 9 to 13 knots (19, 21). Higher wind speeds can result in greater oscillations, elevated landing velocities, landings away from pre-planned areas, and less control on landing (16). Night jumps have been shown to increase injury risk (12, 18, 19, 21), possibly because of difficulties in seeing the ground, in perceiving distance and depth, and in determining the direction of lateral drift (16). Additional equipment may increase injury risk (19, 21) because the added weight increases the descent rate, resulting in higher ground impact forces (16). Furthermore, the release of the equipment on its suspension line can increase horizontal oscillations and lead to less controlled landings.

(b) This is only the second study to perform a multivariate analysis controlling for extrinsic covariates likely to influence injury rates during airborne operations. The other investigation, by Lillywhite (19), involved a group of experienced parachutists. Lillywhite (19) showed in a logistic regression model that greater injury risk was independently associated with greater wind speeds, night descents, more equipment, more jumpers, and the type of drop zone. Likewise, the variables examined in the present study (wind speed, night descents, extra equipment) were independently associated with injury (19).

(4) <u>Risk Factors for Specific Injuries.</u>

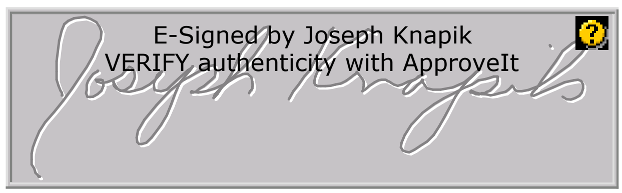
(a) While previous studies (7-9, 11, 12, 18-21) have examined associations between overall injury incidence and various extrinsic risk factors, the present study examined some specific types of injuries and found that risk factors differed depending on the anatomic location/type of injury. Ankle sprains, ankle fractures and overall ankle injuries were associated with greater loads and night jumps but not with higher wind speeds. On the other hand, concussions were not associated with greater loads or night jumps but their occurrence was elevated more than 5-fold as wind speeds increased from 0-1 knot to 10-13 knots. Head injuries are likely to occur during descents in which a proper parachute landing fall cannot be executed and the head impacts the ground. This is especially likely in situations where horizontal drift forces the parachutist into a backward landing and heels, buttocks and head hit the ground in sequence (9, 15). It is not clear why elevated wind speed was not associated with ankle sprains, ankle fractures, or overall ankle injuries.

(b) The protective effect of the PAB for ankle fractures decreased when considered in a multivariate model with night jumps and combat loads (the risk ratio (no brace/brace) decreased from 1.89 to 1.47). Jumps with combat loads were associated with almost twice the risk of an ankle fracture when compared with the risk for all injuries or with ankle sprains. As noted above, combat loads probably increased the descent rate resulting in higher ground impact forces. Rucksacks (the largest single item of the combat load) were attached to the jumper by a quick-release strap that the jumper was instructed to activate just before impact with the ground. If this was done with proper timing, the load hit the ground before the jumper; however, this process probably slowed the jumper's descent rate just before impact and could alter the "timing" of the jumper's ground impact, thereby inhibiting the proper execution of the parachute landing fall. Additionally, the load represented a drop zone hazard in that a jumper could land on top of it, also resulting in an improper parachute landing fall. Parachutists were in training and generally performed only one combat load jump, making the possibility of errors greater. It should also be noted that the PAB provides lateral support and may be able to reduce ankle fractures due to excessive lateral movement but not fractures due to vertical impacts, those in which excessive force is experienced along the long axis of the body. Higher vertical impacts may be more likely with combat loads.

(5) <u>Limitations.</u> There are several limitations to this investigation. First, this study was ecological/observational in design and not a randomized intervention trial, the type that provides the strongest test of an intervention (13). The classes that received the braces could have had lower injury risk because of factors not associated with ankle brace use. However, this is unlikely since airborne training procedures were well standardized across the unit involved. Further, the present study had well defined groups (brace wearers and non-wearers) and the results are supported by other studies that found similar results (2, 24, 25). Another potential limitation was that the present investigation recorded only injuries that occurred on the drop zone and that were initially treated by medics there. There was strong incentive to delay treatment of minor injuries so that students could complete training. However, the method of data collection used here obtained the more serious injuries, those most in need of acute medical care. Another limitation was the recording of wind speeds. Wind speeds were averaged over the entire jump operation and did not reflect what an individual jumper may have experienced during his or her jump. Wind gusts are intermittent and could have had large effects on the lateral drift and oscillations of individual jumpers. Finally, accuracy in defining injuries was likely to vary depending on the level of medical care reached by the student and the persistence of follow-up by those responsible for doing so.

8. CONCLUSIONS. The results of the current investigation were consistent with past studies in regard to injury incidence and identification of risk factors associated with injury. This investigation confirmed previous work (2, 24, 25) that showed that the PAB was effective in reducing the incidence of ankle sprains and ankle injuries during military parachuting. It expanded on previous work by showing that this protective effect was retained even when other known extrinsic parachute injury risk factors were taken into account. The PAB did not increase the incidence of other lower body injuries or parachute entanglements between those wearing and not wearing the brace.

9. RECOMMENDATIONS. The PAB should be used during military parachute training to reduce injuries. Further studies in operational units should be conducted with experienced parachutists to see if the PAB can increase operational combat capability through injury reduction.



Joseph Knapik
Research Physiologist

Appendix A
References

1. Amoroso P.J., Bell N.S., and Jones B.H. (1997). Injury among female and male parachutists. *Aviation, Space and Environmental Medicine.* 68: 1006-1011.
2. Amoroso P.J., Ryan J.B., Bickley B.T., Taylor D.C., Leitschuh P., Taylor D.C., and Jones B.H. (1998). Braced for impact: reducing military paratrooper's ankle sprains using outside-the-boot braces. *Journal of Trauma.* 45: 575-580.
3. Army Regulation 40-5 (2005). Preventive Medicine. Washington DC: Headquarters, Department of the Army.
4. Army Field Manual 57-220. (1996). Static Line Parachuting Techniques and Training. Washington DC: Headquarters, Department of the Army.
5. Bar-Dayan Y., Shemer J., and Bar-Dayan Y. (1998). Parachute injuries: a retrospective study of 43,542 military jumps. *Military Medicine.* 163: 1-2.
6. Bricknell M.C.M., and Craig S.C. (1999). Military parachute injuries: a literature review. *Occupational Medicine.* 49: 17-26.
7. Craig S.C., and Lee T. (2000). Attention to detail: injuries at altitude among U.S. Army military static line parachutists. *Military Medicine.* 165: 268-271.
8. Craig S.C., and Morgan J. (1997). Parachuting injury surveillance, Fort Bragg, North Carolina, May 1993 to December 1994. *Military Medicine.* 162: 162-164.
9. Essex-Lopresti P. (1946). The hazards of parachuting. *British Journal of Surgery.* 133: 1-13.
10. Flanagan E.M. (2002). Airborne. A Combat History of American Airborne Forces. New York: Ballantine Books.
11. Hadley A.T., and Hibst J.D. (1984). Reduction of military high-altitude parachute entanglements using the controlled alternating parachute exit system. *Aviation, Space and Environmental Medicine.* 55: 65-68.
12. Hallel T., and Naggan L. (1975). Parachute injuries: a retrospective study of 83,718 jumps. *Journal of Trauma.* 15: 14-19.
13. Jekel J.F., Elmore J.G., and Katz D.L. (1996). Epidemiology, Biostatistics, and Preventive Medicine. Philadelphia: W.B. Saunders.
14. Kiel F.W. (1965). Hazards of military parachuting. *Military Medicine.* 130: 512-521.
15. Kirby N. (1974). Parachuting injuries. *Proceeding of the Royal Society of Medicine.* 67: 17-21.
16. Knapik J.J., Craig S.C., Hauret K.G., and Jones B.H. (2003). Risk factors for injuries during military parachuting. *Aviation, Space and Environmental Medicine.* 74: 768-774.
17. Kotwal R.S., Meyer D.E., O'Connor K.C., Shahbaz B.A., Johnson T.R., Sterling R.A., and Wenzel R.B. (2004). Amy Ranger casualty, attrition and surgery rates for

airborne operations in Afghanistan and Iraq. *Aviation, Space and Environmental Medicine.* 75: 833-840.

18. Kragh J.F., Amoroso P.J., Jones B.H., and Heekin R.D. (1996). Parachuting injuries among Army rangers: a prospective survey of an elite airborne battalion. *Military Medicine.* 161: 416-419.
19. Lillywhite L.P. (1991). Analysis of extrinsic factors associated with 379 injuries occurring during 34,236 military parachute descents. *Journal of the Royal Army Medical Corps.* 137: 115-121.
20. Pirson J., and Pirlot M. (1990). A study of the influence of body weight and height on military parachute landing injuries. *Military Medicine.* 155: 383-385.
21. Pirson J., and Verbiest E. (1985). A study of some factors influencing parachute landing injuries. *Aviation, Space and Environmental Medicine.* 56: 564-567.
22. Rovere G.D., Clarke T.J., Yates C.S., and Burley K. (1988). Retrospective comparison of taping and ankle stablizers in preventing ankle injuries. *American Journal of Sports Medicine.* 16: 228-233.
23. Schmidt M.D., Sulski S.I., and Amoroso P.J. (2004). Effectiveness of an external ankle brace in reducing parachute-related ankle injuries. *Medicine and Science in Sports and Exercise.* 36: S312.
24. Schmidt M.D., Sulsky S.I., and Amoroso P.J. (2005). Effectiveness of an external ankle brace in reducing parachute-related ankle injuries. *Injury Prevention.* 11: 163-168.
25. Schumacher J.T., Creedon J.F., and Pope R.W. (2000). The effectiveness of the parachute ankle brace in reducing ankle injuries in an airborne ranger battalion. *Military Medicine.* 165: 944-948.
26. Sharpe S., Knapik J., and Jones B. (1997). Ankle braces effectively reduce recurrence of ankle sprains in female soccer players. *Journal of Athletic Training.* 32: 21-24.
27. Sitler M., Ryan J., Wheeler B., McBride J., Arciero R., Anderson J., and Horodyski M. (1994). The efficacy of a semirigid ankle stabilizer to reduce acute ankle injury in basketball. *American Journal of Sports Medicine.* 22: 454-461.
28. Tobin W.J., Cohen L.J., and Vandover J.T. (1941). Parachute Injuries. *JAMA.* 125: 318-321.

APPENDIX B
Documents Related to MTTF/DSOC Initiatives on the Parachute Ankle Brace

From: Patton, James T Mr ASA-IE [mailto:James.Patton@hqda.army.mil]
Sent: Monday, May 16, 2005 9:09 AM
To: Angello Joseph J.CIV OSD-P&R; Aslinger, Jerry A. CTR OSD-P&R; Reinhard,Daniel E. CTR OSD-P&R
Cc: Gunlicks, James B Mr. HQDA DCS G-3/5/7; Jones, Bruce H Dr USACHPPM; Curry, Daniel R CW5 HQDA DCS G-3/5/7; Timms, Charles MSG (OCAR-OPS); Back,Joe T COL HQDA DCS G-3/5/7; Romero, Anain J Ms OASA (I&E); Fatz, Raymond J Mr ASA-I&E
Subject: Airborne Ankle Brace Update

Mr. Angello - attached is the Military Training Task Force update on the airborne ankle brace project. Please let us know if any additional information is needed.

Thanks, Jim
James T. Patton
Assistant for Safety
SAIE-ESOH
Room 3D453
110 Army Pentagon
Washington, DC 20310-0110
703/697-3123 (voice), 703/614-5822 (fax)

10 May, 2005

DEFENSE SAFETY OVERSIGHT COUNCIL MILITARY TRAINING TASK FORCE, WASHINGTON, DC 20301

SUBJECT: Update on Parachute Ankle Braces Airborne Training Injury Prevention

1. Implementation for use of the parachute ankle brace (PAB) at the Army Airborne School is progressing well. After a couple of early delays in the schedule due to a prolonged acquisition process, the project is back on track. Delivery the first shipment of braces occurred May 10th and distribution at the School is now scheduled for mid-May. Progress milestones for Phase I of the PAB project at the Airborne School, Ft. Benning, GA since January 2005 include:

Phase I: Evaluation of PAB at Airborne School

- An onsite PAB evaluation coordinator (Mr. Fred Manning) was funded and hired at Ft. Benning in February, 2005

- Army Natick Soldier Center (ANSC) received funds of $130K to purchase 2,000 pairs of braces in mid-February.
- In late February, a request for bids to produce braces meeting ANSC specifications was written and opened for bids.
- Aircast Corporation was awarded the contract on the 25th March 2005.
- First delivery of braces was made to Ft Benning, GA 10 May 2005.
- The Army Research Institute of Environmental Medicine (ARIEM) received partial funds to initiate ankle brace evaluation in mid-February.
- ARIEM (COL Amoroso) has initiated the process for acquisition of Airborne School personnel data/student rosters, medical and safety data for ankle brace evaluation.
    - ARIEM and the Army Center for Health Promotion and Preventive Medicine (CHPPM) had conducted several teleconferences to coordinate activities with the Infantry Training Center QA Office (Ms Livingston) and the onsite PAB coordinator.
    - An Airborne School questionnaire has been developed to assess risk factors for jump-related injuries and injury outcomes at the end of each airborne class.
    - The questionnaire development involved ARIEM, CHPPM, USUHS and the Infantry School QA Office (Attachment file.).
- Infantry Training Center will deliver the questionnaire/survey to establish baseline injury risk factors, injuries and near misses and to follow rates post-PAB implementation.
- Baseline data will be collected until all airborne classes wear the PAB.
- Evaluation/comparison of PAB and Non-PAB use will begin with distribution of braces at the Airborne School in May/June 2005.
- Evaluation will be for 6 to 9 months post PAB distribution.
    - Briefings of results will be provided to the Airborne School, Infantry Training Center, and Defense Safety Oversight Council (DSOC) at the completion of the evaluation period and a written report will be produced for the DSOC.

2. Ground work for initiation of Phase II of PAB implementation in operational units at Ft. Bragg continues simultaneously with the above efforts at Ft. Benning. Milestones for Phase II include:

Phase II: Evaluation of PAB in Operational Units

- FORSCOM HQ and Ft Bragg Operational Airborne Unit briefings.
- PAB purchase, distribution and evaluation for operational units at Ft Bragg will follow a plan and timeline following brace acquisition similar to the Airborne School above.
- Evaluation of the PAB will continue for 6 to 9 months post PAB distribution to units at Ft Bragg.
- ANSC will produce an updated PAB requirements document 6-12 months post evaluation.

- Results from operational units at Ft. Bragg will be briefed to 18th Airborne Corps and 82nd Airborne Division unit Commanders following completion of Phase II evaluation there.

3. Following the conclusion of Phase II at Ft Bragg briefings will be given to the Military Training Task Force and Defense Safety Oversight Council (DSOC) and a final report with conclusions and recommendations regarding PAB implementation will be prepared and delivered to the DSOC.

Jim Gunlicks
Chairman, DSOC MTTF

OFFICE OF THE SECRETARY OF DEFENSE

WASHINGTON, DC 20301

April 15, 2005

MEMORANDUM FOR DEPUTY ASSISTANT SECRETARY OF THE ARMY
(ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH)
AVIATION SAFETY IMPROVEMENTS TASK FORCE CHAIR
MILITARY TRAINING TASK FORCE CHAIR
WORKERS' COMPENSATION TASK FORCE CHAIR

SUBJECT: Defense Safety Oversight Council (DSOC) Follow-up Actions

As discussed in our April 6, 2005 Integration Group meeting, we need to provide a status to the DSOC Chair on the four high priority projects directed in PBD 705. These include the efforts on Return to Work, Military Flight Operations Quality Assurance (MFOQA), Voluntary Protection Program (VPP), and Paratrooper Ankle Braces.

I ask that you submit a brief memorandum on your initiatives to me that includes a description of the process to implement the initiative, the steps taken to date, and future actions. Please also include a financial summary with the status of funds expended to date.

If you have questions or desire additional information, please contact Mr. Jerry Aslinger at 703-604-0838, or by email at Jerry.Aslinger.ctr@osd.mil.

Joseph J. Angello, Jr.
Executive Secretary
Defense Safety Oversight Council

cc: DSOC Integration Group Members
DSOC Task Force Chairs

MTTF Project 13
AIRBORNE TRAINING INJURY PREVENTION

☐ Action Complete

Objective Description: Ankle injuries account for 30 to 60% of all parachuting injuries. Army Airborne trainees who trained during periods when the Parachute Ankle Braces (PABs) were not in use were twice as likely to sustain an ankle injury requiring hospitalization compared to paratroopers who trained while the PABs were in use. Reintroduce PABs in order to reduce frequency and severity of lower extremity injuries during basic airborne school training.

Performance Measure: Reduction in lost training time, clinic visits, hospitalizations, and non-graduation rates due to ankle and lower extremity injuries caused primarily from parachute landing falls during Basic Airborne Training. No increase in other injuries. Injury reduction begins immediately with use of braces. USARIEM has already established metrics for evaluation/assessment.

Return on Investment: Estimated savings of $3.3 million in medical care costs annually due to 50% reduction in serious ankle injuries among trainees and estimated 75-80% reduction in mild ankle injuries; greater efficiency in training cycle; improved readiness.

Lead: MTTF/USARIEM

Action	Target Date	Actual Date	Lead
Develop Plan	Jul 2004	Nov 2004	MTTF
Manufacture, purchase, and delivery of PAB	Oct 2004		MTTF
Obtain Funding	Oct 2004	Dec 2004*	DSOC
Begin evaluation of ankle brace at Airborne School	Nov 2004	Pending Acquisition	MTTF
Evaluate brace in operational units	Pending Funds	Pending Funds	ARIEM
Upon success, field to all airborne units	Pending Funds		MTTF

Objective Assessment: GREEN

Current Status: GREEN

Pending coordination and purchase of braces.

Baseline data collection has been initiated. The Army Airborne School is prepared to launch the re-implementation phase as soon acquisition of braces has been completed.

Implementation in operational units awaits initiation at Airborne School and further coordination.

Key Actions
- Coordinate and plan implementation of brace at AB school
- Purchase braces and begin intervention at Airborne School
- Coordinate evaluation, purchase & implement PAB in operational units
- Conduct evaluation and analyses (USARIEM TAIHOD)
- If successful, procure 20,000 pair of braces (6-8 weeks to manufacture) and field to all Airborne units

Inhibitors
- Airborne community cultural resistance to change
- Cost of the Parachute Ankle braces ($60/pair)

Resource Requirements
- $300K evaluation and analysis of AB School & operational units (2005)
- $1.2M to outfit school & operational units with braces (2005)
- $600K/year out-years cost for brace replacements

*Potential PBD 705 Funding

Updated: February 2005

APPENDIX C
Acknowledgements

We would like to thank Ms Elaine Livingstone from the Fort Benning Quality Assurance Office for help with acquiring the data. We are also indebted to Ms Anita Spiess and Mr Tyson Grier for the technical/editorial review of the paper.