Chapter 8

PRIMARY PREVENTION OF INJURIES IN INITIAL ENTRY TRAINING

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INTRODUCTION

Individuals who join the US Army enter a new environment in which they face both physical and mental challenges.[1,2] The first phase of a new recruit's introduction to the Army, basic combat training (BCT), is where he or she learns basic soldiering skills, Army values, military customs and courtesy, and other information critical to the transformation from civilian to soldier. Immediately after BCT, most soldiers enter advanced individual training (AIT), which is specific to the each military occupational specialty (MOS). In some MOSs, such as infantry, artillery, armor, military police, and combat engineers, BCT and AIT are blended into what is called "one-station unit training" (OSUT). BCT, AIT, and OSUT are collectively referred to as "initial entry training" (IET), the preliminary training in effective soldiering.

All phases of IET include a wide variety of physical tasks: field exercises; motor skills training; and vigorous physical training involving running, calisthenics, and marching. These physical tasks put recruits at risk of injury, now a major concern of IET commanders. Injuries account for 5 to 10 times as many limited duty days as illness[3] and are associated with 6% to 8% of all recruit attrition.[4,5] Progress in identifying modifiable risk factors for injury and the development of successful prevention strategies began in the mid-1980s with the application of epidemiological concepts and analysis. These included classic epidemiological host–agent–environment relationships in BCT[6–9] and specific statistical techniques (stratified chi-square, logistic regression, and survival analysis) to identify injury risk factors and test injury-reduction interventions.[10–15]

The chapter will review the literature on primary injury prevention in IET, covering work performed in the US Army and other services as well as in the basic training units of other countries. A public health model is used to present a systematic review of the literature.

INJURY PREVENTION AND THE PUBLIC HEALTH MODEL

"Primary prevention of injuries" means taking action to avert injuries before they occur. The term "injury prevention" is somewhat of a misnomer because any physical task involves some risk of injury, and preventing all injuries is unlikely. However, "injury prevention" is commonly used to distinguish primary injury prevention from *injury control*. Injury control involves reducing the severity of an injury, once it has occurred, by early detection and treatment.[16]

The public health model offers a systematic methodology for addressing injury problems in five steps[17–19]:

1. surveillance, surveys, or both,
2. research,
3. intervention,
4. program implementation, and
5. program evaluation.

The first step in the injury-prevention process, surveillance and surveys, is critical to determining the size of the injury problem. Surveillance is the routine, systematic collection of data. Surveillance allows tracking of injury rates and trends over time and alerts investigators to changes in injury rates. Where surveillance systems have not been developed or where the specific data needed are not available within a surveillance system, surveys can fill the gaps. Surveys determine injury incidence, rates, or both at specific times in specific groups. Surveillance and surveys provide baseline injury levels that can subsequently be used to determine the effectiveness of interventions designed to reduce injuries.

During the second step, research, investigators determine the causes of injury and identify factors placing individuals at risk of injury. The two types of risk factors are *intrinsic* and *extrinsic*. Intrinsic risk factors are characteristics of the individual, such as gender, age, and physical fitness. Extrinsic risk factors are part of the environment in which the individual is operating, such as training programs, equipment, and weather.

Once an injury problem is identified and causes and risk factors researched, the third step is intervention. Intervention involves developing creative, practical injury-reduction strategies, and then testing them for their effectiveness. Intervention strategies might involve modifying equipment, training procedures, or the training environment through engineering, education, or development and enforcement of regulations.

The fourth step, program implementation, involves putting into practice the most effective injury-reduction strategies developed in the intervention phase. In a military environment, this "putting into practice" must be accomplished by unit commanders. Commanders have the ultimate responsibility for integrating injury-reduction programs with mission accomplishment.

The fifth and final step, program evaluation, seeks to determine the success of a program that has been implemented in the operational environment. This is usually achieved by comparing surveillance or survey data gathered *before* and *after* the implementation.

Surveillance and Surveys

Surveillance systems have recently been developed for the routine tracking of IET injuries. Also, many injury surveys have been conducted that show IET injury prevalence and trends. Most surveys conducted in IET involve systematic reviews of medical records, capturing specific pieces of information such as date of visit, diagnosis, days of limited duty, and final disposition.[1,2,11]

Surveillance of Injuries in Initial Entry Training

Four surveillance systems have been developed to track injury information:

1. Installation Injury Reports (IIRs) from the Defense Medical Surveillance System (DMSS),
2. Training-Related Injury Reports (TRIRs),
3. Physical Training and Rehabilitation Program Surveillance System (PTRPSS), and
4. Aberdeen Proving Ground Injury and Illness Surveillance System (APGIISS).

To compile IIRs, DMSS obtains inpatient and outpatient data on injuries and diseases from military hospitals and clinics. IIRS are available at the Army Medical Surveillance Activity (AMSA) Web site (http://amsa.army.mil). The reports provide information on injury trends, causes of injury hospitalizations, limited duty status, and anatomical location of injuries. An example of an injury report for the entire Army is shown in Figure 8-1. IIRs do not specifically track recruits in IET, however, and provide information only on an entire service (Army, Navy, etc) or installation (Figure 8-2). AMSA also publishes the Medical Surveillance Monthly Report (MSMR), which contains information on specific injury issues often related to IET (also available at AMSA's Web site).

The second surveillance system, TRIR, was begun by AMSA in 2003 to track training-related injuries in BCT. Injury rates are calculated using the *International Classification of Diseases*, 9th revision (ICD-9), codes for overuse injuries of the lower extremities. New injury cases (numerators) from AMSA are linked with personnel data (denominators) provided by the US Army Training and Doctrine Command (TRADOC) to produce monthly injury rates. These rates are exclusively for BCT units at each of the five posts where BCT is conducted (Fort Jackson, South Carolina; Fort Leonard Wood, Missouri; Fort Benning, Georgia; Fort Sill, Oklahoma; and Fort Knox, Kentucky). Figure 8-3 shows an example of the monthly report sent to the TRADOC surgeon's office.

The third surveillance system, PTRPSS, was developed by the Physical Therapy Department at Moncrief Army Community Hospital, Fort Jackson, in 1998. The Physical Training and Rehabilitation

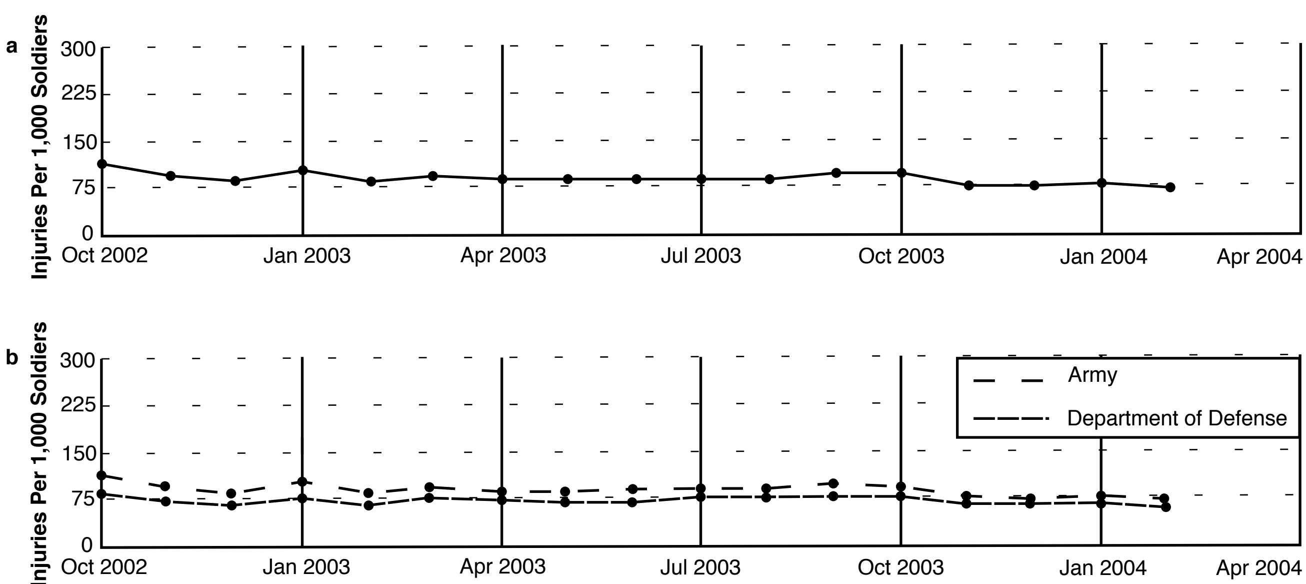


Fig. 8-1. Trends in incident injuries for the entire US Army tracked by the Defense Medical Surveillance System. (**a**) Rate of injury in the Army. (**b**) Rate of injury in the Army compared to the Department of Defense. During February 2004, 34,661 of 487,505 soldiers (7.1%) had an injury requiring medical attention.
Reproduced from: Defense Medical Surveillance System, Army Medical Surveillance Activity. Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2004.

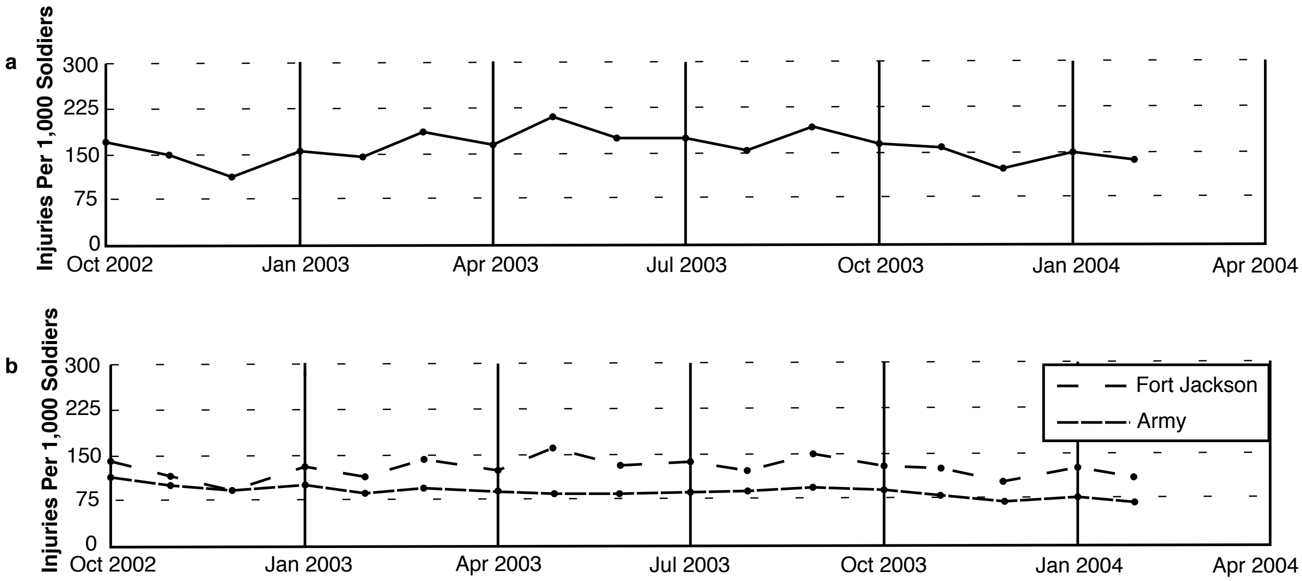


Fig. 8-2. Trends in incident injuries at Fort Jackson, South Carolina, tracked by the Defense Medical Surveillance System. (**a**) Rate of injury at Fort Jackson. (**b**) Rate of injury at Fort Jackson compared to the US Army. During February 2004, 1,172 of 8,447 soldiers (13.9%) had an injury requiring medical attention.
Reproduced from: Defense Medical Surveillance System, Army Medical Surveillance Activity. Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2004.

Program (PTRP) is designed to treat injuries severe enough to prevent a trainee from fulfilling BCT requirements. Recommendations to remove a trainee from BCT are based on medical necessity and are generally made by physical therapists, occupational therapists, or orthopedic surgeons. Commanders usually follow the recommendation and transfer the recruit to PTRP for rehabilitation and recovery away from the BCT environment. PTRPSS contains information on the trainee's battalion, type of injury,

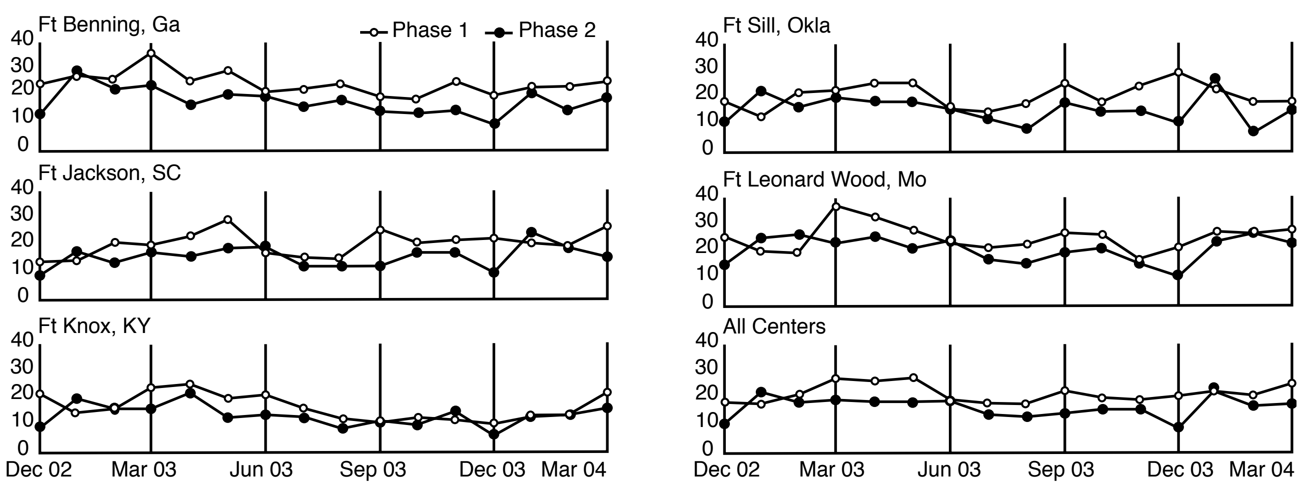


Fig. 8-3. Training-Related Injury Reports (TRIRs) for Army basic training centers. Phase 1 is the injury rate for training days 1 through 28; phase 2 is the injury rate for training days 29 through 93. Injury rates are adjusted for the winter holiday period.
Reproduced from: Defense Medical Surveillance System, Army Medical Surveillance Activity. Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 05 April 2004.

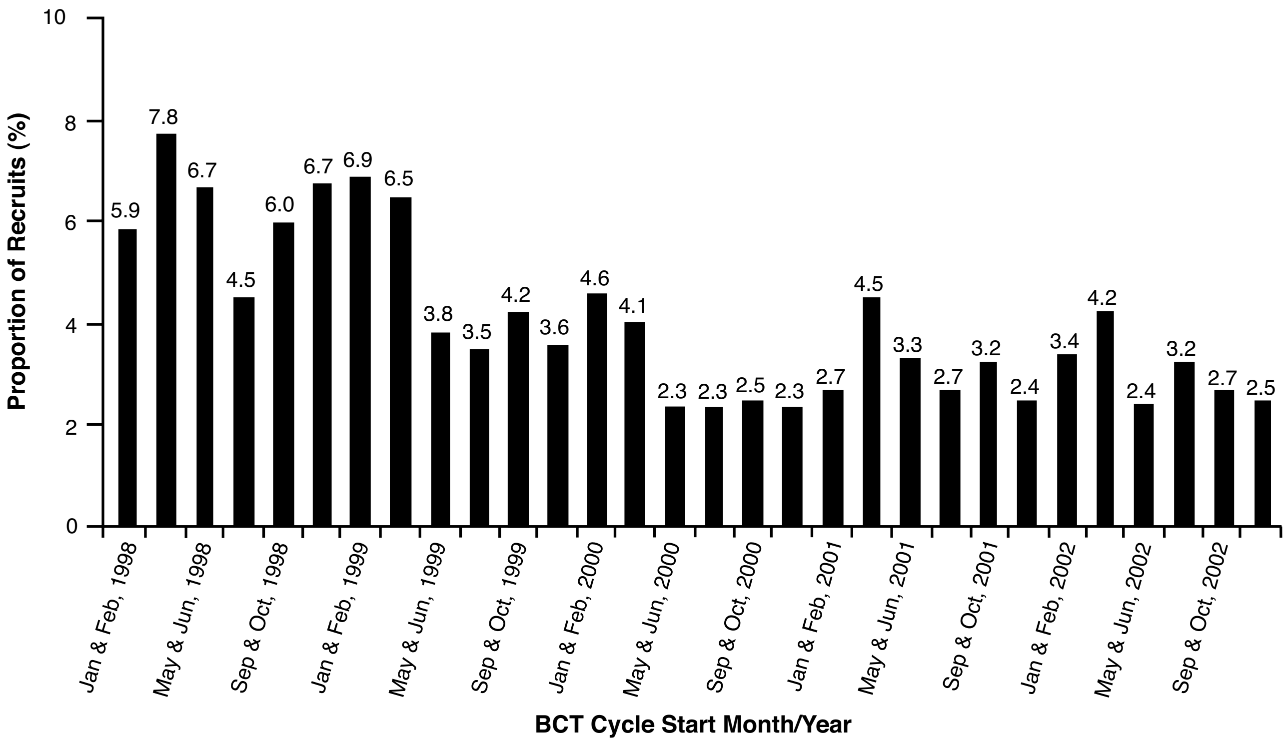


Fig. 8-4. Percentage of recruits sent to the Physical Training and Rehabilitation Program (PTRP) at Fort Jackson, South Carolina, from January 1998 to October 2002. Data were averaged for all battalions that began their BCT cycle in particular 2-month periods. Note the decline in injury rates from 1998 into mid 1999, with further declines into mid-2000.
BCT: basic combat training.
Data from: Physical Training and Rehabilitation Program Surveillance System, Physical Therapy Clinic, Moncrief Army Community Hospital, Ft Jackson, SC; 2002.

and length of time in PTRP. Surveillance reports are sent to battalion commanders at the end of each BCT cycle. Figure 8-4 shows the proportion of recruits sent to PTRP at Fort Jackson from January 1998 to October 2002.

The fourth surveillance system, APGIISS, was developed in 1999 at Aberdeen Proving Ground (APG), Maryland, to track injuries and illnesses among ordnance AIT students. Figure 8-5 shows an APGIIS form, which is filled out by the patient and the healthcare provider and then scanned into a database. At the end of each week, brigade personnel staff provides the current number of soldiers in each of the six companies in the two AIT ordnance battalions at APG. This information is combined with the number of weekly clinic visits to produce the proportion of injured or sick soldiers (eg, injury clinic visits ÷ company strength • 100% = proportion of soldiers with sick call visits). These data are graphed and sent to commanders at company, battalion, and brigade level. A sample graph sent to company commanders is shown in Figure 8-6.

Surveys of Injuries in Initial Entry Training

Surveys of outpatient medical records can provide a more detailed examination of injury rates in specific IET populations.[17] An individual medical record is maintained for each recruit and includes notations for all outpatient medical visits, summaries of inpatient care, and copies of laboratory and radiological reports. Medical records are generally maintained at the IET medical treatment facility that cares for the recruit, and the cumulative record travels with the recruit when he or she moves to new duty stations.

Table 8-1 provides a summary of cumulative injury incidence (recruits with ≥ 1 injuries in BCT) and injury incidence rates (recruits with ≥ 1 injuries per month) of US Army basic trainees. This table was compiled from studies that obtained most of their data from surveys of medical records.[10–13,20–27] One study used a self-report questionnaire,[25] and another obtained data from a surveillance system[26] (included in Table 8-1 because it is the most recent). Most of the data were obtained at Fort Jackson,[11,12,20,21,23–26] but one was conducted at Fort Bliss,

Injury and Illness Sheet

Kirk Army Health Clinic/Army Center for Health Promotion and Preventive Medicine

SSN ___ - __ - ____ LAST NAME ____________ TODAY'S DATE (DD/MM/YY) __ / __ / __

GENDER: O Male O Female **UNIT:** O A-16 O B-16 O C-16 O A-143 O B-143 O C-143 O Other

1. Is this your first visit to the clinic for this medical problem?
O Yes
O No

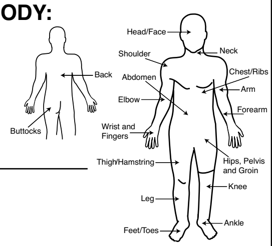
2. Is this problem similar to one you had in basic training?
O Yes
O No

3. Are you:
O Injured? If so complete COLUMN A
O Ill? If so complete COLUMN B
O Injured and Ill? IF SO COMPLETE A & COLUMN B

COLUMN A - INJURY
Complete only for your most serious injury

4. INJURY OCCURRED DURING:
O Sports in free time
O Sports (unit organized)
O Running in free time
O Running (unit organized)
O Physical Training (not running)
O MOS training
O Road marching
O Heat/cold (environmental)
O Fighting/anger related
O Unsure (gradual onset)
O Other ____________

5. INJURY LOCATION ON BODY:
O Head/Face
O Neck
O Shoulder
O Chest/Ribs
O Arm
O Elbow
O Forearm
O Wrist/Hand/Fingers
O Hip/Pelvis/Groin
O Buttock
O Thigh/Hamstring
O Knee
O Leg
O Ankle
O Foot/Toe
O Upper Back
O Lower Back
O Other ____________



COLUMN B - ILLNESS
Complete only for your most serious illness

4. HOW LONG HAS YOUR ILLNESS BEEN GOING ON:
O Began Today
O Began Yesterday
O 2-3 Days
O 4-6 Days
O 1-2 Weeks
O More than 2 Weeks

DO NOT WRITE BELOW THIS LINE
FOR MEDICAL STAFF ONLY

6. Diagnosis (Injury)
O Normal Exam
O Abrasion/Laceration
O Arthritis
O Bite/Sting
O Blister
O Burn
O Cold Injury
O Contusion
O Dislocation/Subluxation
O Fracture
O Heat Injury
O Inflamation (eg, bursitis/tendonitis)
O Ingrown Toenail
O Neuropathy
O Pain
O Instability
O Sprain
O Strain
O Stress Fracture
O Stress Reaction
O Tear/Rupture
O Other ____________

7. DISPOSITION (Injury)
O No Profile
O Profile. List # of days ☐☐
O Quarters. List # of days ☐☐
O Hospitalized
O Other ____________

5. Diagnosis (Illness)
O Eyes (conjuctivitis, iritis, visual changes)
O Ears (hearing loss, labrynthitis, otitis)
O Musculoskeletal (not injury, fibromyalgia, deformities)
O Neck (abscess, adenopathy, mass, goiter)
O Throat (abscess, mass)
O Respiratory (URI, LRI, asthma, TB)
O GT (GERD, constipation, IBS, gastritis, ulcer)
O GU (UTT epididymitis, STD, vaginitis, orchitis)
O Dermatology (dermatitis, tinea, rash, abscess, lesion)
O Neurology (neuropathy, seizure, parathesias)
O Psychiatry (depression, anxiety, maladaptation)
O Other ____________

6. DISPOSITION (Illness)
O No Profile
O Profile. List # of days ☐☐
O Quarters. List # of days ☐☐
O Hospitalized
O Shaving Profile. List # of days ☐☐
O Other ____________

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Fig 8-5. Recording sheet used in the Aberdeen Proving Ground Injury and Illness Surveillance System (APGIISS). Each time a student enters the clinic, he or she completes the top two thirds of a form, and the healthcare provider fills out the bottom third. Reproduced from: APGIISS, Aberdeen Proving Ground, Md; 2003.

Texas,[13] one at Fort Leonard Wood,[22] and two (studies of the 12-week infantry OSUT) at Fort Benning.[10,27] In October 1998, BCT was extended from 8 to 9 weeks (Table 8-1 shows which studies involved the longer and the shorter cycle lengths). With two exceptions,[21,23] these studies include only recruits who graduated from training. As seen in the data from PTRPSS (see Fig. 8-4), injury rates were generally lower after 1998.

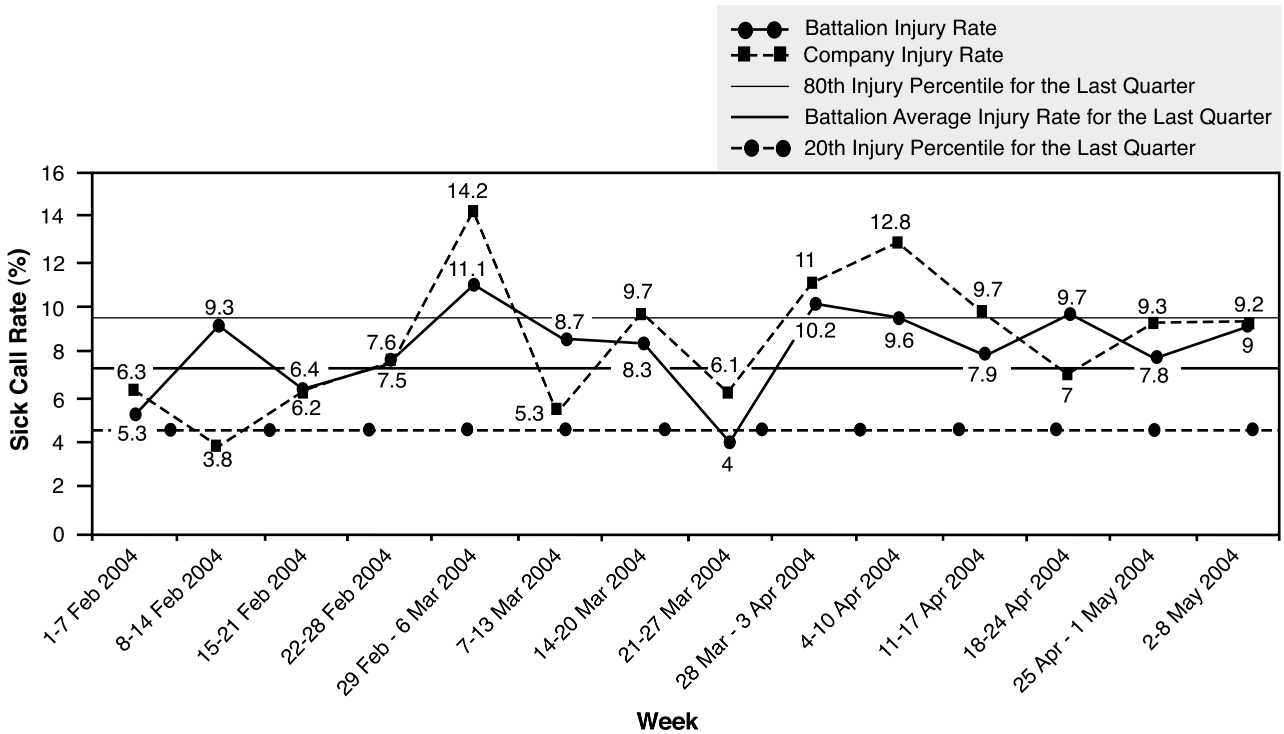

Fig. 8-6. Weekly injury sick call rates at Aberdeen Proving Ground, Maryland, February to May 2004. Tracked by the Aberdeen Proving Ground Injury and Illness Surveillance System (APGIISS).
Reproduced from: APGIISS, Aberdeen Proving Ground, Md; 2004.

Table 8-2 compares cumulative injury incidence and injury incidence rates among recruits who graduated and all recruits, regardless of whether or not they graduated. One problem with this comparison is that the time in BCT was not the same for both groups (those who did not graduate spent less time in BCT and thus had less time at risk of injury). Despite this problem, cumulative injury incidence was 11% to 20% higher for men and 3% to 13% higher for women in the total group compared with graduates only. There are two possible reasons for this difference: (1) a main reason for discharge is a medical condition, often an injury that existed prior to service,[4] and (2) a main reason for restarting training (recycling) is a serious injury for which the trainee is placed in PTRP.

Table 8-3 shows relative rates of injuries and illnesses among basic trainees obtained from surveys of medical records. The outpatient visit rate is similar for injuries and illnesses for both men and women. However, the number of limited duty days is 5 to 8 times higher for injuries than it is for illnesses. These data support the findings of an earlier study[17] showing that injuries in BCT impact lost duty time to a much greater extent than illnesses.

Currently there are 241 MOSs in the US Army, with varying lengths of AIT training from a few weeks to more than a year. Table 8-4 shows injury incidence data collected from six MOSs (including two studies of medics). Data for the medic studies were obtained from screening medical records,[28] and data on the ordnance MOSs were obtained from APGIISS.[14,29]

Research

After surveillance, the next step in the injury-prevention process is research to identify the causes and risk factors, both intrinsic and extrinsic, for injury. Extensive work has been performed identifying intrinsic injury risk factors not only in US Army BCT but also in the basic training programs of other countries, including Australia, Norway, the United Kingdom, and Israel. Identified intrinsic risk factors include female gender,[7,10–12,15,20,25,26,30] high foot arches,[31,32] knee Q angle greater than 15 degrees,[33] genu valgum,[33] past ankle sprains,[10] low aerobic fitness,[2,7,11,12,21,30,34–36] low muscular endurance,[10,12] high and low extremes of flexibility,[2,10,12] low levels of physical activity before BCT,[2,7,8,10–12,35] cigarette smoking before BCT,[2,10,12,35,37] and older age.[10,35] Less consistently demonstrated intrinsic

TABLE 8-1

CUMULATIVE INCIDENCE OF INJURY AND INJURY INCIDENCE RATES DURING US ARMY BASIC COMBAT TRAINING

Length of Training (wk)	Year Data Collected	Recruits (n) Men	Recruits (n) Women	Cumulative Injury Incidence (%) Men	Cumulative Injury Incidence (%) Women	Injury Incidence Rate (%/mo) Men	Injury Incidence Rate (%/mo) Women
8-wk BCT	1978[1,*]	347	770	26.2	62.0	13.1	31.0
	1980[2]	1,840	644	20.7	41.2	10.4	20.6
	1984[3]	124	186	27.4	50.5	13.7	25.3
	1988[4]	509	352	27.0	57.0	13.5	28.5
	1993[5]	ND	165	ND	66.7	ND	33.3
	1996[6]	159	84	41.5	65.5	20.8	32.8
	1998[7]	604	305	30.8	58.0	15.4	29.0
9-wk BCT	1998[8]	655	498	29.9	65.3	13.3	29.0
	2000[9,†]	682/441	579/554	13.5/16.9	36.1/46.8	6.0/7.5	16.0/20.8
	2003[10,†,‡]	442/569	295/377	19.5/27.9	41.0/47.7	8.7/12.4	18.2/21.2
12-wk infantry	1988[11]	303	ND	45.9	ND	15.3	ND
OSUT	1996[12]	768	ND	48.0	ND	16.0	ND

*Injury data from self-report questionnaire
†Cohort study with two groups; data from both groups are presented
‡Injury data from surveillance system
BCT: basic combat training
ND: no data collected on other gender
OSUT: one-station unit training
Data sources: (1) Kowal DM. Nature and causes of injuries in women resulting from an endurance training program. *Am J Sports Med*. 1980;8:265–269. (2) Bensel CK, Kish RN. *Lower Extremity Disorders Among Men and Women in Army Basic Training and Effects of Two Types of Boots.* Natick, Mass: US Army Natick Research and Development Laboratories; 1983. Technical Report TR-83/026. (3) Jones BH, Bovee MW, Harris JM, Cowan DN. Intrinsic risk factors for exercise-related injuries among male and female Army trainees. *Am J Sports Med*. 1993;21:705–710. (4) Bell NS, Mangione TW, Hemenway D, Amoroso PJ, Jones BH. High injury rates among female Army trainees: A function of gender? *Am J Prev Med*. 2000;18(suppl 3):141–146. (5) Westphal KA, Friedl KE, Sharp MA, et al. *Health, Performance and Nutritional Status of US Army Women During Basic Combat Training.* Natick, Mass: US Army Research Institute of Environmental Medicine; 1995. Technical Report T96-2. (6) Jones BH. Injuries among men and women in gender-integrated BCT units: Ft Leonard Wood; 1995. *Medical Surveillance Monthly Report*. 1996;2:2–3, 7–8. (7) Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH. Risk factors for training-related injuries among men and women in Basic Combat Training. *Med Sci Sports Exerc.* 2001;33:946–954. (8) Canham-Chervak M, Knapik JJ, Hauret K, Cuthie J, Craig S, Hoedebecke E. *Determining Physical Fitness Entry Criteria for Entry into Army Basic Combat Training: Can These Criteria Be Based on Injury?* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2000. Epidemiological Consultation Report 29-HE-1395-00. (9) Knapik JJ, Hauret K, Bednarek JM, et al. *The Victory Fitness Program. Influence of the US Army's Emerging Physical Fitness Doctrine on Fitness and Injuries in Basic Combat Training.* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2001. Epidemiological Consultation Report No. 12-MA-5762-01. (10) Knapik JJ, Darakjy S, Scott S, et al. *Evaluation of Two Army Fitness Programs: The TRADOC Standardized Physical Training Program for Basic Combat Training and the Fitness Assessment Program.* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2004. Technical Report 12-HF-5772B-04. (11) Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN. Epidemiology of injuries associated with physical training among young men in the Army. *Med Sci Sports Exerc*. 1993;25:197–203. (12) Hewitson W, Major, Medical Corps, US Army. Personal communication, 1996.

risk factors include lower levels of muscular strength, higher body fat or body mass index, and white ethnicity.[2,7,8,10–12,21,30,35–40] Multivariate analyses have shown that cigarette smoking before BCT, low levels of aerobic fitness, and low levels of physical activity before BCT are independent injury risk factors.[10,12,41]

Extrinsic risk factors that have been identified in BCT include high running mileage, certain training companies, older running shoes, and the summer season. The more running mileage, the greater the likelihood that injuries will occur.[6,42,43] There are large differences in injury rates among US Army training companies,[2,10,40] possibly as a result of differences in training intensities, especially physical training.[6] Older running shoes are associated with a higher risk of stress fractures.[8] Seasonal variations in injury rates appear to occur in BCT, with higher overall rates in the summer and lower rates in the fall.[44]

Only a few studies have examined injury risk factors in AIT. Previously unpublished surveillance data

TABLE 8-2

CUMULATIVE INJURY INCIDENCE AND INJURY INCIDENCE RATES OF US ARMY BASIC COMBAT TRAINEES*

Length of BCT (wk)	Year Data Collected	Status	Recruits (n)		Cumulative Injury Incidence (%)		Injury Incidence Rate (%/mo)	
			Men	Women	Men	Women	Men	Women
8-wk BCT	1980[1,†]	All recruits	2,074	767	23.1	42.4	11.6	21.2
		Completed BCT	1,840	644	20.7	41.2	10.4	20.6
	1998[2,†]	All recruits	733	452	37.0	63.1	16.4	31.6
		Completed BCT	604	305	30.8	58.0	15.4	29.0
9-wk BCT	2000[3,†,‡]	All recruits	759/507	631/640	15.7/18.7	39.6/47.8	7.0/8.3	17.6/21.2
		Completed BCT	682/441	579/554	13.5/16.9	36.1/46.8	6.0/7.5	16.0/20.8
	2003[4,‡,§]	All recruits	518/656	416/482	21.8/31.3	45.9/53.9	9.7/13.9	20.4/24.0
		Completed BCT	442/569	295/377	19.5/27.9	41.0/47.7	8.7/12.4	18.2/21.2

*Table compares incidence and rates of all recruits who entered training and only recruits who completed training
†Injury data from medical records
‡Cohort study with 2 groups; both sets of data given here
§Injury data from surveillance system
BCT: basic combat training
Data sources: (1) Bensel CK, Kish RN. *Lower Extremity Disorders Among Men and Women in Army Basic Training and Effects of Two Types of Boots.* Natick, Mass: US Army Natick Research and Development Laboratories; 1983. Technical Report TR-83/026. (2) Knapik JJ, Sharp MA, Canham ML, et al. *Injury Incidence and Injury Risk Factors Among US Army Basic Trainees at Ft Jackson, SC (Including Fitness Training Unit Personnel, Discharges, and Newstarts).* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 1999. Epidemiological Consultation Report 29-HE-8370-99. (3) Knapik JJ, Hauret K, Bednarek JM, et al. *The Victory Fitness Program. Influence of the US Army's Emerging Physical Fitness Doctrine on Fitness and Injuries in Basic Combat Training.* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2001. Epidemiological Consultation Report No. 12-MA-5762-01. (4) Knapik JJ, Darakjy S, Scott S, et al. *Evaluation of Two Army Fitness Programs: The TRADOC Standardized Physical Training Program for Basic Combat Training and the Fitness Assessment Program.* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2004. Technical Report 12-HF-5772B-04.

from two battalions of soldiers attending ordnance AIT are shown in Figure 8-7. These data indicate that about 53% to 63% of injuries are related to physical training and sports.[14] Injury risk factors among men in ordnance school at APG include lower rank; self-reported prior injury; prior cigarette smoking; and lower performance on push-ups, sit-ups, or 2-mile runs.[45] In multivariate analysis, independent risk factors for injury included prior self-reported injury and low physical fitness (lower performance on any of the three Army Physical Fitness Test events).[45] A study examining injury risk factors among medics in

TABLE 8-3

RELATIVE RATES OF INJURIES AND ILLNESSES AMONG US ARMY TRAINEES

Category	Recruit Sample	Injury (Events/100 Person-months)	Illness (Events/100 Person-months)	Ratio (Injury/Illness)
Outpatient visits	Men	16	16	1.0
	Women	29	28	1.0
Days of limited duty	Men	110	21	5.2
	Women	266	32	8.3

Data sources: (1) Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH. Risk factors for training-related injuries among men and women in Basic Combat Training. *Med Sci Sports Exerc.* 2001;33:946–954. (2) Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH. Same cohort as in data source 1. Previously unpublished data, 2001.

TABLE 8-4

INJURY INCIDENCE AND INCIDENCE RATES AMONG US ARMY SOLDIERS IN ADVANCED INDIVIDUAL TRAINING

Year(s) Data Collected	Military Occupational Specialty	Length of Training (wk)	Cumulative Injury Incidence (%)		Incidence Rate (Injuries/100 Person-months)		Study (Data Source)
			Men	Women	Men	Women	
1996	Medic	10	24	30	10	12	1
1997	Medic	10	22	38	9	15	2
2000–2002	Fuel and Electrical System Repairer	9	28.3	30.8	12.6	ID	3
	Self-Propelled Field Artillery System Mechanic	10	27.9	ND	11.2	ND	
	Track Vehicle Mechanic	12	34.9	61.5	11.6	ID	
	Wheel Vehicle Repairer	13	35.2	50.4	10.8	15.5	
	Track Vehicle Repairer	16	36.8	52.0	9.2	13.0	

ID: insufficient data (sample size < 50)
ND: no data on women
Data sources: (1) Henderson NE, Knapik JJ, Shaffer SW, McKenzie TH, Schneider GM. Injuries and injury risk factors among men and women in US Army combat medic Advanced Individual Training. *Mil Med.* 2000;165:647–652. (2) Henderson NE, Colonel, Specialist Corps, US Army. Previously unpublished data, approximately 1997. (3) Knapik JJ, Canada S, Epidemiologist, US Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Md. Previously unpublished data, 2002.

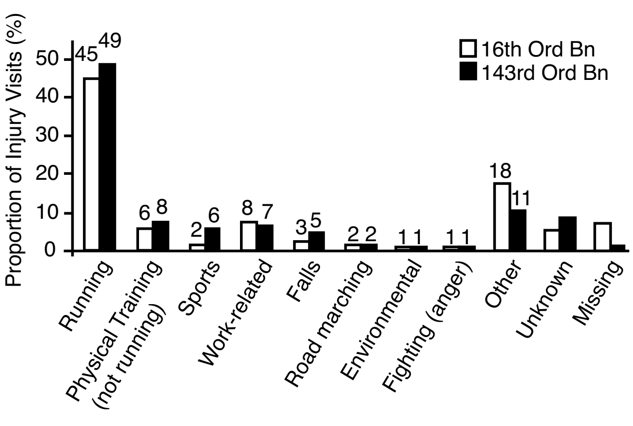

Fig. 8-7. Activities associated with injury in ordnance advanced individual training at Aberdeen Proving Ground, Maryland, from January through December, 2001. About 60% of injuries are due to physical activity. Running, physical training (not running), and sports, combined, account for 53% of all injuries in the 16th Ordnance Battalion and 63% of all injuries in the 143rd.
Ord Bn: ordinance battalion
Reproduced from: Knapik JJ, Bullock SH, Canada S, et al. *The Aberdeen Proving Ground Injury Control Project: Influence of a Multiple Intervention Program on Injuries and Fitness Among Ordnance School Students in Advanced Individual Training.* Aberdeen Proving Ground, Md: US Army Center for Health Promotion and Preventive Medicine; 2003. Technical Report 12-HF-7990-03.

AIT training at Fort Sam Houston found that, among women, higher body weight, older age, and a break in training between BCT and AIT (about 9 months) were associated with injury in both univariate and multivariate analyses. No injury risk factors for men were identified.[28]

Intervention Trials

The early steps in the injury-control process—surveillance and research—provide the raw material for the next step—intervention trials. Once modifiable injury risk factors have been identified, then interventions to reduce injuries can be conceptualized and subsequently tested for effectiveness. Intervention trials include, most importantly, specific injury-outcome measures (eg, "Did the program reduce recruit overuse injuries?") and other variables that may be affected by the program (eg, "What happened to the physical fitness level of the recruits?"). Interventions that have been examined in IET environments involve primarily modifications to physical training programs and changes in equipment. Information on successful intervention trials can be disseminated to leaders or commanders who are in a position to integrate programs into their training activities.

Physical Training Interventions

Physical training interventions that have been examined in BCT environments include reduced running mileage, stretching before exercise, elimination of running in the third week of BCT, and preconditioning. In addition, a number of studies have introduced multiple interventions into the IET environment and evaluated them for their effects on injuries.

Reducing Running Mileage. Several civilian studies[46–49] and observational military studies in basic training[6,43] have identified high running mileage as an injury risk factor. An obvious intervention involves reducing the amount of running performed by recruits. An investigation by the US Naval Health Research Center in San Diego, California, was conducted during a 12-week Marine Corps boot camp.[42] Stress fractures were tracked in three groups of marine recruits, with each group performing different amounts of organized running. Table 8-5 shows the running distances, stress fracture incidence, and final 3-mile run times. As total running distance decreased, the stress fracture incidence decreased. A 40% reduction in running distance was associated with a 53% reduction in stress fracture incidence and only slightly slower (2.5%) 3-mile run times. Thus, reducing running mileage reduced stress fracture incidence, with minimal effects on aerobic fitness.[42]

Another study[50] examined the effect on injuries of substituting foot marches for running during a 12-week Australian Army recruit training course. One group of recruits performed 16 miles of programmed running (called the "run group"), the usual amount in the course. Whenever a run was scheduled, another group of recruits substituted foot marches with backpack loads (the "walk group"). Foot marches for the walk group involved progressively increasing distances and pack weights. At the end of the 12 weeks, the walk group had fewer injuries than the run group (38% vs 47%, $P = .09$). Compared with the walk group, the run group had more lower-limb injuries (25% vs 42%, $P < .01$), more knee injuries (9% vs 19%, $P = .01$), and almost twice as many restricted duty days and hospitalizations. Both groups performed 3-mile run tests at weeks 3 and 6 of the training program, but the results of the runs were not reported.

TABLE 8-5

MILEAGE, STRESS FRACTURE INCIDENCE, AND FINAL THREE-MILE RUN TIMES AMONG THREE GROUPS OF MALE US MARINE CORPS RECRUITS

Marines(n)	Total Run Distance (km)	Stress Fracture Incidence (n/100)	Final 3-Mile Run Times (min)
1,136	89	3.7	20.3
1,117	66	2.7	20.7
1,097	53	1.7	20.9

Source: Shaffer RA. Musculoskeletal Injury Project. Paper presented at: The 43rd Annual Meeting of the American College of Sports Medicine; May 29–June 1, 1996; Cincinnati, Ohio.

Stretching. For many years, sports medicine professionals have recommended stretching before physical activity as a method for reducing the risk of injury.[51–53] The effectiveness of this intervention was not tested until relatively recently, however. Studies generally show that stretching before[34,54] or both before and after physical training[55] does *not* reduce the risk of injury. Studies that did show an effect of stretching on injuries have been nonrandomized trials,[56,57] were confounded with interventions other than stretching,[58] or had other major design problems,[59] including some form of stretching in the control group.[57] Furthermore, epidemiological data has indicated that extremes of flexibility (too much or too little) may not be desirable. Studies of basic trainees,[2,10] Special Forces trainees,[60] and collegiate athletes[61] have shown that both high and low levels of flexibility are associated with increased risk of injury. This may imply that stretching might assist individuals with low flexibility in reducing injuries, but also that stretching might be contraindicated for individuals who have high flexibility. Further research in this area is warranted.[62]

One randomized prospective cohort study compared injury rates between two groups of male Australian basic trainees in the 12-week program.[34] One group did not stretch, while the other group performed 20-second stretches of six lower extremity muscle groups before exercise. Lower extremity injuries that required at least 3 days of limited duty were tracked. There were no significant differences between the two groups for overall injury rates ($P = .67$), soft-tissue–related injury rates ($P = .17$), or bone-related injury rates ($P = .27$). These data indicate that pre-exercise stretching in basic training has no effect on injury rates. The time spent in pre-exercise stretching may be more effectively used in warm-up exercises that include low-intensity activities similar to the training activities (eg, walking before running).

Eliminating Running in the Third Week of Basic Combat Training. Some military studies have found that stress fractures seem to reach a maximum in the early weeks of BCT,[63,64] but there is some disagreement.[65,66] A pilot study in BCT suggested that eliminating running in the third week of BCT might reduce the incidence of stress fractures.[67] However, another, more adequately controlled, study[68] investigated the effects on stress fractures of eliminating running during weeks 2, 3, or 4 of an 8-week BCT cycle. It found evidence that a rest from running reduced the incidence of stress fractures or other overuse injuries.

Multiple Interventions. A number of studies have examined the effects of introducing multiple training-related injury-prevention interventions into BCT and AIT environments. The problem with multiple interventions is the limited ability to determine the effectiveness of individual interventions and thus identify the most effective ones. However, multiple strategies may be successful because different individuals respond to different aspects of the program or because the interventions may have a synergistic effect. At a minimum, multiple intervention programs provide clues to effective strategies that can be investigated individually in subsequent studies.

A historical cohort study[69] of New Zealand recruit training examined the combined effect of three interventions: (1) no running in boots for the first 5 weeks of training, (2) gradual introduction of boots during runs, and (3) organized physical training in running shoes. In the preintervention cohort, 65% of recruits were injured, and in the postintervention cohort, 50% were injured ($P = .02$). Time on light duty and days off duty was also reduced in the postintervention group. It should be noted that sample sizes were small in this study (n = 159 in the control group, n = 78 in the intervention group). Studies in the US Army have shown that injury rates between training companies can vary more than 2-fold with no programmed intervention, whereas differences in injury rates between battalions tend to be more stable.[2]

A retrospective historical cohort study examined the effects of multiple interventions on pelvic stress fractures in female Australian recruits. The interventions were (*a*) reducing road-march speed from 7.5 to 5 km/h without reducing distance, (*b*) allowing women to march at their own stride length rather than marching in step, (*c*) encouraging marching and running in more widely spaced formations to aid in obstacle awareness, (*d*) conducting running on grass in preference to roads wherever possible, (*e*) substituting interval running for longer distance runs wherever possible, and (*f*) reducing the total running distance. The incidence of pelvic stress fractures was 11.2% in the preintervention cohort and 0.6% in the postintervention cohort ($P < .01$).[70]

Another retrospective historical cohort study investigated a second set of changes in Australian recruit training. The interventions were (*a*) cessation of running in formation and a 16-mile reduction in formation running distance; (*b*) introduction of interval training (400- and 800-m sprints) on grassy surfaces; (*c*) reduction in run test distance from 3 to 1.5 miles; (*d*) standardization of foot marches including control of march speed, progressive load increments, and a prohibition on running; and (*e*) introduction of running in water as a cross-training technique. Compared with the preintervention cohort, injury rates in the postintervention cohort decreased 46% ($P < .01$) for men and 35% ($P = .06$) for women. Medical discharges decreased 41% among men ($P < .01$) but unexpectedly rose 58% for women ($P = .01$).[71]

Two studies modified physical training in US Army BCT in an effort to reduce injuries. Both studies involved reduced running mileage, no stretching before exercise, a wide variety of exercises, and the gradual introduction of exercise stress (progressive overload). The physical training program was laid out in a day-to-day, exercise-to-exercise schedule so that exercise progression and overload were very prescriptive. In the first study,[15,24] an experimental group (n = 1,284) performed calisthenics; dumbbell exercises; movement drills (eg, running backwards, running sideways, running with leg cross-overs); interval training; long-distance running; and running in formation for 17 miles. A control group (n = 1,296) conducted the usual BCT physical training program, consisting of stretching, calisthenics, sit-up and push-up practice, and running in formation for 38 miles. At the end of the 9-week BCT cycle, men and women in the control group were, respectively, 1.5-fold (95% confidence interval [CI] = 1.0–2.1) and 1.4-fold (95% CI = 1.1–1.8) more likely to be injured than the men and women in the experimental group. There were no group differences in traumatic injuries. Army Physical Fitness Test (APFT) failures were lower in the experimental group than in the control group (1.6% vs 3.7%, $P < .01$).

US Army leadership expressed some concern about this new physical training program because of the cost and logistics associated with dumbbells and potential problems with some of the exercises. The leadership also thought that although the Army field manual on physical training[72] contained many of the necessary principles for enhancing fitness and reducing injuries, it inadequately presented how these principles should be applied in BCT. A new BCT physical training program was developed to take these considerations into account, and a second study was undertaken.[26] Again, the program was prescriptive. An experimental battalion (n = 829) that implemented the revised physical training program was compared with a control battalion (n = 1,138) that implemented a traditional BCT physical training program. At the end of the 9-week

BCT cycle, men and women in the control group were, respectively, 1.6-fold (95% CI = 1.2–2.0) and 1.5-fold (95% CI = 1.2–1.8) more likely to be injured compared with men and women in the experimental group. APFT failures were also lower in the experimental group than in the control group (1.7% vs 3.3%, $P = .03$).

A final US Army study[14,29] examined a multiple intervention program in ordnance AIT at APG. Four interventions made up the program: (1) modification of physical training, (2) cadre injury education on injury prevention, (3) a battalion injury surveillance system, and (4) a battalion injury control advisory committee that reviewed injury causes and rates and developed possible strategies to reduce injuries. The physical training program was almost identical to the one used in the first Army BCT physical training study (previously described).[24] At the end of the evaluation, men and women in the control group were, respectively, at 1.5-fold (95% CI = 1.2–1.8) and 1.6-fold (95% CI = 1.0–2.5) higher risk of injury compared with men and women in the experimental group. After adjustment for differences in initial scores, APFT scores did not differ between the groups. The multiple intervention program was successful in reducing injuries while maintaining improvements in physical fitness necessary to pass the APFT.

Equipment Modification Interventions

Equipment interventions tested in military populations include the use of special sock systems and antiperspirants to reduce the incidence of foot blisters; the use of shock-absorbing boot insoles, high-topped shoes, and shock-absorbent boots; and changes in training surfaces.

Sock Systems and Antiperspirants. Foot blisters are among the most common injuries experienced by marching soldiers and marines.[73–77] Blisters are caused by friction between the skin and sock. Sweating during physical activity increases friction and is likely to increase blister incidence.[78] Some studies suggest that reducing moisture around the foot through the use of special socks[79] or antiperspirants[80] will reduce the likelihood of foot blisters.

One investigation examined special sock systems used by three groups of marine recruits undergoing their 12 weeks of basic training. One group of recruits (the control group) wore the standard US military outer sock composed primarily of a wool and cotton blend. A second group (the liner group) wore a polyester liner sock inside the standard wool and cotton outer sock. The polyester sock presumably moved moisture away from the foot through a combination of metabolic heat and the inability of the polyester material to hold moisture (“wicking”). A third group (the liner + sock group) wore the same polyester liner sock as the liner group as well as a specially designed thick wool and polyester blend outer sock, which presumably assisted with the wicking action while reducing friction. At the conclusion of basic training, the liner + sock group had a lower overall incidence of blisters than the control group (40% vs 69%, $P < .01$). Both the liner and liner + sock groups had lower incidences of blisters and cellulitis resulting in limited duty compared with the control group (39%, 16%, and 17% in the control, liner, and liner + sock groups, respectively; $P < .01$).

Other studies have strongly suggested that eliminating sweat through the use of antiperspirants might reduce the incidence of foot blisters[80] if emollients were not included in the antiperspirant preparation.[81] A double-blind investigation examined foot blisters in US Military Academy cadets who used either a placebo or an antiperspirant preparation (a 20% solution of aluminum chloride hexahydrate in a denatured ethyl alcohol base). Cadets in basic training were asked to apply the preparations to their feet in the evening for 5 consecutive days before a 13-mile foot march. Cadets performed the march on a hot day, and their feet were examined for blisters both before and after the march. There was variable compliance with the 5-day application schedule. Nonetheless, when cadets who had used the preparations for at least 3 days before the march were counted, the antiperspirant group had a considerably lower blister incidence compared with the placebo (21% vs 48%, $P < .01$). However, 57% of those in the antiperspirant group reported experiencing irritant dermatitis compared with only 6% in the placebo group ($P < .01$). The irritant dermatitis problem was also cited in another study,[80] suggesting that this side effect needs to be addressed before this intervention can be widely recommended.

Insoles. Studies of the use of insoles in the boots of basic trainees have yielded mixed results. Investigations of polyurethane and Sorbothane (Sorbothane Inc, Kent, Ohio) insoles worn in the boots of US Marine Corps or US Army recruits during military training have shown no effect on stress fractures, lower extremity musculoskeletal injury rates, or sick call rates.[8,82,83] A study[84] that examined a polyurethane insole worn in the boots of Israeli basic trainees found a reduction in femoral stress fractures but no influence on tibial or metatarsal stress fractures. When the incidence of all types of stress fractures was combined, however, there was a significant reduction in incidence among the insole users.

Studies using neoprene insoles have also shown mixed results. Neoprene insoles in the boots of US Army basic trainees resulted in no effect on lower limb pain,[85] but another study of neoprene insoles in the boots of US Coast Guard recruits found a reduction in injuries related to shock and friction (eg, foot contusions, foot blisters).[86] In South African basic trainees, neoprene boot insoles were associated with a reduction in total overuse injuries and tibial stress fractures.[87] It should be noted that most, but not all,[86] of the studies finding negative results were conducted during basic training in the US military, whereas studies finding positive results were conducted during basic training in the Israeli and South African armed forces. Differences in training environments might influence the results. Future studies should (*a*) characterize the degree of shock absorbency, durability, and other important characteristics of insoles using objective measures[88]; and (*b*) use random assignment of insole conditions within training companies.

Training Shoes and Boots. A study conducted during Israeli infantry recruit training examined differences in injury rates between recruits wearing high-top basketball shoes and recruits wearing the standard lightweight infantry boot. The basketball shoes had leather uppers and ethylene vinyl acetate soles. Recruits training in the basketball shoes had a lower incidence of overuse foot injuries, but the overall incidence of overuse injuries was the same in each group.[89]

Another study[90] examined two groups of women participating in US Navy basic training wearing either the standard Navy boot or a boot with 32% greater shock-absorbing capability. The sole of the boot with greater shock absorbency was composed of polyurethane. Recruits in the shock-absorbing boot had fewer lower extremity injuries (7% vs 15%, $P < .01$), fewer podiatric visits (29% vs 38%, $P < .05$), and fewer severe stress fractures ($P < .01$).

Program Implementation and Program Monitoring

The next step in the injury-prevention process, program implementation, is a command responsibility. Program implementation is the critical step in the injury-prevention process, because it is where injury prevention is put into practice. Once intervention trials have been completed, effective interventions can be recommended to commanders. Only commanders can implement programs, because only commanders can decide how to integrate injury-prevention measures into their units while still accomplishing their primary missions. On occasion, commanders may make decisions to implement programs without intervention trials but rather based on experience or risk factor data alone. This is not an uncommon practice in injury epidemiology.[16]

Regardless of how or why an injury-reduction program is implemented, it is reasonable to examine whether or not the program is affecting injuries in the operational environment. The final step in the injury-control process is program monitoring. In the simplest case, program monitoring compares injury rates before a program was introduced with injury rates after the program was implemented. If commanders implement programs without intervention trials, these programs can still be monitored for effectiveness after the fact.

Modifications to the Basic Combat Training Physical Training Program

A successful program implementation was the recent introduction of the TRADOC Standardized Physical Training Program, a modified BCT physical training program. Two multiple intervention trials (discussed in the Physical Training Interventions section)[14,24] demonstrated the injury-reduction effectiveness of a prescriptive exercise program involving the gradual introduction of exercise stress (progressive overload), reduced running mileage, a greater variety of exercises, and no preexercise stretching. Based on findings from these studies and advocacy efforts by the US Army Physical Fitness School, the commander of the Army Accessions Command mandated on 12 February 2004 the new physical training program for all US Army BCT units.[91] Full implementation was accomplished by May 2004 when the Physical Fitness School completed drill sergeant training at the US Army's five basic training posts. Preliminary analysis from TRIR during the program phase is shown in Table 8-6. The data in the table suggest an approximate 23% reduction in injury rates across all BCT posts. Tracking injury rates, now that the program is fully implemented, will be the next step in the program monitoring process.

Preconditioning Before Basic Combat Training

Low levels of physical fitness have been shown to be associated with higher injury rates[2,7,11,12,21,30,34–36] and greater attrition[4] in BCT. These data suggest that increasing physical fitness before BCT might reduce injury risk during BCT. In 1998, new physical fitness criteria were established for entry into BCT at Fort Jackson[92] based on command experience and risk factor data. Fitness criteria had existed since 1987, but their only requirement for entry to BCT was 1 push-up for women and 13 push-ups for men.[93] In 1998 the Fort Jackson Training Center commander changed the entry test to a three-event evaluation including push-ups, sit-ups, and a 1-mile run. In October 1999, fitness standards for entry to BCT were mandated by TRADOC

TABLE 8-6

US ARMY INJURY RATES BEFORE (FEB–MAY 2003) AND DURING (FEB–MAY 2004) PHASE-IN OF TRADOC STANDARDIZED PHYSICAL TRAINING PROGRAM FOR BASIC COMBAT TRAINING

BCT Location	Phase*	Feb–May 2003 (Injuries/100 Recruits)	Feb–May 2004 (Injuries/100 Recruits)	Change from 2003 to 2004 (%)
Ft Benning, Ga	1/2	29.4/26.6	21.1/20.1	–28.2/–24.4
Ft Jackson, SC	1/2	24.4/23.3	17.0/16.2	–30.3/–30.5
Ft Knox, Ky	1/2	21.3/19.4	16.7/16.2	–21.6/–16.5
Ft Sill, Okla	1/2	25.0/21.1	19.4/14.1	–22.4/–33.2
Ft Leonard Wood, Mo	1/2	28.9/27.4	23.8/24.1	–17.6/–12.0
All posts†	1/2	25.8/23.6	19.6/18.1	–24.0/–23.3

*Phase 1 is BCT days 1–28; phase 2 is BCT days 29–63
†Calculations are made from raw data from all posts; thus, all data from all posts are combined and injury rates calculated from the entire data set
BCT: basic combat training
TRADOC: Army Training and Doctrine Command
Data source: June 2004 reports from US Army Center for Health Promotion and Preventive Medicine and TRADOC surgeons.

for all five locations where Army BCT was conducted[94] (shown in Table 8-7). Individuals who failed to meet the standard on any single test event entered the Fitness Training Unit (FTU), a specific training program that included running, weight training, push-up and sit-up improvement, road marching, and stretching. Once an FTU trainee met the fitness criteria, he or she could enter BCT. The program was monitored in 1998 at Fort Jackson by comparing low-fit FTU women who, after training, reached the same aerobic fitness level as women who met the fitness criteria on their first attempt. These two groups of women had similar injury incidence and graduation rates in BCT.[92]

In 2000 the FTU's name was changed to the Fitness Assessment Program (FAP). A 2003 study[26] evaluated the effectiveness of the FAP by examining three groups of recruits. A preconditioning (PC) group was composed of recruits who failed the test, trained in the FAP, and entered BCT after passing the test. A "no preconditioning" (NPC) group was composed of recruits who failed the test but entered BCT without going into the FAP. A "no need of preconditioning" (NNPC) group was composed of recruits who passed the test and directly entered BCT. At the end of the 9-week BCT cycle, the proportion of the NPC, PC, and NNPC groups who completed the BCT cycle were, respectively, 59%, 83%, and 87% for men ($P < .01$), and 52%, 69%, and 78% for women ($P < .01$). Compared with NNPC men, injury risk was 1.5-fold (95% CI = 1.0–2.2) and 1.7-fold (95% CI = 1.0–3.1) higher in PC and NPC men, respectively. Compared with NNPC women, injury risk was, respectively, 1.2-fold (95% CI = 0.9–1.6) and 1.5-fold (95% CI = 1.1–2.1) higher in PC and NPC women. This study showed that low-fit recruits who trained in the FAP before BCT had lower attrition and tended to have lower injury risk.

The FAP was eliminated in July 2004 when the US Army Accessions Command decided to have the physical fitness test administered by recruiters at the recruit's home station before induction. Recruiters will work with potential recruits to increase their physical fitness and self-esteem in an effort to further reduce BCT attrition. Recruits will not be allowed to leave their recruiting areas until they have demonstrated they can meet the criteria in Table 8-7. The effectiveness of this program modification has not been evaluated.

Changes in Training Surfaces

Some interventions designed to reduce injuries may actually cause an increase in injury rates. Such an event occurred at an obstacle course used during Australian recruit training. Rubber matting had been placed on the obstacle course in an effort to (*a*) improve shock absorption, (*b*) provide a durable and consistent surface for jump landings, and (*c*) reduce the incidence of ankle sprains and stress fractures. Routine injury surveillance by medical personnel detected an outbreak of anterior cruciate ligament (ACL) ruptures during training, and further investigation traced the ruptures to the obstacle course. Research suggested that ACL injuries were caused by a high coefficient of friction between the recruits' rubber-soled boots and the rubber matting on the course. A detailed analysis of ACL injuries showed that for an 18-month period before the matting was placed on the obstacle course, no ACL ruptures

TABLE 8-7

FITNESS CRITERIA TO ENTER BASIC COMBAT TRAINING

Event	Men	Women
Push-ups (repetitions)	13	3
Sit-ups (repetitions)	17	17
1-mile run (min)	8.5	10.5

Data source: Knapik JJ, Canham-Chervak M, Hoedebecke E, et al. The Fitness Training Unit in Basic Combat Training: Physical fitness, training outcomes, and injuries. *Mil Med*. 2001;166:356–361.

occurred. For a 20-month period when the matting was in place, 8 ACL ruptures were recorded. The matting was removed and replaced with raked 20-mm river pebbles. In the 12-month period after the matting was removed, no ACL injuries occurred. This investigation demonstrated the usefulness of routine injury surveillance and research for detecting and identifying the causes of injuries.[95,96] It also suggests that new interventions should be tested in the intervention step of the public health process before they are implemented.

Multiple Interventions

Multiple interventions were shown to be associated with an overall reduction in injuries at Fort Jackson during the period 1998 through 2000. During the latter part of 1998, the Fort Jackson Training Center commander increased the emphasis on reducing injury rates. The US Army Center for Health Promotion and Preventive Medicine established an injury-control coordinator position to provide state-of-the-art advice and material support for commanders and drill sergeants in reducing injury rates. Information from PTRPSS was routinely provided to battalion commanders so they could track and compare their injury rates with their previous cycles and other BCT battalions. All recruits were required to buy new running shoes before beginning BCT. Recruits who could not meet the newly established fitness criteria were trained until they could either meet the criteria or were discharged from service. Program monitoring from surveys (see Table 6-1) and PTRPSS (see Figure 6-4) suggested that these multiple actions were associated with reductions in injury rates during 1999 and 2000, and that the reduced injury rates continued into 2003.

SUMMARY

Using the public health model as a framework, this chapter reviewed the literature on primary injury prevention in IET. Primary prevention uses (1) surveillance and surveys to define the size of the injury problem, (2) research to identify causes and risk factors for injuries, (3) intervention trials to determine what strategies work to prevent injuries, (4) program implementation to introduce injury-prevention measures into IET environments, and (5) program monitoring to determine the effectiveness of programs that have been implemented in operational environments.

Surveillance tools that have been developed for IET environments include DMSS IIRs, TRIR, PTRPSS, and APGIISS. The fact that 5- to 10-fold more limited duty days result from injuries than from illnesses emphasizes the importance of injury prevention in BCT.

Research shows that extrinsic risk factors in BCT include high running mileage, the training company, older running shoes, and the summer season. Intrinsic risk factors in BCT have been researched extensively and include female gender, high foot arches, knee Q angle greater than 15 degrees, genu valgum, past ankle sprains, low aerobic fitness, low muscular endurance, high and low extremes of flexibility, prior low levels of physical activity, prior cigarette smoking, and older age. Multivariate analyses have shown that cigarette smoking before BCT, low levels of aerobic fitness, and low levels of physical activity before BCT are independent injury risk factors. The few studies on risk factors in AIT indicate that about 53% to 63% of ordnance school injuries are related to physical training and sports. Risk factors in ordnance AIT include lower rank; self-reported prior injury; prior cigarette smoking; and lower performance on push-ups, sit-ups, or 2-mile runs. Among female medics in AIT, risk factors included higher body weight, older age, and a break in service between BCT and AIT.

Intervention trials in BCT indicate that reducing the amount of running in recruit training considerably reduces injuries with little or no effect on aerobic fitness. The common practice of stretching before exercise does not appear to influence injury rates. Multiple intervention programs make it difficult to partition out the most effective interventions for reducing injuries. However, the two studies done on BCT physical training demonstrated that injuries could be considerably reduced and fitness improvement maintained by combining prior knowledge of successful and unsuccessful interventions (reduced running mileage and stretching before exercise) with (*a*) a well-designed physical training program involving a wide variety of exercises and (*b*) adherence to the exercise principle of progressive overload. The likelihood of foot blisters can be reduced by the use of special sock systems. Boots with increased shock absorbency reduced lower extremity injuries, podiatric visits, and severe stress fractures in US Navy basic training. Other promising interventions that require further investigation include the use of antiperspirants to reduce foot blisters and the use of special insoles in footwear.

Several programs have been implemented and monitored in BCT. The TRADOC Standardized Physical Training Program involves the gradual introduction of exercise stress (progressive overload), reduced running mileage, a greater variety of exercises, and no pre-exercise stretching. Preliminary monitoring shows that this program is associated with a reduction in BCT injuries. Requiring low-fit recruits to meet a minimum physical fitness standard before entry into BCT was shown to reduce attrition and tended to lower injury rates. A reduction in injuries at Fort Jackson was shown to be associated with a multiple intervention program from 1998 through 2000. The interventions included increasing emphasis on injury reduction, supplying injury-control education and support by a full-time injury control coordinator, providing injury surveillance information (eg, PTRPSS) to commanders, requiring minimum fitness standards for entry to BCT, and requiring that all trainees buy new shoes before entering BCT.

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