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Physical Training Injuries and Interventions for Military Recruits

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ABSTRACT Low physical fitness levels are associated with increased musculoskeletal injury risk and attrition among military recruits. The authors review physical fitness trends, injury risk factors, and Department of the Army initiatives to address recruit fitness, injuries, and attrition. Initiatives include the Fitness Assessment Program, which reduced injury risk and attrition among low-fit trainees, and the Assessment of Recruit Motivation and Strength, which enabled the Army to enlist individuals exceeding body composition accession standards without increasing attrition. Physical Readiness Training (PRT) is the Army's primary initiative to address training-related injuries and attrition. PRT's inherent injury control and exercise progression components are designed to address low fitness levels across entry-level training. PRT has been shown to decrease injury rates, but low-fit recruits remain at increased risk regardless of program design. The authors recommend resuming pre-enlistment fitness screening and fitness programming before low-fit recruits begin entry-level training. The decision whether to screen for fitness before beginning entry-level training could be based upon the existing recruiting environment in terms of applicant supply and the demand for recruits. However, the Army should anticipate increased injury and attrition rates when discontinuing screening and/or fitness programming for low-fit recruits.

INTRODUCTION

Initial Military Training (IMT)-related musculoskeletal injuries significantly impact the Department of the Army; approximately 25% of male and 50% of female recruits sustain one or more injuries during Basic Combat Training (BCT).[1] These injuries consistently account for more than 80% of disability-related medical discharges among first-year recruits.[2,3] The associated cost during fiscal year (FY) 2005 was estimated at $57,500 per discharged recruit.[4] Assembled by the National Academies, the National Research Council Committee on the Youth Population and Military Recruitment has highlighted entry-level training-related injuries as "the single most significant medical impediment to military readiness."[5]

The authors will review the impact of physical fitness on musculoskeletal injury risk and provide a rationale for resuming pre-enlistment fitness screening and fitness programming before low-fit recruits begin BCT. The focus of this review is overuse injuries, which account for 70 to 80% of IMT-related musculoskeletal injuries and thus more than half of all disability discharges among first-year recruits.[2,3,6,7] Unless noted, the authors will use the term "training-related injury" when discussing IMT-related overuse musculoskeletal injuries.

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PHYSICAL FITNESS AND TRAINING-RELATED INJURY RISK

Researchers have identified multiple risk factors for training-related injury (Table I). Physical fitness figures prominently among these factors. Fitness components include aerobic endurance, muscular endurance, muscular strength, body composition, flexibility, mobility, and dynamic balance.[10,11] Each component impacts risk to a varying degree.

Aerobic fitness is typically assessed by timed running performance or maximal or peak oxygen consumption (VO_{2max} or VO_{2peak}). Low aerobic fitness is the component most strongly and consistently associated with increased injury risk.[8,12] Muscular endurance measures ability to repeatedly move a load. Low muscular endurance has consistently been associated with increased risk, although less so than aerobic fitness.[13,14] Muscular strength measures maximal force generation capability. The association between strength and injury risk is inconsistent; strength asymmetries (left-to-right-side differences) have been associated with increased risk.[13–16]

Body composition or body fatness can be directly estimated by hydrostatic weighing, dual-energy X-ray absorptiometry, bioelectrical impedance, skinfold thickness, and circumferential measures. The Army uses specified anatomic circumferential measurements to estimate body fat percentage. Body mass index (BMI) frequently serves as a proxy or indirect measure to predict body composition. BMI is a weight–height ratio expressed as weight in kilograms divided by height in meters squared (kg/m^2); it does not distinguish between fat and fat-free tissues such as bone and muscle. BMI generally serves as a fair proxy for body fat, excluding those with high muscle mass.

The association between BMI and injury risk is inconsistent.[13] A bimodal relationship may exist; high and low extremes of BMI appear to be at increased risk.[14,17] The

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TABLE I. Risk Factors for Training-Related Injury[1,5,8,9]

Demographic Factors
Female Gender[a]
Caucasian Race
Age > 24 years
Anatomical Factors
Rigid, High Arched Foot
Flexible, flat foot[b]
Knee Q Angle > 15 degrees
Genu Valgus
Decreased Ankle Dorsiflexion
Increased Rearfoot Inversion
Physical Fitness Factors
Low Aerobic Fitness
Extremes of Flexibility
Low Muscular Endurance
Low Muscular Strength
Extremes of BMI and Composition
Behavioral Factors
Cigarette Smoking
Low Levels of Physical Activity/Exercise/Running Before IMT
Medical Factors
History of Musculoskeletal Injury (esp. Ankle Sprain)
—

[a]Conflicting reports concerning whether female risk is equal to that of males when matched for aerobic fitness.
[b]Conflicting reports concerning association with training-related injury.

Accession Medical Standards Analysis & Research Activity (AMSARA), Walter Reed Army Institute of Research has identified enlistees with BMI < 18 and those with BMI > 33 as being at greatest risk for medical discharge.[18] AMSARA has recommended that body composition interventions target underweight and obese Soldiers.[18]

More important than body composition alone is the interaction between BMI and fitness level with injury risk. Recruits with both low aerobic fitness and low BMI appear to be at greatest risk.[19] Low BMI could indicate lesser muscle or bone mass; underweight individuals may lack the strength required for strenuous tasks including standard load bearing.[19,20]

Training Circular 3-22.20 (Army Physical Readiness Training) defines mobility as "movement proficiency" or functional strength and endurance application.[11] Fundamental movement pattern components include dynamic balance, strength, and flexibility.[16] Flexibility extremes and asymmetries appear to increase injury risk.[8,16,21] Researchers have associated Functional Movement Screen performance deficits with increased risk (although not overuse injury risk) among professional football players and Marine officer candidates.[16,22] Similarly, decreased or asymmetrical balance per Star Excursion Balance Test performance has been associated with increased lower extremity injury risk among basketball players.[23]

CIVILIAN AND MILITARY FITNESS TRENDS

Today's youth appear less prepared for entry-level training than their predecessors given the close relationship between timed running performance and IMT aerobic fitness requirements. Pate has reported low aerobic fitness levels among one-third of American youths aged 12 through 19.[24] Other reports concerning aerobic fitness trends among American youth are conflicting, with fitness levels remaining stable or decreasing for adolescent males and females from the late 1930s onward.[5,25]

Knapik found no change in male recruits' aerobic fitness (VO_{2max}) and slightly improved female recruit fitness between 1975 and 1998.[26] In what might appear contradictory, recruits' timed running performances slowed between 1984 and 2003.[26] Similarly, running performances have slowed among males and females up to high school age across time.[26] Running performance is affected by factors other than VO_{2max}, including motivation, pacing ability, environmental issues, running economy (energy expenditure when running at a given speed), and anaerobic capacity.[24,26,27]

Few studies address muscular strength or endurance trends. The President's Council on Physical Fitness and Sports reported that American youths' upper body strength and endurance were consistently poor between 1965 and 1985.[28] Limited data indicate that male and female recruits' muscular strength increased between 1978 and 1998, whereas muscular endurance remained unchanged between 1984 and 2003.[26]

Steadily increasing failure rates on the Army's 1-1-1 physical assessment test suggest a decline in recruit fitness. The 1-1-1 test consisted of timed 1-minute push-up, 1-minute sit-up, and 1-mile run events (Table II). As per Knapik's findings and unpublished data, it appears that male recruit first-time failure rates increased from 4% in 2003 to 34% in 2009, whereas female failures increased from 10 to 47%[29] (Table III). Note that testing procedures followed through 2003 were not identical to procedures followed in subsequent years.

The Centers for Disease Control has reported increased obesity (defined as BMI > 30) among Americans across the past 2 decades.[30] Obesity prevalence among American children and adults (excluding the heaviest male youths) has apparently stabilized across the past 5 to 10 years.[31–33] Nevertheless, excessive weight/body fat remains the primary reason listed for recruit medical disqualifications, accounting for 16 to 17% of disqualifications.[3] Further, the prevalence of active duty military personnel diagnosed as being overweight or obese more than doubled from 1998 to 2008.[34]

TABLE II. U.S. Army's 1-1-1 Physical Assessment Test (Minimum Standards)[28]

Event	Male	Female
Push-Ups (Repetitions)	13	3
Sit-Ups (Repetitions)	17	17
1 Mile Run (Minutes)	8.5	10.5

TABLE III. 1-1-1 Test Failures at Fort Jackson, South Carolina: Absolute Numbers (When Available) and Percentages by Year[28]

	January to August 1998	FY 2000	FY 2001	FY 2002	FY 2003	FY 2006[a]	FY 2009[a]	FY 2010[a]
Male	7%	4%	4%	5%	858 (4%)	3746 (22%)	3666 (37%)	5785 (40%)
Female	24%	12%	13%	15%	1580 (10%)	3734 (40%)	2587 (52%)	3269 (54%)

[a]K.W. Williams, personal communication.

CURRENT STATUS OF PHYSICAL FITNESS SCREENING

Despite the associations between physical fitness and injury risk, only the Marines and Navy screen recruits' pre-enlistment fitness levels. Marine recruits must pass a standardized Initial Strength Test (IST) administered by recruiters before proceeding to Basic Training (Table IV). Recruits must again pass the IST upon arrival at Basic Training. IST failures are assigned to a Physical Conditioning Platoon (PCP) to improve fitness before beginning Basic Training. PCP program metrics are shown in Table V. Significant variability was observed from FY 2009 to FY 2011. Although multifactorial in nature, variability may be partly due to an improved recruiting environment enabling the Marines to be more selective of applicants (B.J. McGuire, personal communication).

Beginning in 1999, the Army's Training and Doctrine Command administered the 1-1-1 test to all recruits before beginning IMT. Recruits who failed were assigned to a Fitness Training Unit (FTU), later redesignated as Fitness Assessment Program (FAP). These individuals remained within the FTU/FAP until passing the 1-1-1 test and progressing to BCT. The FAP reduced injury risk and attrition, enabling the Army to retain approximately 516 recruits and save over $14 million annually in the early 2000s.[29,35,36]

The Army eventually discontinued 1-1-1 testing and automatic assignment to the FTU/FAP (currently designated as FTU). FTU assignment is limited to recruits who repeatedly fail the Army Physical Fitness Test (APFT) despite completing all other BCT requirements. As of July 2011, approximately 93% of recruits in the FTU at Fort Jackson achieved BCT standards for the APFT (50 points per event) after performing Physical Readiness Training (PRT) for 2 to 4 weeks (M. Reed, personal communication, 2011).

Recruits assigned to the FTU perform PRT for 1.5 to 2 hours daily. Injured FTU recruits perform modified PRT and rehabilitation exercises prescribed by a physical therapist to enhance fitness while promoting soft tissue healing. Overall, FTU recruits exercise for 12 hours weekly, with 8 hours being PRT specific. In comparison, recruits in the training brigades perform PRT for not more than 1 hour daily or 6 hours weekly. When not exercising, FTU recruits perform light administrative duties or rest.

From 2005 until 2009, the Army conducted an Assessment of Recruit Motivation and Strength (ARMS). ARMS consisted of a modified Harvard step test and 1-minute push-up test. An incremental dynamic lift test was discontinued in 2006 because of high pass rates and assessment time considerations. Initially, all Army applicants underwent ARMS testing at six Military Entrance Processing stations. Attrition rates were significantly higher among those who failed ARMS testing.[4] ARMS subsequently targeted recruits who exceeded weight-for-height and body composition accession standards per anatomic circumferential measurements.[37] Recruits who passed the ARMS test received body composition enlistment waivers. They were found to be at increased risk of injury but not attrition.[38] RAND reported that the ARMS program accessed an additional 3,690 recruits in FY 2007 at an estimated per-recruit cost of $163.[39] The Army discontinued ARMS testing in September 2009 because of an improved recruiting environment.

ONGOING INJURY CONTROL INITIATIVES

The primary initiative to address training-related injuries and attrition is the PRT program.[11] PRT's inherent injury control and exercise progression components are designed to address low fitness levels across IMT. A key PRT component is decreased running frequency and duration, with greater emphasis on intensity to compensate for decreased volume. Reduced volume is based upon findings that limiting slower

TABLE IV. U.S. Marine Corps' IST (Minimum Standards)

Event	Male	Female
Pull Ups (Repetitions)	2	NA
Flexed-Arm Hang (Seconds)	NA	12
Crunches in 2 Minutes (Repetitions)	44	44
1.5 Mile Run (Minutes)	13.5	15.0

Physical Training, Marine Corps Recruit Depot, Parris Island. Available at http://www.mcrdpi.usmc.mil/training/physical.asp; accessed January 13, 2012.

TABLE V. U.S. Marine Corps' PCP Enrollment at Parris Island, South Carolina: Length of Stay and Return to Training

	FY 2009	FY 2010	FY 2011
Total Accessions	16,570 (M) 2,595 (F)	15,294 (M) 2,673 (F)	16,027 (M) 2,491 (F)
Recruits Assigned to PCP	391 (M) 255 (F)	61 (M) 103 (F)	54 (M) 54 (F)
PCP Assignments as % of Total Accessions	2.4% (M) 9.8% (F)	0.4% (M) 3.9% (F)	0.3% (M) 2.2% (F)
Average Length of Stay	59 Days (M) 42 Days (F)	17 Days (M) 20 Days (F)	23 Days (M) 25 Days (F)
Recruits Returned to Training	86% (M) 69% (F)	64% (M) 58% (F)	73% (M) 59% (F)

T.L. Bockelman, personal communication.

recruits' mileage to approximately 25 miles across a 9 week BCT minimizes risk while sufficiently improving performance to pass the APFT.[40] Across three studies, the adjusted risk of injury was 1.5 to 1.8 times greater among Soldiers performing traditional physical training when compared with Soldiers performing PRT.[41]

The Army has instituted additional initiatives to reduce injury risk and improve performance within the IMT and operational environments. The Initial Entry Training Soldier Athlete Initiative introduces a musculoskeletal action team seeking to determine the best combination of health care and fitness professionals for injury prevention, performance optimization, and musculoskeletal rehabilitation in IMT. At the operational level, the Military Power, Performance, and Prevention (MP3) trial promotes automated technology to more efficiently perform a battery of fitness assessments (including Functional Movement Screen and Y-balance performance) on more than 1,750 Soldiers. The MP3 trial's primary purpose is to determine which functional assessments are predictive of injury risk at the operational level. Should the MP3 trial achieve this purpose, further research could evaluate whether these functional assessments are predictive of injury risk during IMT (T.L. Pendergrass and D.S. Teyhen, personal communication).

RECOMMENDED INTERVENTIONS

Disagreement exists concerning preaccession fitness screening. Describing Basic Training as an "expensive screening function," the National Research Council recommends preaccession testing for all Services.[5] In contrast, the Joint Services Physical Training Injury Prevention Work Group, chartered by the Defense Safety Oversight Council, found insufficient evidence to recommend pre-Basic Training fitness assessment and programming for the least-fit recruits.[42]

The authors recommend resuming 1-1-1 testing at recruiting stations for all recruits and ARMS testing at Military Entrance Processing stations for recruits exceeding body composition accession standards. One could defer recruits failing 1-1-1 or ARMS testing, provide training guidance, and retest in 8 to 12 weeks. A pre-IMT fitness program and standardized fitness guide address this need.[43,44]

Low-fit recruits could be placed in Delayed Entry Program-type status, with enlistment contingent upon passing the retest.[5] Eight to 12 weeks of training should suffice for fitness improvement; greatest aerobic and strength gains typically occur during the first 2 to 3 months after beginning exercise.[45,46] Requiring recruits to meet minimum pre-enlistment fitness standards could screen out individuals who fail to respond or lack the motivation to adhere to an exercise program. Screening could positively influence injury and attrition rates; physical fitness and motivation levels have been associated with attrition during IMT.[4]

The authors also recommend that recruits again undergo 1-1-1 testing upon arrival at BCT. Although this may seem redundant, the Marines' experience with recruits passing the recruiting station IST, but subsequently failing the Basic Training IST highlights the potential benefit. Recruits who fail could train per PRT principles within the FTU until passing a retest.

Delaying 1-1-1 testing until arrival at BCT and subsequent FTU assignment for low-fit recruits is a less desirable alternative to testing at both the recruiting station and BCT. This option would enable larger recruiting pools and still provide fitness programming to low-fit recruits before beginning BCT. However, the cost associated with accessing recruits who are subsequently discharged for repeated 1-1-1 test failures despite FTU assignment is a trade-off with this alternative.

The authors do not recommend resuming gender-separate physical training during BCT. The Army has maintained integrated physical training since 1995, with recruits separated into ability-based running groups. The integrated approach is supported by findings that males and females are at relatively equal risk for injury when matched for aerobic fitness.[8] Integrated training is also supported by Knapik's report in 1999 that female recruits' injury incidence relative to their male counterparts remained consistent despite switching from gender-separate to integrated training.[47]

However, gender-separate training remains an option should PRT and ability-based running groups not sufficiently address female injury and attrition rates. Athletic women may still be at slightly greater risk for stress fractures when compared with male athletes of relatively similar fitness levels.[48] Also, there are trends of increased injury risk among female recruits with lesser load carrying and dynamic lifting capabilities.[7] The National Research Council has questioned whether gender-based anatomical and physiological differences place female recruits at increased risk regardless of injury prevention and fitness-based interventions.[5]

CONCLUSIONS

Training-related injuries negatively impact the Army. Low (particularly aerobic) fitness levels among recruits are associated with increased risk for injury and attrition. PRT programming has been shown to decrease injury rates, but low-fit recruits remain at increased risk regardless of program design.

The authors recommend pre-enlistment fitness screening whenever possible. Delaying enlistment of low-fit recruits or immediately placing them in FTU-based programs until they met minimal standards would likely decrease the incidence of injuries. Further, pre-enlistment ARMS testing would enable the Army to screen in fit and motivated recruits who exceed weight-for-height and body composition accession standards.

The decision whether to screen for fitness before beginning BCT could be based upon the existing recruiting environment. The Army could screen out low-fit recruits during relatively strong recruiting periods. It could screen in fit and motivated recruits that exceed body composition accession standards via ARMS testing during lean recruiting periods. It could also provide FTU-based fitness programming to low-fit recruits before beginning BCT during lean recruiting periods. The Army should anticipate increased injuries and attrition when discontinuing screening and/or fitness programming for low-fit recruits.

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