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

USACHPPM

# GUIDANCE FOR ABILITY GROUP RUN SPEEDS AND DISTANCES IN BASIC COMBAT TRAINING

**USACHPPM PROJECT NO. 12-HF-5772A-03**


**US Army Center for Health Promotion and Preventive Medicine**
**Aberdeen Proving Ground, MD**

**US Army Physical Fitness School**
**Ft Benning, GA**

**US Army Research Institute of Environmental Medicine**
**Natick, MA**


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

*The lineage of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) 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 who 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.*

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13. ABSTRACT *(Maximum 200 words)*
During the first few days of Basic Combat Training (BCT), new recruits take an initial assessment run and they are ranked from fast to slow. Four roughly equally sized "ability groups" are established from these rankings and recruits run together in these groups for their aerobic training. There is no formal guidance on how fast or how far these ability groups should run. This paper provides this guidance and a rationale for systematically progressing ability group runs. The major considerations in the development of the guidance were 1) minimizing injuries, 2) the initial fitness level (maximum oxygen uptake or VO2max) of recruits, 3) improvements in run times during BCT, 4) running speeds of the slower individuals in each ability group 5) running speeds that must be achieved to "pass" the 2-mile run in BCT, 6) the gender composition of the ability groups, and 7) recommendations from the trainers. Data were analyzed from 3 databases that contained a total of 16,716 men and 11,600 women. Four steps were used in the analyses: 1) establishment of representative ability groups, 2) determination of initial (starting) run speeds, 3) determination of changes in run speeds and estimated VO2max during BCT, 4) establishment of run speeds and distances for the duration of BCT. Efforts were made to 1) keep the running speeds between 70 to 83% of the estimated VO2max for all ability groups in consonance with recommendations from the American College of Sports Medicine 2) consider the 2-mile running pace of the slower individuals in each ability group, and 3) keep the total running distance for the two slower ability groups below a total of 25 miles. The paper presents a chart that provides speeds and distances for each ability group at each week of BCT. Pacing charts are also provided that show the time at each ¼-mile interval necessary to achieve the pace. Using the recommended speeds and distances should allow trainees to improve their aerobic fitness, pass the APFT, and minimize injuries that result in lost training time and lower fitness levels.

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## Executive Summary

GUIDANCE FOR ABILITY GROUP RUN SPEEDS
AND DISTANCES IN BASIC COMBAT TRAINING
USACHPPM Project Number 12-HF-5772A-03

**1. INTRODUCTION.** Running is one of the major means of improving the aerobic fitness of new recruits in Basic Combat Training (BCT). Because recruits arrive with a wide range of fitness levels they perform running in "ability groups". Ability groups are formed on the basis of an initial run test after which recruits are ranked from fast to slow. Four roughly equally sized groups are established and trainees run together in these groups for aerobic training. While determining ability groups is relatively easy, there is no formal guidance on the speeds or distances that these groups should run to improve aerobic fitness. This report presents this guidance and the rationale for it.

**2. CONSIDERATIONS IN DEVELOPMENT OF RUN SPEED AND DISTANCE GUIDANCE.** There were seven major considerations. The first consideration was reducing injuries. The literature suggests that limiting total running distance to about 25 miles during BCT will minimize injuries while producing the desired improvements in fitness. The second consideration was the initial fitness level of recruits. This was determined from a previous study that collected $VO_2$max data on a group of new recruits. $VO_2$max is the highest rate at which oxygen can be taken up and used by the body. Oxygen uptake ($VO_2$) is linked to the rate at which the body can produce energy and thus, the rate at which long-term physical activity can be performed. $VO_2$max is a measure of aerobic fitness for these reasons. The third consideration in the development of run speeds and distances was the improvements in aerobic endurance (run time) that normally occur during BCT. This was obtained by examining biweekly improvements in 2-mile run times from three historical databases. The fourth consideration was the running paces of slower individuals in each ability group. The frequency distribution of the biweekly 2-mile runs on the Army Physical Fitness Test (APFT) was used to determine the pace of the slower individuals in each ability group. The fifth consideration was the run time that trainees must achieve to "pass" the 2-mile run on the APFT. In the youngest age group (comprising about 75% of trainees), men and women must run 16.6 min and 19.7 minutes, respectively, so the run speed guidance was established to attain these speeds before the final APFT was administered. The sixth consideration was the gender composition of the ability groups. Women comprise the majority of the slowest group with a mix of men and women in the second slowest group. Thus, the female passing rate was targeted for the slowest group and the male passing speed for the second slowest ability group. This also requires men to move out of the slowest ability group as soon as possible. The seventh consideration was the recommendations from the trainers. The primary recommendations were to allow enough distance and speed to "challenge" the two fastest ability groups and to assure the greatest number of trainees passed the test by the seventh week of training when the final APFT was administered.

## 3. METHODS.

a. Three databases were used in these analyses. These databases contained 2-mile run times on a total of 16,716 male and 11,600 female basic trainees. Two databases contained biweekly 2-mile run times, while the third database contained directly measured $VO_2$max data (uphill running protocol) in addition to 2-mile run times.

b. Four steps were used in the analyses. The first step was to establish representative ability groups. Two-mile run times from the 3 databases were separated into four equally sized ability groups and compared. The second step was to determine initial (starting) run speeds. The average $VO_2$max of all individuals in each of the four ability groups was calculated. Initial running speeds were established between 70% and 83% $VO_2$max consistent with the recommendation of the American College of Sports Medicine to improve or maintain aerobic fitness. To calculate the running speed equivalent to a particular $VO_2$ the following formula was used:

$$\text{Speed (min/mile)} = \frac{1\text{kcal}}{\text{kg*km}} \times \frac{1\text{ km}}{0.62\text{ mile}} \times \frac{1000\text{mL}O_2}{4.85\text{ kcal}} \times \frac{1}{VO_2\ (\text{mL}O_2/\text{kg*min})} \quad \text{[equation1]}$$

The third step was to determine changes in aerobic endurance and estimated $VO_2$max during BCT. The average changes in 2-mile run times in the ability groups during the course of BCT were determined in the three databases. A regression equation was calculated to predict $VO_2$max from 2-mile run times (r=0.69, SEE=6.1 mL/kg/min):

$$\text{Estimated } VO_2\text{max} = 75.00 - 1.55 * (\text{2-mile run time}) \quad \text{[equation 2]}$$

The changes in 2-mile run times at Weeks 3, 5 and 7 were used to calculate the changes in the estimated $VO_2$max. The fourth step was to establish run speeds and distances for the duration of BCT. Speeds were determined from Equation 1 using the run data at Weeks 3, 5, and 7. Efforts were made to keep the ability groups in the 70-83% $VO_2$max range based on the new estimated $VO_2$max values. Additional considerations were: the 2-mile running speed pace of the slower individuals in each ability group, recommendations from trainers, and keeping the pace to the nearest 15 sec/mile. Run distances were progressively and systematically increased while attempting to keep the total running distances of the two slower ability groups at or below about 25 miles.

**4. RESULTS.** Initial 2-mile run time ranges for ability groups A, B, C, and D were 9.8 to 16.4, 16.5 to 18.7, 18.8 to 21.5, and 21.6 to 33.6 min, respectively. Recruits who performed the $VO_2$max test appeared to be representative of the entire population of recruits in terms of their 2-mile run times. When the sample who took the $VO_2$max test were compared to all recruits over a 1-year period, the initial 2-mile run times were almost identical and the changes in 2-mile run times were very similar. The Table below shows the recommended run speed and distance using the considerations described above.

| Training Week | Ability Group | Distance (miles) | Pace (min/mile) | Total Run Time (min) | Initial %$VO_2$max | Adjusted %$VO_2$max[a] |
|---|---|---|---|---|---|---|
| 1 | A (fast) | 2.0 | 8.0 | 16 | 78 | 78 |
| | B | 1.7 | 9.0 | 15 | 79 | 79 |
| | C | 1.0 | 10.5 | 10 | 75 | 75 |
| | D (slow) | 0.8 | 12.0 | 10 | 72 | 72 |
| 2 | A | 2.0 | 7.5 | 15 | 83 | 83 |
| | B | 1.8 | 8.5 | 15 | 83 | 83 |
| | C | 1.2 | 10.0 | 12 | 79 | 79 |
| | D | 1.1 | 11.0 | 12 | 78 | 78 |
| 3 | A | 2.7 | 7.5 | 20 | 80 | 82 |
| | B | 2.4 | 8.5 | 20 | 84 | 80 |
| | C | 1.4 | 9.5 | 14 | 83 | 77 |
| | D | 1.3 | 10.5 | 14 | 82 | 72 |
| 4 | A | 2.7 | 7.5 | 20 | 83 | 82 |
| | B | 2.4 | 8.5 | 20 | 84 | 80 |
| | C | 1.7 | 9.5 | 16 | 83 | 77 |
| | D | 1.6 | 10.0 | 16 | 86 | 76 |
| 5 | A | 2.8 | 7.25 | 20 | 88 | 84 |
| | B | 2.5 | 8.0 | 20 | 89 | 83 |
| | C | 2.0 | 9.0 | 18 | 88 | 79 |
| | D | 1.9 | 10.0 | 18 | 86 | 73 |
| 6 | A | 3.4 | 7.25 | 25 | 86 | 84 |
| | B | 3.1 | 8.0 | 25 | 89 | 83 |
| | C | 2.4 | 8.5 | 20 | 93 | 84 |
| | D | 2.1 | 9.5 | 20 | 90 | 77 |
| 7 | A | 3.4 | 7.25 | 25 | 86 | 83 |
| | B | 3.1 | 8.0 | 25 | 92 | 82 |
| | C | 2.4 | 8.25 | 20 | 96 | 85 |
| | D | 2.1 | 9.5 | 20 | 90 | 74 |
| 8/9 | A | 4.1 | 7.25 | 30 | 86 | 83 |
| | B | 3.8 | 8.0 | 30 | 92 | 82 |
| | C | 2.4 | 8.25 | 20 | 96 | 85 |
| | D | 2.2 | 9.0 | 20 | 95 | 78 |

[a]Considers changes in estimated $VO_2$max with training

**5. DISCUSSION.** The present study developed guidance for ability group running speeds and distances based on both actual data and a wide variety of considerations. Data included 2-mile run times and directly measured $VO_2$max data gathered from samples of men and women in basic training at Ft Jackson South Carolina. Consideration was given to initial fitness, changes in fitness, the run speeds of slower individuals in each ability group, assuring training intensities sufficient to pass the run portion of the APFT, and the recommendations of the trainers. Running distance was based on minimizing injuries in the two slower ability groups while assuring trainees ran the 2-mile distance before the final APFT at Week 7 of BCT. Using the recommended speeds and distances should allow trainees to improve their aerobic fitness, pass the APFT, and minimize injuries that result in lost training time and lower fitness levels.

Guidance for Ability Group Run Speeds and Distances in Basic Combat Training
USACHPPM Project Number 12-HF-5772A-03

**1. REFERENCES.** Appendix A contains the references used in this report.

**2. INTRODUCTION.** One of the major goals of Basic Combat Training (BCT) is to improve the aerobic fitness of new recruits. Running and interval training are the major training activities whereby this goal is achieved. A key challenge in improving aerobic fitness is the wide variety of initial fitness levels of new recruits (1,2,3). Running too slow will cause higher fit recruits to lose aerobic fitness to an excessive extent. Running too fast will cause low fit recruits to drop out of the run or become injured so they actually receive less training. While the most appropriate solution may be to allow recruits to train individually, this is not possible or practical. Drill sergeants must supervise the trainees at all times and there are a limited number of drill sergeants assigned to a BCT company. Many recruits are not familiar with exercise intensities necessary to improve aerobic fitness and they may run too fast or too slow if allowed to train on their own.

a. Since at least 1985 (4) the challenge of different initial fitness levels has been overcome by assigning recruits to ability groups. Ability groups are composed of recruits with similar run performance capabilities indicative of similar aerobic fitness levels. Ability groups are formed on the basis of an initial run test usually performed within 1 to 3 days after starting BCT. After the run, recruits are ranked from fast to slow and four roughly equal groups are established. These four groups run at different speeds for aerobic training under the supervision of a drill sergeant. Individual soldiers who develop the capability to run at speeds faster than the ability group to which they are initially assigned can move into a faster ability group.

b. Establishing ability groups is relatively easy. However, after recruits are assigned to ability groups for running there is no formal guidance on the speeds or distances for these groups to optimally improve aerobic fitness. Trainers typically run at speeds and distances that are comfortable for them or at speeds and distances they know the ability groups can accomplish based on their past experience.

c. LTG Cavin, Commander of the US Army Accessions Command, recently mandated that physical training (PT) would be standardized for all of BCT. The US Army Physical Fitness School (USAPFS) was tasked to develop this standardized PT program. As part of this standardization, the USAPFS worked with the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) and the U.S. Army Research Institute of Environmental Medicine (USARIEM) to develop guidance for ability group running speeds and distances. This report presents this guidance and the rationale for it. The paper is organized to:

a) Review background literature on the energy cost of running and the relationship between running speeds and improvements in aerobic fitness;

b) Provide the considerations in the development of the running speeds and distances for PT in BCT;

c) Describe the analyses used in developing the running speeds; and

d) Provide the specific running speeds and distances for each ability group as part of the TRADOC Standardized Physical Training Program for BCT.

## 3. BACKGROUND LITERATURE.

### a. Energy Cost of Running

(1) The energy cost of running is a constant once the weight of the individual is taken into account. This energy cost is 0.73 kilocalories (kcals) per pound of body weight per mile run or 1 kcal per kg body weight per km run (5). An average male trainee who weighs 166 lbs (6,7) will expend 121 kcals/mile (0.73 kcals/lb/mile X 166 lbs). As running speed increases the total energy cost of running does not change but the *rate* of energy expenditure does increase. For example, if an average 166 lb trainee completes a 1-mile run in 6 minutes, he or she expends energy at a rate of 20.2 kcals/min (0.73 kcals/lb/mile X 166 lbs X 1 mile / 6 min). If he or she completes the mile in 10 minutes, the energy expenditure rate is 12.1 kcals/min (0.73 kcals/lb/mile X 166 lbs X 1 mile / 10 min). In both cases, the trainees expends a *total* of 121 kcals/mile (20.2 kcals/min/mile X 6 min or 12.1 kcals/min/mile X 10 min).

(2) Oxygen taken up by the body during running is directly related to the energy cost of running. One liter of oxygen consumed by the body is the energy equivalent of about 4.85 kcals. This value assumes a near equal use of fats and carbohydrates for energy production. The actual energy equivalent of a liter of oxygen will vary depending on the types of fuel (fats or carbohydrates) used by the body to supply the energy. The range is from 4.69 kcals, assuming a utilization of all fats, to 5.05 kcals, assuming a utilization of all carbohydrates (8). However, for most purposes the figure 4.85 kcals/liter will be approximately correct. These calculations do not include the resting energy expenditure which is energy used for basal metabolic functions. Resting energy expenditure can range from about 0.8 to 1.4 kcals/min depending on a number of factors, especially body size (9). Thus, calculated energy expenditure rates during running would be about 1 kcal/min higher because this resting energy expenditure must be included. The body still maintains basal functions when running.

b. **Measuring Aerobic Fitness.** Maximal oxygen uptake ($VO_2max$) is the highest rate at which oxygen can be taken up and used by the body during exercise (10). Oxygen uptake is directly related to energy production as described above. The faster the rate at which oxygen can be used, the faster the rate at which energy can be

produced. If energy is produced at a fast rate, longer-term physical activity (like running) can be performed at a faster rate. Thus, $VO_2$max is a measure of aerobic fitness because it is a direct measure of the maximal rate at which longer-term physical activity can be performed.

(1) The $VO_2$max of an individual can be measured by progressively and systematically increasing exercise intensity while measuring the oxygen uptake ($VO_2$). Exercise intensity during running can be increased by increasing speed and/or the grade of the running surface. $VO_2$ is quantified by measuring the difference between the amount of oxygen in the air and the amount of oxygen in the expired gases of an individual. $VO_2$ will increase each time the exercise intensity is increased because the rate of energy expenditure is increasing. Eventually, a point will be reached where the $VO_2$ will not increase any further despite an increase in the exercise intensity. This highest $VO_2$ is called the $VO_2$max. $VO_2$max can be measured in mL of oxygen consumed by the body per kilogram of body weight per minute. $VO_2$max is limited by many factors including training, heredity, gender, body composition, age, and other factors (8,10).

(2) An individual with a higher $VO_2$max can run for a longer period of time at a higher speed compared to an individual with a lower $VO_2$max. To understand this, assume there are two male recruits (166 lb), one of which has a $VO_2$max of 50 mL/kg*min and another that has a $VO_2$max of 40 mL/kg*min. If they are running at 6 mph (10 min/mile), the energy cost of the run is 12.1 kcals/min. This is equivalent to an oxygen uptake of 36 mL/kg*min (see Appendix B for calculations). The more fit individual (higher $VO_2$max) will be running at 72% $VO_2$max (36 mL per kg per min/50 mL per kg per min) while the less fit individual (lower $VO_2$max) will be running at 90% $VO_2$max (36 mL per kg per min/40 mL per kg per min). The fitter individual (higher $VO_2$max) perceives the exercise as relatively less intense and can continue the run for a longer period of time.

c. **Improving Aerobic Fitness.** Based on past training studies (11,12), the American College of Sports Medicine (ACSM) generally recommends that to improve or maintain aerobic fitness, individuals exercise at between 60% to 90% of their maximal heart rate or 45% to 85% of the maximal heart rate reserve (12). This corresponds to about 42% to 83% of the $VO_2$max (8) or 45% to 85% of the $VO_2$max reserve (12). Trained runners prefer to run at about 75%$VO_2$max (13). Studies indicate that improvements in aerobic fitness progressively increase as the intensity of training increases from 50% to 100% $VO_2$max. The greatest improvements occur at intensities of 90% to 100% of $VO_2$max (11). However, at least two factors mitigate against running at >90%$VO_2$max in BCT. First, it is difficult to maintain running at very high intensities and trainees in BCT are more likely to drop out of ability group runs and actually receive less training. Second, in any ability group there will be trainees who will be on the lower end of aerobic fitness for that particular group. These individuals will be running at a higher relative intensity than the average for the group and they will have a more difficult time keeping up with the group.

**d. Injuries In BCT.** During BCT, 19% to 42% of men and 42% to 67% of women are injured at least once (14,15). Low levels of aerobic fitness, and longer running mileage are both associated with higher injury rates in BCT (16,17,18,19,20). Civilian research studies have also found that higher running mileage is associated with higher injury rates (21,22,23,24).

(1) Reducing running mileage in military basic training appears to reduce injuries without compromising improvements in aerobic fitness (19,20,25). While the literature does not provide a "threshold" mileage below which injuries are minimized, several studies suggest that total running distances of about 25 miles in basic training result in lower injury rates and similar improvements in aerobic fitness compared to running longer distances. One study (19) showed that during 12 weeks of Marine recruit basic training, men running a total of 33 miles had a substantially lower incidence of stress fractures and similar 3-mile run time improvements when compared to a group running 55 miles. If the 33 miles of running in 12 weeks is prorated for the 9-week Army BCT cycle, the total mileage is 25.

(2) Another study (7,25) showed that a BCT battalion running a total distance of 17 miles had lower injury rates and similar improvements in 2-mile run times compared to a battalion that ran a total distance of 38 miles. The lower running mileage battalion in this study also performed some interval training for which mileage was not obtained. A third study (20) compared male Naval recruits assigned to basic training divisions that ran either 12 to 18 miles or 26 to 44 miles. The lower mileage division had lower injury rates and 1.5-mile run time improvements that were the same as the higher mileage divisions.

(3) Only one investigation has examined the influence of frequency and duration of running on injuries. Injuries increased disproportionately with little additional fitness improvements if running was performed more than 3 times per week or if the amount of time spent running in a single session was greater than 30 minutes (26).

**e. Summary.**

(1) The energy cost of running is a constant at 0.73 kcal/lb/mile (5). Energy cost can be related to $VO_2$ (oxygen uptake) since 1 liter of oxygen consumed by the body during long-term running is the energy equivalent of about 4.85 kcals (8). If $VO_2$max is known, the proportion of the $VO_2$max (i.e., %$VO_2$max) needed to run at a specific speed can be calculated. If this %$VO_2$max is between 42% and 83%, the running speed will be within the exercise intensities recommended to improve or maintain aerobic fitness (12). To illustrate, assume a recruit performs a run at 6 miles/hour (10 min/mile). If the body weight of the recruit is 166 lbs, the energy expenditure rate is 12.1 kcals/min. This is equivalent to an oxygen uptake of 36 mL/kg*min (including resting energy expenditure, see Appendix B for calculations). If the recruit has a $VO_2$max of 50

mL/kg*min, that individual will be running at 72% of $VO_2$max (36 mL/kg/min / 50 mL/kg/min). This is within the zone to improve or maintain aerobic fitness.

(2) High running mileages are associated with higher injury rates. Basic training studies indicate that lower running mileage is associated with lower injury rates. Total running distances below 25 miles appear to be sufficient to improve aerobic fitness while minimizing injuries during BCT. Injuries increase disproportionately with little additional fitness improvements if running is performed more than three times per week or longer than 30 minutes per session.

**4. CONSIDERATIONS IN DEVELOPING RUN SPEED AND DISTANCE GUIDANCE.** There were seven major considerations. These were:

> Minimizing injuries;

> The initial fitness level (maximum oxygen uptake) of recruits;

> Expected improvements in aerobic endurance (run time) during BCT;

> The running speed of slower individuals in each ability group;

> Run speeds that must be achieved to "pass" the 2-mile run;

> The gender composition of the ability groups; and

> Recommendations from the trainers.

**a. Minimizing Injuries.** The literature suggests that a total running distance of about 25 miles during BCT is sufficient to physically condition trainees to pass the running test while minimizing injuries (19,20,25). BCT injury incidence is much higher in groups with lower aerobic fitness compared to groups with higher aerobic fitness (14,17). Further, lower fit individuals appear to show much greater improvements in aerobic fitness during BCT compared to individuals of higher fitness (2,27) even though the lower fit individuals tend to run at slower speeds and over shorter distances in their ability groups. When the duration of running is greater than 30 minutes or the frequency greater than 3 times per week, injuries appear to increase disproportionately with little additional changes in aerobic fitness (26). It thus appears important and appropriate to keep the total mileage as low as possible (in consonance with improving fitness) and to limit the duration and frequency of running to ≤30 minutes and ≤3 times per week, respectively.

**b. Initial Fitness of Recruits.** Initial aerobic fitness levels were obtained from a previous study (1,6,17,28,29) in which male and female recruits at Ft Jackson, South Carolina, volunteered for a maximal oxygen uptake ($VO_2$max) test prior to BCT. The

$VO_2$max of the recruits was used to determine the running speeds at the start of training.

**c. Changes in Aerobic Endurance During BCT.** Historical changes in aerobic endurance (run times) as a result of BCT training programs were determined by examining changes in running speeds during BCT in 3 databases. The databases contained 2-mile run times on a total of 28,316 male and female trainees at Ft Jackson, South Carolina. Two databases contained 2-mile run times at Week 1, Week 3, Week 5, and Week 7 of BCT allowing a systematic look at improvements in aerobic endurance during the course of BCT.

**d. Run Speed Capability.** Slower (less fit) trainees in each ability group should be able to run at the pace prescribed for the ability group they populate. That is, if the 25$^{th}$ percentile trainee in the fastest ability group ran 2 miles in 15 minutes on their last APFT, they should be able to run a 2-mile training run at a 7.5 min/mile pace. This would be very difficult for that person (a maximal effort) but less difficult for the person in the 20$^{th}$ percentile, less difficult yet for the 15$^{th}$ percentile person, and so on. To determine the running speed of slower individuals in each group percentile rankings were calculated to determine the running paces of individuals who were in the lower percentiles of each ability group.

**e. Two-Mile Run Times Required to "Pass" the APFT.** The 2-mile run times required to pass the run portion of the APFT are age and gender adjusted. These times are shown in Table 1. The target for the purpose of determining run speed guidance was the 17-21 year age group since analyses of existing databases showed that 70% to 76% of trainees fell into this age range (6,7). Also, since a "final" APFT is given at Week 7 of the 9-week BCT cycle, training must progress to allow achievement of these speeds by Week 7.

Table 1. Two-Mile Run Times (min) Needed to Pass the APFT in BCT[a]

| Gender | Age Group (years) | | | |
|---|---|---|---|---|
| | 17 to 21 | 22 to 26 | 27 to 31 | 32 to 36 |
| Men | 16.6 | 17.5 | 17.9 | 18.8 |
| Women | 19.7 | 20.6 | 21.7 | 23.1 |

[a] To "pass" the 2-mile run in BCT, only 50 points are needed. After BCT, 60 points are required (30)

**f. Gender Composition of the Ability Groups.** In a typical BCT company, both men and women generally populate all four ability groups at the start of training. However, the two fitter groups contain a majority of men and the two least fit groups contain a majority of women. The lowest fit ability group is composed mostly of women. Because of this, efforts were made to target the female passing score (Table 1) to this group. The male passing score was targeted to the second lowest fit group. On a practical level, this requires that any men in the lowest fit ability group move out of that group as soon as possible and into the second lowest group. The trainers must monitor this closely.

**g. Recommendations from the Trainers.** We coordinated our guidance with drill sergeants and the command groups of 10 BCT companies over 3 BCT cycles. A major concern was to provide a sufficient "challenge" for the two most fit ability groups. This was accomplished by increasing the speed and distance of the runs of the higher fit ability groups beyond the minimum required to enhance the fitness of the lowest fitness groups. The two most fit ability groups tended to have fewer injuries than the lower ability groups (17,31). Another concern of the trainers was that as many trainees as possible pass the final APFT when it is administered during Week 7 of training. If a trainee does not pass the Week 7 APFT, additional APFTs can be administered but this is a large administrative burden on the trainers. The run training schedule was progressed to achieve an adequate running speed to pass the APFT by Week 7. Some additional adjustments in speeds and distances were based on specific recommendations of the trainers.

## 5. METHODS TO DETERMINE RUNNING SPEEDS AND DISTANCES

a. **Databases.** Three databases were used in these analyses. Database 1 was obtained from the Directorate of Information Management (DOIM) at Ft Jackson. The DOIM routinely compiled Army Physical Fitness Test (APFT) raw scores from a company level data management tool called the Master Tracking System (MTS). After each company completed its training cycle, the DOIM downloaded data from the MTS including APFT scores. The DOIM provided 2-mile run times from 4 APFTs taken by each recruit during BCT from May 1999 to April 2000. Although there was some variation, these 4 APFTs were generally administered: 1) within 1-3 days of arrival for BCT, 2) during Week 3 of BCT, 3) during Week 5 of BCT, and 4) during Week 7 of BCT week. There were 15,901 men and 10,794 women in Database 1.

(1) Database 2 was initially constructed as part of an evaluation of a new physical training program designed for basic trainees (7,25). There were two battalions examined in this evaluation, one using the new program and a control battalion using a traditional program. Since the new program was not implemented, only the control battalion was analyzed for the present purposes. The training cycle of the battalion was from 21 September 2000 through 23 November 2000. One to 3 days after recruits entered their BCT units they performed an APFT and additional APFTs were conducted at Weeks 3, 5, and 7. Two-mile run times were extracted from the MTS of each company in the battalion. Database 2 contained information on 645 men and 651 women.

(2) Database 3 was initially constructed as part of a study examining injury risk factors and changes in physical fitness among recruits (1,17). Database 3 contained $VO_2$max values and 2-mile run times on 170 men and 155 women. The $VO_2$max test was conducted in the Reception Station, prior to recruits entering their BCT units. Recruits performed a 2-mile run as part of an APFT within 1 to 3 days of arrival in their BCT unit and they performed a final APFT in Week 7 of training. Two-mile run times

were extracted from the MTS of each company. The training cycles of the recruits extended from 8 May 1998 through 9 July 1998.

(3) The $VO_2max$ data in Database 3 were directly measured using a continuous, uphill treadmill running protocol (1). An initial 5-min warm-up was run at 0% grade and 6 mph for men and 5 mph for women. If the heart rate was less than 150 beats/min by minute 5 of the warm-up, treadmill speed was increased 0.5 mph for the remainder of the test. Following the warm-up, the treadmill grade was increased by 2% every 3 minutes until there was an increase of less than 2 $mL \cdot kg^{-1} \cdot min^{-1}$ (or 0.15 $l \cdot min^{-1}$) with an increase in treadmill grade, or until voluntary exhaustion. Volunteers wore a nose clip and were connected to the oxygen uptake measuring device by a mouthpiece. The on-line oxygen uptake system consisted of an Applied Electrochemistry S-3A oxygen analyzer, a Beckman LB-2 carbon dioxide analyzer and a K.L. Engineering flowmeter turbine, interfaced with a Hewlett-Packard model 9122 computer. Trained personnel monitored a single-lead electrocardiogram during the test to determine heart rate and ensure the safety of the trainee.

(4) The 2-mile run times in Databases 1, 2, and 3 were obtained as part of the routinely administered APFT. The APFT consisted of three events: push-ups, sit-ups and a two-mile run, administered in that order. For push ups and sit ups, recruits generally lined up in 5 to 15 rows and were tested individually by drill sergeants. Drill sergeants recorded the number push-ups and sit-ups successfully completed in separate 2-minute periods. After a rest (10-30 minutes) recruits were marched to a track for the 2-mile run. Recruits wore a numbered vest or carried a numbered plaque for identity. Drill sergeants lined up the recruits at a starting point, started the run, and recorded the time it took for each recruit to complete the distance.

**b. Analyses.** Four steps were used in the analyses. These were----

> Establish representative ability groups,

> Determine initial (starting) run speeds,

> Determine changes in aerobic endurance and estimated $VO_2max$ during BCT

> Establish training run speeds and distances for each ability group for the duration of BCT.

**(1) Establish Representative Ability Groups.** Four equally sized ability groups were established in the three databases using the initial 2-mile run times. This was done to see if the ability group ranges were similar in the three databases. Average 2-mile run times were also compared. Database 1 served as the reference since it contained the largest number of recruits tested over the longest period of time. We could be relatively sure that the recruit samples in Databases 2 and 3 were

representative of the larger population of recruits if the ability group ranges and the average run times were similar to those in Database 1. The ability groups established from Database 1 were used in subsequent analyses.

**(2) Determine Initial Run Speeds.** The average $VO_2$max of individuals in each of the four ability groups was calculated from Database 3. The %$VO_2$max values were determined by multiplying the decimal percentage by the $VO_2$max value (e.g., 70%$VO_2$max=0.70 * $VO_2$max).

To calculate the running speed equivalent to a particular $VO_2$ the following formula was used:

$$\text{Speed (min/mile)} = \frac{1\text{kcal}}{\text{kg*km}} \times \frac{1\text{ km}}{0.62\text{ mile}} \times \frac{1000\text{mL}O_2}{4.85\text{ kcal}} \times \frac{1}{VO_2\ (\text{mL}O_2/\text{kg*min})} \quad \text{[equation1]}$$

Initial running speeds were established between 70% and 83% $VO_2$max consistent with calculation of speeds to the nearest 15 sec/mile.

**(3) Determine Changes in Aerobic Endurance and Estimated $VO_2$max During BCT.** The average changes in 2-mile run times in the ability groups during the course of BCT were determined in the three databases. This was to define how much run times could be expected to improve. To estimate the changes in $VO_2$max that corresponded with these changes in run times, a regression equation was developed. $VO_2$maxs were regressed on 2-mile run times in Database 3. The correlation between 2-mile run time and $VO_2$max was 0.69 with a standard error of estimate of 6.1 mL/kg/min. The resultant regression equation was

$$\text{Estimated } VO_2\text{max} = 75.00 - 1.55 * (\text{2-mile run time}) \quad \text{[equation 2]}$$

In equation 2, $VO_2$max is in mL/kg/min and 2-mile run times are in minutes. The changes in 2-mile run times in Database 1 at Weeks 3, 5 and 7 were used to calculate the changes in the estimated $VO_2$max at these time points.

**(4) Establish Run Speeds and Distances for the Duration of BCT.** Running speed guidance was adjusted in an effort to keep the ability groups in the 70-83% $VO_2$max range based on the new estimated $VO_2$max values available at Weeks 3, 5 and 7. Speeds were cross checked by examining the 2-mile run pace of the individuals in the lowest percentiles of each ability group (±5 percentile rankings). The running pace of slower individuals only served as a secondary check since the actual run distances were often less than or greater than 2 miles. Speeds were primarily determined from Equation 1 using a $VO_2$ in the 70-85% $VO_2$max range and consistent with keeping the pace to the nearest 15 sec/mile. Few changes in speed were made in Ability Group A since their run times (and consequently estimated $VO_2$max) changed very little. On the other hand, more changes in run speed were made in Ability Group D since their run times changed substantially, especially early in training. Run distances

were progressively and systematically increased while keeping the total distance in the two slower ability groups below a total of 25 miles.

## 6. RESULTS.

### a. Establishment of Representative Ability Groups and Comparison of Databases.

(1) Table 2 shows a comparison of the means and ranges of initial run times in the ability groups in the three databases. The mean values are almost identical and differ by no more than 0.2 minutes across the three databases. The ranges are also similar in all three databases, except for the highest and lowest values where single cases can have large influences. Exclusive of these lowest and highest values, the ranges in Databases 1 and 2 differed by no more than 0.4 minutes; Databases 1 and 3 differed by no more than 0.3 minutes; Databases 2 and 3 differed by no more than 0.3 minutes.

Table 2. Initial Two-Mile Run Times (Mean and Range in min) in Databases 1, 2, and 3

| | Database 1 | | Database 2 | | Database 3 | |
|---|---|---|---|---|---|---|
| Ability Group | Mean±SD | Range | Mean±SD | Range | Mean±SD | Range |
| A (fast) | 15.0±1.1 | 9.8-16.4 | 15.0±1.0 | 12.0-16.0 | 14.9±1.1 | 11.1-16.3 |
| B | 17.6±0.7 | 16.5-18.7 | 17.6±0.6 | 16.1-18.7 | 17.7±0.7 | 16.4-19.0 |
| C | 20.1±0.8 | 18.8-21.5 | 20.2±0.8 | 18.8-21.6 | 20.0±0.8 | 19.1-21.5 |
| D (slow) | 23.8±1.7 | 21.6-33.6 | 23.6±1.5 | 21.7-31.6 | 23.9±1.9 | 21.6-32.2 |

(2) Table 3 shows a comparison of the average 2-mile run times for subjects in the three databases. The average values differ by only 0.1 minute.

Table 3. Comparison of Two-Mile Run Times (minutes) of Recruits in Databases 1, 2, and 3

| Database | Mean | Standard Deviation |
|---|---|---|
| 1 | 19.1 | 3.4 |
| 2 | 19.0 | 3.2 |
| 3 | 19.1 | 3.3 |

### b. Initial Running Speeds and Initial Aerobic Fitness.

(1) Table 4 shows the average oxygen uptake ($VO_2$) for each ability group at various %$VO_2$max calculated from Database 3. The 100% $VO_2$max is the actual (not estimated) $VO_2$max of the respective ability group. The average±SD $VO_2$maxs for the men and women were 50.6±6.2 and 39.3±5.3, respectively. Average±SD $VO_2$max for men and women combined was 45.2±8.1.

(2) Equation 1 in the Methods section was used to calculate the running speed equivalent to a particular %$VO_2$max for each trainee in Database 3. Table 5 shows the average±SD initial running speeds (minutes/mile) for trainees in each ability group at various %$VO_2$max. The ability group ranges are those established from Database 1.

Table 4. Relative $VO_2$ (mL/kg*min) for Each Ability Group (values are Mean±SD)

| Ability Group | 70% $VO_2$max | 75% $VO_2$max | 80% $VO_2$max | 85% $VO_2$max | 100% $VO_2$max |
|---|---|---|---|---|---|
| A (fast) | 37.5±4.2 | 40.2±4.5 | 42.8±4.8 | 45.5±5.1 | 53.5±6.0 |
| B | 32.8±4.2 | 35.2±4.5 | 37.5±4.8 | 39.8±5.1 | 46.9±6.0 |
| C | 29.5±3.6 | 31.6±3.8 | 33.7±4.1 | 35.8±4.3 | 42.2±5.1 |
| D (slow) | 27.1±4.1 | 29.0±4.4 | 30.9±4.6 | 32.9±4.9 | 38.7±5.8 |

Table 5. Running Speeds (minutes/mile) at Various Percentages of Maximal Aerobic Capacity (values are Mean±SD)

| Ability Group | 70% $VO_2$max | 75% $VO_2$max | 80% $VO_2$max | 85% $VO_2$max | 100% $VO_2$max |
|---|---|---|---|---|---|
| A (fast) | 9.0±1.1 | 8.4±1.1 | 7.9±1.0 | 7.4±0.9 | 6.3±0.8 |
| B | 10.3±1.3 | 9.6±1.2 | 9.0±1.1 | 8.5±1.1 | 7.2±0.9 |
| C | 11.4±1.4 | 10.7±1.3 | 10.0±1.2 | 9.4±1.2 | 8.0±1.0 |
| D (slow) | 12.5±1.7 | 11.7±1.6 | 11.0±1.5 | 10.3±1.4 | 8.8±1.2 |

### c. Improvements in Two-Mile Run Times and Estimated $VO_2$max at Successive Points During BCT

(1) Tables 6, 7, and 8 show changes in 2-mile run times in Databases 1, 2 and 3, respectively. The initial run times are similar in all databases differing by no more than 0.4 minutes in any ability group. Improvements in run times in Databases 1 and 3 are very similar while changes in Database 2 are somewhat smaller. Improvements in run times are progressively greater moving from faster to slower ability groups.

Table 6. Improvements in 2-Mile Run Times During BCT in Database 1

| Ability Group | 2-Mile Run Times (min)* | | | | Improvements in 2-Mile Run Times (min) | | | Improvements in 2-Mile Run Time, Initial–Final (%) |
|---|---|---|---|---|---|---|---|---|
| | Initial | Week 3 | Week 5 | Final | Initial - Week 3 | Initial - Week 5 | Initial – Final | |
| A (fast) | 15.0±1.1 | 14.5±1.7 | 14.1±1.6 | 13.9±1.3 | 0.5 | 0.9 | 1.1 | 7.3 |
| B | 17.6±0.7 | 16.2±1.7 | 15.5±1.5 | 15.1±1.2 | 1.4 | 2.1 | 2.5 | 14.2 |
| C | 20.1±0.8 | 18.1±1.9 | 17.2±1.9 | 16.6±1.5 | 2.0 | 2.9 | 3.5 | 17.4 |
| D (slow) | 23.8±1.7 | 20.6±2.4 | 19.3±2.2 | 18.3±1.8 | 3.2 | 4.5 | 5.5 | 23.1 |

* Values are Mean±SD

(2) Estimated $VO_2$max values were calculated from 2-mile run times for each trainee in Database 1 using Equation 2. Table 9 shows the average±SD estimated $VO_2$max data and the changes in the estimated $VO_2$max during BCT for each ability group. Comparisons of the actual $VO_2$max values in Table 4 (i.e., 100%$VO_2$max) with the estimated initial $VO_2$max values in Table 9 show that the largest difference is 1.7 mL/kg/min (Ability Group A). Changes in estimated $VO_2$max during training were progressively larger in slower ability groups. There were larger changes earlier in training and progressively smaller changes later in training.

Table 7. Improvements in 2-Mile Run Times During BCT in Database 2

| Ability Group | 2-Mile Run Times (min)* | | | | Improvements in 2-Mile Run Times (min) | | | Improvements in 2-Mile Run Time, Initial–Final (%) |
|---|---|---|---|---|---|---|---|---|
| | Initial | Week 3 | Week 5 | Final | Initial–Week 3 | Initial–Week 5 | Initial–Final | |
| A (fast) | 15.0±1.1 | 14.6±1.6 | 14.3±1.3 | 14.1±1.1 | 0.4 | 0.7 | 0.9 | 6.0 |
| B | 17.6±0.7 | 16.4±1.8 | 15.8±1.4 | 15.5±1.3 | 1.2 | 1.8 | 2.1 | 11.9 |
| C | 20.2±0.8 | 18.7±2.1 | 18.0±1.8 | 17.3±1.5 | 1.5 | 2.2 | 2.9 | 14.4 |
| D (slow) | 23.4±1.4 | 20.9±2.4 | 19.9±2.0 | 18.8±1.7 | 2.5 | 3.5 | 4.6 | 19.7 |

* Values are Mean±SD

Table 8. Improvements in Two-Mile Run Times During BCT in Database 3

| Ability Group | 2-Mile Run Time (min)* | | Improvements in 2-Mile Run Time (min) | Improvements in 2-Mile Run Time (%) |
|---|---|---|---|---|
| | Initial | Final | | |
| A (fast) | 14.9±1.1 | 13.7±1.3 | 1.2 | 8.0 |
| B | 17.6±0.7 | 15.3±1.3 | 2.3 | 13.1 |
| C | 20.0±0.8 | 16.7±1.6 | 3.3 | 16.5 |
| D (slow) | 23.6±1.7 | 18.0±1.9 | 5.6 | 23.7 |

Values are Mean±SD

Table 9. Improvements in Estimated $VO_2$max in Database 1

| Ability Group | Estimated $VO_2$max (mL/kg/min) | | | | Improvements in $VO_2$max (mL/kg/min) | | | Improvements in $VO_2$max, Final - Initial (%) |
|---|---|---|---|---|---|---|---|---|
| | Initial | Week 3 | Week 5 | Final | Week 3 - Initial | Week 5 – Week 3 | Final – Week 5 | |
| A (fast) | 51.8±1.7 | 52.6±2.7 | 53.2±2.4 | 53.5±2.0 | 0.8 | 0.6 | 0.3 | 3.2 |
| B | 47.7±1.0 | 50.0±2.6 | 51.0±2.3 | 51.6±1.9 | 2.3 | 1.0 | 0.6 | 8.2 |
| C | 43.8±1.2 | 47.0±3.0 | 48.3±2.9 | 49.3±2.4 | 3.2 | 1.3 | 1.0 | 12.6 |
| D (slow) | 38.1±2.7 | 43.1±3.8 | 45.0±3.4 | 46.6±2.8 | 5.0 | 1.9 | 1.6 | 22.3 |

(3) For the purposes of determining run speeds from the $VO_2$max data, the actual $VO_2$max values served as the starting point (Table 5). Changes in $VO_2$max in Table 9 were added to these actual $VO_2$max values. The $VO_2$max values used for adjusting the run speeds are shown in Table 10.

Table 10. $VO_2$max (mL/kg/min) Values Used to Calculate Changes in Run Speeds During BCT

| Ability Group | Week 1 & 2 | Week 3 & 4 | Week 5 & 6 | Week 7& 8/9 |
|---|---|---|---|---|
| A (fast) | 53.5 | 54.3 | 54.9 | 55.2 |
| B | 46.9 | 49.2 | 50.2 | 50.8 |
| C | 42.2 | 45.4 | 46.7 | 47.7 |
| D (slow) | 38.7 | 43.7 | 45.6 | 47.2 |

**d. Run Speed Capability.** Table 11 shows the cumulative frequency distribution of trainees by 2-mile run times for each of the APFTs in Database 1. This table was used to determine the 2-mile run pace of slower trainees in each ability group. It was difficult to establish exact 25$^{th}$, 50$^{th}$, 75$^{th}$ and 100$^{th}$ percentiles consistent with run paces

to the nearest 15 sec/mile so a range of ±5 percentile units was used. For Ability Group A this was a range from the 20th to the 30th percentile, for Ability Group B the 45th to 55th percentile, for Ability Group C the 70th to 80th percentile, and for Ability Group D the 90th to the 100th percentile. The target for Ability Group D was the 95th percentile (±5 percentile units) because of the fact that this group improves their running speed so rapidly and the 100th percentile is likely to be too slow for this group.

Table 11. Cumulative Frequency Distribution of Trainees by 2-Mile Run Times from Database 1.

| Two-Mile Time (min) | Average Pace for 2-Mile Run (min/mile) | Cumulative Proportion of Trainees (%) | | | |
|---|---|---|---|---|---|
| | | Initial | Week 3 | Week 5 | Final |
| 14.0 | 7.00 | 5 | 13 | 18 | 21 |
| 14.5 | 7.25 | 7 | 19 | 26 | 30 |
| 15.0 | 7.50 | 11 | 25 | 34 | 39 |
| 15.5 | 7.75 | 16 | 33 | 43 | 48 |
| 16.0 | 8.00 | 21 | 41 | 51 | 57 |
| 16.5 | 8.25 | 26 | 47 | 57 | 64 |
| 17.0 | 8.50 | 32 | 53 | 63 | 70 |
| 17.5 | 8.75 | 37 | 59 | 68 | 74 |
| 18.0 | 9.00 | 42 | 64 | 74 | 79 |
| 18.5 | 9.25 | 47 | 69 | 78 | 84 |
| 19.0 | 9.50 | 53 | 74 | 83 | 90 |
| 19.5 | 9.75 | 58 | 78 | 87 | 94 |
| 20.0 | 10.00 | 63 | 82 | 90 | 97 |
| 20.5 | 10.25 | 67 | 86 | 93 | |
| 21.0 | 10.50 | 72 | 88 | 95 | |
| 21.5 | 10.75 | 75 | 91 | 96 | |
| 22.0 | 11.00 | 79 | 93 | | |
| 22.5 | 11.25 | 82 | 94 | | |
| 23.0 | 11.50 | 85 | 96 | | |
| 23.5 | 11.75 | 87 | | | |
| 24.0 | 12.00 | 91 | | | |
| 24.5 | 12.25 | 92 | | | |
| 25.0 | 12.50 | 97 | | | |

**e. Training Run Speed and Distance Guidance.** Table 12 shows the recommended run speed and distance guidance by ability group and week based on the considerations and data discussed above. Examining training schedules proposed by the USAPFS for the new TRADOC Standardized Physical Training program for BCT (32) shows that there are a total of 9 ability group runs over the course of BCT. In addition, there are 3 fitness tests that include a 1-mile run when soldiers arrive for BCT and 2-mile APFT runs at Weeks 5 and 7. Speed running (interval training) involved estimated distances of 5.2, 4.8, 4.3, and 3.9 miles for Ability Groups A, B, C, and D, respectively. These data indicate that the total estimated running distance in BCT would be 37.5, 34.7, 26.2, and 24.2 miles for Ability Groups A, B, C, and D, respectively.

Table 12. Ability Group Run Speed and Distance Guidance for BCT

| Training Week | Ability Group | Distance (miles) | Pace (min/mile) | Total Run Time (min) | Initial %$VO_2$max | Adjusted %$VO_2$max[a] |
|---|---|---|---|---|---|---|
| 1 | A (fast) | 2.0 | 8.0 | 16 | 78 | 78 |
| | B | 1.7 | 9.0 | 15 | 79 | 79 |
| | C | 1.0 | 10.5 | 11 | 75 | 75 |
| | D (slow) | 0.8 | 12.0 | 10 | 72 | 72 |
| 2 | A | 2.0 | 7.5 | 15 | 83 | 83 |
| | B | 1.8 | 8.5 | 15 | 83 | 83 |
| | C | 1.2 | 10.0 | 12 | 79 | 79 |
| | D | 1.1 | 11.0 | 12 | 78 | 78 |
| 3 | A | 2.7 | 7.5 | 20 | 80 | 82 |
| | B | 2.4 | 8.5 | 20 | 84 | 80 |
| | C | 1.4 | 9.5 | 13 | 83 | 77 |
| | D | 1.3 | 10.5 | 14 | 82 | 72 |
| 4 | A | 2.7 | 7.5 | 20 | 83 | 82 |
| | B | 2.4 | 8.5 | 20 | 84 | 80 |
| | C | 1.7 | 9.5 | 16 | 83 | 77 |
| | D | 1.6 | 10.0 | 16 | 86 | 76 |
| 5 | A | 2.8 | 7.25 | 20 | 88 | 84 |
| | B | 2.5 | 8.0 | 20 | 89 | 83 |
| | C | 2.0 | 9.0 | 18 | 88 | 79 |
| | D | 1.9 | 10.0 | 19 | 86 | 73 |
| 6 | A | 3.4 | 7.25 | 25 | 86 | 84 |
| | B | 3.1 | 8.0 | 25 | 89 | 83 |
| | C | 2.4 | 8.5 | 20 | 93 | 84 |
| | D | 2.1 | 9.5 | 20 | 90 | 77 |
| 7 | A | 3.4 | 7.25 | 25 | 86 | 83 |
| | B | 3.1 | 8.0 | 25 | 92 | 82 |
| | C | 2.4 | 8.25 | 20 | 96 | 85 |
| | D | 2.1 | 9.5 | 20 | 90 | 74 |
| 8/9 | A | 4.0 | 7.5 | 30 | 86 | 83 |
| | B | 3.8 | 8.0 | 30 | 92 | 82 |
| | C | 2.4 | 8.25 | 20 | 96 | 85 |
| | D | 2.2 | 9.0 | 20 | 95 | 78 |

[a]Considers changes in estimated $VO_2$max from Table 10

**f. Pacing Chart.**

(1) Table 13 displays the pace chart for the ability groups. The pace chart show the time that it should take the ability groups to reach distances at ¼ mile intervals. These charts may be useful for drill sergeants who perform training runs with the ability groups.

(2) As an example of how to use the chart, assume Ability Group D is doing their Week 3 run. That group should reach 1/2 mile at 5 minutes and 28 seconds, 1 mile at 10 minutes and 56 seconds, and so on. If recruits are in Week 6 and running in Group A, they should reach the 2-mile point at 14 minutes.

Table 13. Pacing Times for Ability Group Runs (values are minutes:sec)

| WEEK | GROUP | Distance (miles) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/4 | ½ | ¾ | 1 | 1¼ | 1½ | 1¾ | 2 | 2¼ | 2½ | 2¾ | 3 | 3¼ | 3½ | 3¾ | 4 |
| 1 | A | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | 12:00 | 14:00 | 16:00 | | | | | | | | |
| | B | 2:15 | 4:30 | 6:45 | 9:00 | 11:15 | 13:30 | 15:45 | | | | | | | | | |
| | C | 2:38 | 5:15 | 7:53 | 10:30 | | | | | | | | | | | | |
| | D | 3:00 | 6:00 | 9:00 | 12:00 | | | | | | | | | | | | |
| 2 | A | 1:53 | 3:45 | 5:38 | 7:30 | 9:23 | 11:15 | 13:08 | 15:00 | | | | | | | | |
| | B | 2:08 | 4:15 | 6:23 | 8:30 | 10:38 | 12:45 | 14:53 | | | | | | | | | |
| | C | 2:30 | 5:00 | 7:30 | 10:00 | 12:30 | | | | | | | | | | | |
| | D | 2:45 | 5:30 | 8:15 | 11:00 | | | | | | | | | | | | |
| 3 | A | 1:53 | 3:45 | 5:38 | 7:30 | 9:23 | 11:15 | 13:08 | 15:00 | 16:53 | 18:45 | 20:38 | | | | | |
| | B | 2:08 | 4:15 | 6:23 | 8:30 | 10:38 | 12:45 | 14:53 | 17:00 | 19:08 | 21:15 | | | | | | |
| | C | 2:23 | 4:45 | 7:08 | 9:30 | 11:53 | 14:15 | | | | | | | | | | |
| | D | 2:38 | 5:15 | 7:53 | 10:30 | 13:08 | | | | | | | | | | | |
| 4 | A | 1:53 | 3:45 | 5:38 | 7:30 | 9:23 | 11:15 | 13:08 | 15:00 | 16:53 | 18:45 | 20:38 | | | | | |
| | B | 2:08 | 4:15 | 6:23 | 8:30 | 10:38 | 12:45 | 14:53 | 17:00 | 19:08 | 21:15 | | | | | | |
| | C | 2:23 | 4:45 | 7:08 | 9:30 | 11:53 | 14:15 | 16:38 | | | | | | | | | |
| | D | 2:30 | 5:00 | 7:30 | 10:00 | 12:30 | 15:00 | 17:30 | | | | | | | | | |
| 5 | A | 1:49 | 3:38 | 5:26 | 7:15 | 9:04 | 10:53 | 12:41 | 14:30 | 16:19 | 18:08 | 19:56 | | | | | |
| | B | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | 12:00 | 14:00 | 16:00 | 18:00 | 20:00 | | | | | | |
| | C | 2:15 | 4:30 | 6:45 | 9:00 | 11:15 | 13:30 | 15:45 | 18:00 | | | | | | | | |
| | D | 2:30 | 5:00 | 7:30 | 10:00 | 12:30 | 15:00 | 17:30 | 20:00 | | | | | | | | |
| 6 | A | 1:49 | 3:38 | 5:26 | 7:15 | 9:04 | 10:53 | 12:41 | 14:30 | 16:19 | 18:08 | 19:56 | 21:45 | 23:34 | 25:23 | | |
| | B | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | 12:00 | 14:00 | 16:00 | 18:00 | 20:00 | 22:00 | 24:00 | | | | |
| | C | 2:08 | 4:15 | 6:23 | 8:30 | 10:38 | 12:45 | 14:53 | 17:00 | 19:08 | 21:15 | | | | | | |
| | D | 2:23 | 4:45 | 7:08 | 9:30 | 11:53 | 14:15 | 16:38 | 19:00 | | | | | | | | |
| 7 | A | 1:49 | 3:38 | 5:26 | 7:15 | 9:04 | 10:53 | 12:41 | 14:30 | 16:19 | 18:08 | 19:56 | 21:45 | 23:34 | 25:23 | | |
| | B | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | 12:00 | 14:00 | 16:00 | 18:00 | 20:00 | 22:00 | 24:00 | 26:00 | | | |
| | C | 2:04 | 4:08 | 6:11 | 8:15 | 10:19 | 12:23 | 14:26 | 16:30 | 18:34 | 20:38 | | | | | | |
| | D | 2:23 | 4:45 | 7:08 | 9:30 | 11:53 | 14:15 | 16:38 | 19:00 | | | | | | | | |
| 8/9 | A | 1:53 | 3:45 | 5:38 | 7:30 | 9:23 | 11:15 | 13:08 | 15:00 | 16:53 | 18:45 | 20:38 | 22:30 | 24:23 | 26:15 | 28:08 | 30 |
| | B | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | 12:00 | 14:00 | 16:00 | 18:00 | 20:00 | 22:00 | 24:00 | 26:00 | 28:00 | 30:00 | |
| | C | 2:04 | 4:08 | 6:11 | 8:15 | 10:19 | 12:23 | 14:26 | 16:30 | 18:34 | 20:38 | | | | | | |
| | D | 2:15 | 4:30 | 6:45 | 9:00 | 11:15 | 13:30 | 15:45 | 18:00 | 20:15 | | | | | | | |

**g. Practical Application of the Pacing Charts.** To apply the pacing charts, trainers will need to accurately measure the running course and use a stop watch to measure run times during ability group training runs.

**(1) Measuring the Course.** To accurately measure a running course, the trainer should first define a starting point for the run. Adequate distance prior to the starting point should be considered for a walk that will serve as a warm-up. From the starting point the trainers should clearly mark off ¼–mile distances. Car odometers should not be used to measure distances because the accuracy of the odometer at small distances can be questionable and most odometers do not provide units of 0.25 miles. A car can be useful for a rough estimate of the course before a more accurate assessment is performed. Distances are accurately determined by walking the course with commercially available measuring wheels that can be found on the internet (e.g., Rolatape®, Meterman™, Digiroller™). Courses should be measured at least twice to assure no errors occurred on the first walk-through. Accuracy is important because the pace charts will only be as precise as the measured distances.

**(2) Pacing the Run.** When actually performing an ability group run, the trainer will need a stopwatch to measure the time. Prior to the run, trainers should have trainees walk rapidly to the starting point. A rapid walk serves as a task specific warm-up. On beginning the run, the trainer should start his or her stopwatch. At each ¼ mile, the trainer should check his or her watch and compare the watch time to the time on the pace chart. The running speed of the group should be adjusted appropriately by speeding up or slowing down so that the times in the pacing chart are achieved as closely as possible.

## 7. DISCUSSION.

a. The present study developed guidance for ability group running speeds and distances based on actual data and a wide variety of considerations. Data included 2-mile run times and directly measured $VO_2$max data gathered from samples of men and women in basic training at Ft Jackson SC. Consideration was given to initial fitness, changes in fitness, the run speeds of slower individuals in each ability group, assuring training intensities sufficient to pass the run portion of the APFT, and the recommendations of the trainers. Running distance was based on minimizing injuries in the 2 slower ability groups while assuring trainees ran the 2-mile distance before the final APFT at Week 7 of BCT.

b. Recruits who performed the $VO_2$max test appeared to be representative of the entire population of recruits in terms of their 2-mile run times. When the sample who took the $VO_2$max test (Database 3) were compared to all recruits at Ft Jackson over a 1-year period (Database 1), the initial 2-mile run scores were almost identical and the changes in 2-mile run times were very similar. Since 2-mile run times are highly correlated with $VO_2$max (33), it can also be assumed that the aerobic capacities were very similar in the two groups.

c. Run speeds at Week 1 were based on actual $VO_2$max values on the representative group of trainees in Database 3. Run speeds after Week 1 were based on changes in estimated $VO_2$max from a regression equation. Since these were estimates, consideration was given to assuring that slower individuals in each ability group were capable of running at the set pace. Adjustments were made for the fact that the paces were 2-mile paces and ability groups would sometimes run distances longer or shorter than 2 miles.

d. The run speed guidance was actually tested over 3 BCT cycles and the opinions and concerns of the drill sergeants and other training cadre were considered. Although the final guidance presented here was not tested, the changes that were made since the final version tested in a BCT cycle were relatively minor.

e. An attempt was made to establish run speeds between 70 and 83%$VO_2$max as recommended by the ACSM. The 2-mile run paces of the slower individuals in each ability group were also considered in determining the pace. In 5 cases the

recommended exercise intensity values were slightly exceeded. Ability Group A at Weeks 5 and 6 exceeded the ACSM exercise intensity recommendation. Cumulative run frequencies showed that 26% of the trainees could run a 7.25 min/mile pace for 2-miles by Week 5. The distance for Ability Group A at Week 5 was 2.8 miles and this increased to 4.1 miles by Weeks 8/9. Deference was given to the trainers who requested a faster running speed for this group.

f. Other points that exceeded the ACSM recommended criterion was Ability Group C at Weeks 6 to 9. A pace of 8.25 min/mile was considered necessary because this was the average pace necessary to pass the 2-mile run. If Ability Group C trainees could maintain this pace in training they could have some degree of confidence that they would pass the APFT. Drill sergeants also viewed the pace more favorably since it was the minimum average pace necessary to pass the run portion of the APFT. In addition, this pace began to prepare Group C trainees for the 60-point 2-mile run time criterion (15.9 minutes for men) necessary to pass the APFT after BCT in Advance Individual Training.

g. In conclusion, we took a broad approach in establishing ability group run speeds and distances. We used physiological data, performance data, information from the literature, and the practical recommendations from trainers to arrive at the speeds and distances. Using these recommendations should allow trainees to improve their aerobic fitness, pass the APFT, and minimize injuries that result in lost training time and lower fitness levels.

## Appendix A
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## Appendix B.
## Calculations used in Paragraphs 3b(2) and 3e(1)

1. Paragraph 3b(2)

    a. To 12.1 kcal/min add 1 kcal/min for resting energy expenditure

    b. 13.1 kcal/min / 4.85 kcal/liter $O_2$ = 2.70 liters $O_2$/min

    c. (2.7 liters $O_2$/min X 1000mL/liter $O_2$) / 75 kg = 36 mL/kg/min

2. Paragraph 3e(1)

    a. 12.1 kcal/min = 166 lbs X 0.73 kcal/lb/min

    b. 36 mL/kg/min

    a. To 12.1 kcal/min add 1 kcal/min for resting energy expenditure

    b. 13.1 kcal/min / 4.85 kcal/liter $O_2$ = 2.70 liters $O_2$/min

    c. (2.7 liters $O_2$/min X 1000mL/liters $O_2$) / 75 kg = 36 mL/kg/min

    c. 72%$VO_2$max = (36 mL/kg/min / 50mL/kg/min) X 100%

## Appendix C
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