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

USCHPPM

SECULAR TRENDS IN THE PHYSICAL FITNESS OF AMERICAN YOUTH, YOUNG ADULTS AND ARMY RECRUITS

USACHPPM REPORT NO. 12-HF-01Q9B-04

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

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

Center for Accessions Research
Ft Knox, KY

Readiness Thru Health

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

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

This paper reviews the literature and existing databases for information on secular trends in the physical fitness of young Americans and describes changes in fitness during Basic Combat Training (BCT). The VO2max of male youth and new Army recruits has not changed while that of female youth and new recruits has improved slightly from at least 1975 to 1998. Performance has declined on endurance running tasks in a similar time period. It may be that youth and recruits are not as proficient at applying their physiological capability to performance tasks like timed runs, possibly because of factors such as reduced experience with running, lower motivation, and/or environmental factors. Limited data on Army recruits demonstrate an increase in strength from 1978 to 1998 that is consistent with an increase in the frequency of self-reported youth strength training and an estimated increase in fat-free body mass over the same time period. Data on muscular endurance is not consistent. Among young Americans there is strong evidence that body weight and body mass index (BMI) have progressively increased since about 1980 and this increase continues into the 2000s. Available evidence suggests that the increases in BMI and body weight are associated with an increase in caloric intake. Most physical fitness trends can be modeled using linear regression and there is little reason to think the trends cited above will not continue into the future. During BCT, men improved their push-up, sit-up, and 2-mile run performance by an average of 56%, 47%, and 17%, respectively; women improved an average of 189%, 77% and 18%, respectively. To track future trends in BMI, cardiorespiratory endurance, and muscular endurance in the Army, appropriate surveillance systems should be developed to systematically collect Army Physical Fitness Test data.

14. SUBJECT TERMS
age, gender, race, physical training, military personnel, muscle contraction, cardiorespiratory endurance, VO2max, muscle strength, muscular endurance, body mass index, body weight, height, body fat, fat-free mass, push-ups, sit-ups, 2-mile run

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REPLY TO
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Executive Summary

SECULAR TRENDS IN THE PHYSICAL FITNESS OF AMERICAN YOUTH, YOUNG ADULTS, AND ARMY RECRUITS

USACHPPM REPORT NO. 12-HF-01Q9B-04

1. INTRODUCTION. The Center for Accession Research (CAR) requested that the Army Center for Health Promotion and Preventive Medicine (CHPPM) assess the current and future state of the physical fitness of Americans who are of military recruiting age and determine potential changes in physical fitness of this group by gender and race. To do this the CHPPM proposed to examine the literature as well as existing databases for information on secular trends in the physical fitness of American youth (aged <18 years), young adults (aged 18-21 years), and military recruits. This would provide an assessment of past and current trends in physical fitness that might be projected into the future. To determine fitness potential, the CHPPM proposed examining the literature and existing databases for studies indicating how much fitness can be expected to change among recruits in Basic Combat Training (BCT). All new recruits participate in BCT and this provides the most realistic estimate of how much fitness can be expected to change in the short term in a military environment.

2. DEFINING PHYSICAL FITNESS. Physical fitness is a set of attributes or components that allow individuals to perform physical activity. The components of physical fitness include cardiorespiratory endurance, muscle strength, muscular endurance, coordination, balance, flexibility, and body composition.
These attributes or components of physical fitness can be linked to energy systems that fuel the muscular contraction necessary for physical activity. The components can also be linked to physical measurements (e.g., time, distance, force) that allow quantification.

3. CONSIDERATIONS AND LIMITATIONS. To examine secular trends in youth and young adult fitness it is necessary to have objective measures of the various components of physical fitness over time. Fitness test batteries used in American schools have changed over time making it difficult to follow secular trends. A few studies have reported on test events that have been retained over a period of a few years for high-school aged individuals (generally 15 to 18 years of age). We could find no systematic testing of the broad population of young adults for any fitness component other than certain aspects of body composition. On the other hand, studies of new military recruits have periodically been conducted since 1975. These military studies have collected the same fitness measures over relatively long periods of time.

4. SECULAR CHANGES IN YOUTH AND YOUNG ADULT FITNESS

Maximal oxygen uptake (VO_2max) is a measure of cardiorespiratory endurance because it is directly proportional to the maximal rate at which energy can be produced for longer-term physical activity. A compilation of studies on the VO_2max of boys and girls (ages 15-19 years) showed that there was no change in the VO_2max of boys from the 1930s into the mid-1990s. For girls, VO_2max values rose from the 1960s into the mid-1980s, declined again in the late 1980s and early 1990s, but the latest data shows a further rise in VO_2max. Contrary to the studies on VO_2max, studies on endurance running showed a secular decline in performance. On the 20-meter shuttle run, performance of boys and girls declined 0.43% per year over the last 20 years (1981-2000); for adolescent (17 and 18 year olds), the rate of decline was 0.75% to 1.0% per year. In a nation-wide sample, the 1-mile run times of 14 to 17 year old boys and girls, declined 15% and 11%, respectively, from 1980-1989.

With regard to muscular endurance, from 1958 to 1985 there was an increase in the proportion of 16 to 17 year old boys able to complete at least 5 pull-ups and 16- to 17-year old girls able to hold a flexed arm hang for at least 12 seconds. From 1980 to 1989 sit-up performance of 14 to 17 year old boys and girls increased by 9%. From 1980 to 1989, pull-up performance of 14- to 17-year old boys changed little; the performance of the girls on the flexed-arm hang improved substantially in 1986 then remained unchanged into 1989.

National surveys conducted by the National Center for Health Statistics provide trends in body weight and body mass index (BMI). Different investigations use slightly different definitions for overweight and obese but in general, for adults, BMIs of 25 to 30 kg/m^2 are defined as overweight and BMIs>30 kg/m^2 are defined as obese. There were only minor changes in the prevalence of overweight or obesity from 1960 to 1980. After 1980 the prevalence of both overweight and obesity has steadily increased into 2000. For 17-year olds and 20 to 29 year olds, temporal shifts towards higher BMI occurred in most BMI categories. However, by far the largest increases were among overweight or obese individuals.

To examine trends in physical activity, raw data was obtained from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System (BRFSS) and Youth Risk Behavior Survey (YRBS). The BRFSS involves a national telephone interview that collects self-reported, state-specific behavioral risk factor information from adults (ages ≥18 years). Data from the BRFSS from 1990 to 2002 indicates a decline in the number of 18-21 year olds reporting no physical activity in the last month. The YRBS is a self-administered questionnaire taken by high school students (grades 9 to 12) every 2 years in the spring from 1991 to 2001. Data from the YRBS indicated that there was a decline in the number of days youth performed intense physical activity from 1991 to 1997; the days of intense activity returned to the 1991 level in 1999 and 2001. The frequency of strengthening exercises among youth was higher in 1999 and 2001 compared to prior years. The number of days in physical education classes declined in 1995 and 1997 but returned to near 1991 levels in 1999 and 2001.

5. CHANGES IN THE PHYSICAL FITNESS OF U.S. ARMY RECRUITS. Studies examining the relative VO_2max (ml/kg/min) of male recruits on entry to service show no differences between 1975, 1978 and 1998; women had 4% to 8% higher relative VO_2max in 1998 compared to 1975 and 1978, respectively. Two-mile run times were 5% slower for men and to 6% slower for women in 2003 compared to 1988. Limited data on the muscle strength of new recruits showed that on 4 separate tests, maximum voluntary strength was 3% to 34% higher (depending on the muscle group examined) in 1998 compared to 1978 and/or 1983. Trends in the muscular endurance of new recruits were mixed: for men, push-ups (PU) performance improved from 1984 to 2003 but sit-up (SU) performance declined; for women, there was virtually no secular trend for PU or SU in this same time period. There were increases in body weight, BMI, body fat, and fat-free mass from 1978 to 1998 for both men and women. One study indicated that about ½ the body weight gain was from fat and about ½ from fat-free mass.

6. PHYSICAL FITNESS CHANGES DURING BCT. Fort Jackson provided Army Physical Fitness Test (APFT) raw scores and demographics for 14,499 men and 9,595 women who participated in BCT from May 1999 through April 2000. Most of the men and women were single (about 87%), white (about 60%); high school graduates (about 78%) and were in the Regular Army (about 62%). Black men made up about ¼ of the male sample and Black women 1/3 of the female sample. Men improved their PU, SU and 2-mile run performance by an average of 18 repetitions, 20 repetitions, and 2.9 minutes, respectively. This represented an average relative improvement of 56%, 47% and 17%, respectively. Women improved their PU, SU and 2-mile run performance by an average of 17 repetitions, 26 repetitions, and 3.8 minutes, respectively. This represented an average relative improvement of 189%, 77% and 18%, respectively. When the data were analyzed by the racial categories Black, White and Other, some differences emerged. For men, the "Other" racial category and Blacks performed more PU than White recruits at the start of training and generally maintained the difference throughout training. Male Black recruits performed more SU than White recruits at the start of training but White recruits had reduced the difference by the end of training. Female Black recruits ran slower than female White recruits at the start of training but Black recruits had reduced the initial time gap by ½ by the end of training.

7. GENERAL DISCUSSION. The review suggests that the VO_2max of male youth and recruits has not changed while that of female youth and recruits improved from the 1960s into the 1990s. Performance on endurance running tasks has declined (run times are slower). It may be that youth and recruits are not as proficient at applying their physiological capability (VO_2max) to performance tasks like runs for time possibly because of factors such as reduced experience with running, lower motivation, and/or environmental factors. There is some limited evidence that increased participation in sports and exercise is associated with the improvement in female youth and recruit VO_2max.

Limited data on Army recruits demonstrate an increase in strength from 1978 to 1998 that is consistent with the increase in strength training frequency reported in the YRBS and an estimated increase in muscle mass over the same time period. Among youth, young adults and recruits there is strong evidence that body weight and BMI have progressively increased since 1980 and this increase continues into the 2000s. Available evidence suggests that the increases in BMI and body weight are due primarily to an increase in caloric intake. Physical activity appears to have increased but this increase has apparently not been enough to offset the intake of food.

It is difficult to explain the lower PU and SU performance of White men compared to Black men. There was little literature on this topic. Black women demonstrated lower VO_2max, lower hemoglobin levels, greater smoking prevalence, and lower lung capacity than their White counterparts. These differences could account for some of the difference in run time at the start of BCT. During BCT, Black women improved their running speed at a faster rate than White women and the literature indicates that they have lower overall attrition during training.

8. SUMMARY AND CONCLUSIONS. Most physical fitness trends involving cardiorespiratory endurance, muscle strength, muscular endurance, body weight, and BMI can be modeled using linear regression. From a mathematical point of view there is little reason to think the trends cited above will not continue into the future. However, actions taken at the national level and supported by data on youth physical activity from the YRBS may suggest that there has been some moderation of unfavorable trends like the decline in running performance. A1996 U.S. Surgeon General's report highlighted the lack of physical activity among youth, young adults and adults. Increased self-reported youth physical activity and increased participation in physical education classes can be observed in the YRBS data after publication of this report and the attention generated by it.

There is currently no data indicating that the trend toward increased body weight and BMI will be mitigated. In 2001, the U.S. Surgeon General highlighted the trend in overweight and obesity with a publication and call to action that generated increased media attention regarding the topic. Whether or not this will influence the trends in overweight and obesity is not known at this point, but data from the National Health and Nutrition Examination Survey (NHANES) and BRFSS can be used to track future trends in body weight and BMI.

9. RECOMMENDATION. To track future trends in the fitness of the Army appropriate surveillance systems should be developed within the Army using the Army Physical Fitness Test (APFT) as the basis. The APFT is given on a regular basis in BCT and Advanced Individual Training (AIT) and twice a year in operational Army units. Databases already exist on many Army company and battalion-level computer systems that allow tracking individual soldier's weight, height, PU score, SU score, and run score. This system could be standardized in a user-friendly way so military units can obtain the information they need (e.g., who is overweight, who failed the APFT, who scored high on the APFT) while the data enters a broader Army surveillance system. The broader surveillance system would allow systematic tracking over time (and over soldiers' careers) of BMI, cardiorespiratory endurance, and muscular endurance.

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SECULAR TRENDS IN THE PHYSICAL FITNESS OF AMERICAN YOUTH, YOUNG ADULTS, AND ARMY RECRUITS

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1. REFERENCES. References used in this report are in Appendix A.

2. INTRODUCTION.

There is a perception that young Americans are less physically active and less physically fit than they have been in past years. Press reports cite the facts that young people are overweight, physically inactive, and are not obtaining proper nutrition (92,139). There is a concern that individuals are entering the military physically unprepared and this could have an impact on future readiness (18,30,139). However, some of these reports are based on anecdotal or self-reported information (18,30) and do not address objective measures of physical fitness. Other articles (92,139) cite specific problems but do not consider the broader scope of physical fitness. Physical fitness has many components (e.g., cardiorespiratory endurance, muscle strength, muscular endurance, body composition) and to effectively evaluate the fitness of young Americans each of these fitness components should be considered.

The Center for Accession Research (CAR) requested that the Army Center for Health Promotion and Preventive Medicine (CHPPM) assess the current and future state of fitness of Americans of recruiting age and determine potential changes in the physical fitness of this group. Specifically, the CAR asked the CHPPM to measure or estimate the current fitness level of the Army's prime market by gender and race examining both fitness level and fitness potential. In addition, it was requested that the future fitness level of the Army's prime market be determined. The Army prime market was defined as 17 to 21 year olds with a high school diploma. To accomplish the CAR request, CHPPM proposed to review the literature for studies that examined secular trends in the physical fitness of American youth and young adults. This would allow an examination of past and current trends in physical fitness that could be projected into the future. To determine fitness potential, the CHPPM proposed examining the literature and existing databases for information indicating how much fitness can be expected to change in Basic Combat Training (BCT). All new recruits participate in BCT and this provides the most realistic estimate of how much fitness can be expected to change in the short term once a recruit has entered military service.

This paper will first define physical fitness to achieve a common understanding of the term for the purposes of this paper. The civilian literature and available databases will then be examined to determine whether or not there have been changes over time (secular changes) in the physical fitness of American youth and young adults. Military studies and databases will then be reviewed both to examine secular changes in the fitness of new recruits and to examine how much physical fitness can be expected to change in BCT. After presenting this information inferences will be made on future trends in physical fitness.

a. Definitions. In this paper "youth" is used to refer to individuals who are less than 18 years of age. "Young adult" is used to refer to individuals 18 to 21 years of age. "Adults" refers to individuals over 21 years of age. Individuals <18 years of age are referred to as boys and girls. Individuals ≥18 years of age and older are referred to as men and women. Where populations or groups overlap, the predominate age group determines the use of a descriptive term.

b. Note on Data Analyses. At times, databases were obtained from a number of sources and secondary analyses were performed on these databases to answer specific questions. Where particular statistical techniques were used, these are described in the appropriate locations. Differences are generally calculated as: ((Final Value-Initial Value)/Initial Value) X 100%. A variety of curve fitting procedures were used to examine trends in various fitness measures over time including linear, polynomial, exponential, logarithmic, and power fits. With a few exceptions that will be discussed, a linear fit was able to account for almost as much variance as alternate fits. Alternatives to linear modeling generally added little explanatory information in all but a few cases.

3. DEFINING PHYSICAL FITNESS.

A review of the literature on youth physical fitness must necessarily start with a definition of the concept of physical fitness. There appears to be broad agreement on what constitutes physical fitness but different authors have defined the term in somewhat different ways (16,22,48,56,107,135). A commonly cited definition is "the ability to carry out daily tasks with vigor and alertness, without fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies" (1). Another definition is "a set of attributes that relate to the ability of people to perform physical activity" (91). The World Health Organization defined fitness as "the ability to perform muscular work satisfactorily" (16).

The term "physical fitness" implies the ability to move in an energetic, optimal, or at least satisfactory manner (i.e., "fitness") in the corporeal (i.e., "physical") environment. For human movement to occur, muscular contraction is needed and to accomplish a task, muscular contractions must be coordinated and goal directed. Physical fitness is not a single characteristic but has a number of attributes or components that can be identified and quantified. Based on these physical and physiological considerations a more appropriate definition of physical fitness might be a set of attributes that allows individuals to performance of purposeful, coordinated physical activity in a satisfactory manner.

These definitions provide a broad description of physical fitness but the concept can be further refined by describing the specific types of behaviors, attributes, or capabilities involved. These are termed the “components” of physical fitness and provide measurable constructs that can be used to quantify physical fitness. Fitness components were determined by presenting individuals with a broad array of physical tasks for which quantitative performance measures could be obtained. Correlational and factor analytic techniques were used to assemble the physical tasks into groups having a hypothetical common performance requirement. In a series of studies, a number of factors were identified and these have been categorized somewhat differently by different authors (13,25,39,40,41,54,95,107,145). There are at least three different approaches to characterizing fitness components that can be identified in the literature: the Ability Requirement Approach, the Physical Education Approach, and the Physiological Approach.

a. Components of Physical Fitness: Ability Requirements Approach

Fleishman and Quaintance (41) developed the Ability Requirement Approach, the general objective of which was to describe the fewest independent ability categories that are useful and meaningful in describing human performance on the widest variety of tasks. The physical proficiency factors described in Table 1 were identified using the factor analytic techniques described above (39,40,41,54,95). Note that the Ability Requirement Approach does not attempt to define physical fitness components *per se* but rather characterize human physical capabilities. The capabilities shown in Table 1 are those that require primarily physical rather than cognitive performance.

Table 1. Human Physical Capabilities Defined from the Ability Requirement Approach (from Reference Number 41)

Physical Capability	Definition
Stamina	Ability to sustain physical effort involving the cardiovascular system
Static Strength	Ability to exert maximal strength against a fairly immovable object
Dynamic Strength	Ability to exert muscular force repeatedly or continuously over time
Trunk Strength	Ability to exert muscular force of the trunk muscles repeatedly or continuously over time
Explosive Strength	Ability to expend a maximum of energy in one or a series of bursts
Gross Body Coordination	Ability to perform movements that simultaneously involve the entire body
Gross Body Equilibrium	Ability to maintain or regain body balance, especially where equilibrium is threatened
Extent Flexibility	Ability to extend or stretch the body
Dynamic Flexibility	Ability to move trunk and limbs quickly and through a wide range of motion

b. Components of Physical Fitness: Physical Education Approach

Physical educators (25,48,107) have distinguished between athletic fitness (also called motor or skill- related fitness) and health-related fitness. Athletic fitness involves a wide range of components involved in human movement ability. The smaller number of health-related fitness components are those demonstrated to be related to the improvement or maintenance of health. Table 2 shows the fitness components associated with athletic and health-related fitness (25,107). Corbin et al. (25) provides specific definitions for these fitness components and these definitions are shown in

Table 3. The health-related fitness components have been endorsed and adopted by epidemiologists (22).

Table 2. Components of Athletic and Health-Related Fitness (Modified from Reference Number 107)

Component	Athletic Fitness[a]	Health–Related Fitness[a]
Muscular Strength	Yes	Yes
Muscular Endurance	Yes	Yes
Cardiorespiratory Endurance	Yes	Yes
Flexibility	Yes	Yes
Body Composition	Yes	Yes
Power	Yes	No
Speed	Yes	No
Agility	Yes	No
Balance	Yes	No
Coordination	Yes	No

[a]A 'yes' indicates that the component of fitness in the row is included in the column definition (athletic or health-related fitness) while a 'no' indicates it is not

Table 3. Components of Physical Fitness Defined in the Physical Education Literature (from Reference Number 25)

Physical Capability	Definition
Muscular Strength	Amount of external force that a muscle [group] can exert
Muscular Endurance	Ability of muscle groups to exert external forces for many repetitions or successive exertions
Cardiorespiratory Endurance	Ability of the circulatory and respiratory systems to supply fuel during sustained physical activity
Flexibility	Range of motion available at the joint
Body Composition	Relative make up of the body in muscle, fat, bone and other vital parts
Power	Ability to transfer energy into force at a fast rate of speed
Speed	The ability to perform movements in a short period of time
Agility	Ability to rapidly change positions of the entire body in space with speed and accuracy
Balance	Maintenance of equilibrium while stationary or moving
Coordination	Ability to use the senses, such as sight or hearing, together with the body parts in performing motor tasks smoothly and accurately

c. Components of Physical Fitness: Physiological Approach

The Physiological Approach refines the Ability Requirement and Physical Education approaches by more accurately characterizing the components of fitness in terms of the physical principles involved, the energy systems recruited to fuel the activity, and the neuromuscular control necessary to accomplish the physical activity (44,55,75,91,135). Body composition is an important fitness component because the quantity and distribution of muscle, fat and other tissue will determine the capacity for optimal physical performance.

Muscle strength is the ability of a muscle group to exert a maximal force in a single voluntary contraction. An example is the ability to manually lift a box that contains as much weight as possible for an individual to lift. Energy is derived primarily from splitting phosphagen molecules from adenosine triphosphate (ATP) in the active muscles.

Muscular endurance is the ability of a muscle group to perform short-term, high-intensity physical activity. Early in the muscular endurance activity (first few seconds) energy will be derived from ATP and creatine phosphate (CP) but as the duration of the activity lengthens to more than a few seconds, energy will be derived from glycogen in the active muscles. Examples of muscular endurance events are 200-400 meter sprints, push-ups (PU), or manually lifting heavy boxes so that fatigue occurs relatively quickly (<1.5min).

Muscular power is related to muscle strength and muscular endurance but also involves a time component. Power is defined as force/time and thus muscular power is the ability of a muscle group to develop force quickly. If the activity is performed very quickly energy will be derived primarily from adenosine triphosphate (ATP) in the active muscles. If power is required for a short period of time (<10 sec), not only ATP but also creatine phosphate (CP) in the active muscle will be used as an energy source. Examples of maximal power events are quickly lifting a heavy weight (power lifting) or jumping up to reach the top of a wall. An example of a sustained power event is a short sprint (<30 sec).

Cardiorespiratory endurance is the ability to sustain long-term, low-power physical activity. Cardiorespiratory endurance depends on the functioning of the circulatory and respiratory systems. Energy is primarily derived from carbohydrates (glucose, glycogen) and lipids with minor amounts from protein. Carbohydrates and lipids are stored in the active muscles and other organs (liver, kidney, adipose tissue). Examples of cardiorespiratory events include long-distance running or manually lifting lighter boxes for several minutes or hours.

Body composition refers to the amount of various tissues in the body. Body composition can be quantified by a number of methods and the intact human body can be partitioned into compartments that include fat mass and fat-free mass (120). The fat-free mass compartment includes everything that is not fat and is composed primarily of muscle, bone, and mineral. Some techniques allow bone tissue to be partitioned out of fat-free mass so that 3 compartments (fat, bone, and lean tissue) can be distinguished and the remaining lean tissue compartment has a larger proportion of muscle tissue mass (88). Muscle mass is highly correlated with absolute strength (58,59,89), power production (51), cardiorespiratory endurance (136) and the performance of many physical tasks (52,136). Individuals with more fat tend to have more difficultly performing certain tasks, especially those requiring weight bearing activity and cardiorespiratory endurance (28,136).

Agility, balance and coordination involve muscular contraction and will recruit energy systems in proportion to the intensity of the contraction and the duration of the activity. However, neuromuscular control is a primary characteristic of tasks requiring agility, balance, or coordination. For example, consider an obstacle course. The ability to quickly move over, under and around obstacles requires the coordinated action (neuromuscular control) of a number of muscle groups. The movement is "agile" in proportion to its speed and to the extent that unnecessary movements are avoided (economical movement). In the case of balance, neuromuscular control is used to inhibit unwanted muscular contractions to obtain a required state of static (little or no movement) or dynamic (movement in a specific direction) equilibrium. For example, consider standing on a narrow board. The individual is "balanced" in proportion to his or her ability to sustain static muscular contractions that result in little or no movement on the board.

For convenience, fitness components are portrayed as discrete elements. However, many of these components, specifically muscular strength, muscular endurance, and cardiorespiratory endurance, actually exist on a continuum. This continuum is characterized by the intensity of the muscular contraction, the energy systems used, and how soon fatigue ensues. Very short term, very high intensity contractions that results in fatigue in a few seconds will recruit primarily ATP-CP. These involve primarily strength-type activities. High intensity contractions that results in fatigue in a longer period of time (20-90 seconds) will recruit ATP-CP early in the contraction but also glucose later in the contraction. As the intensity of the contraction further diminishes (<15% of a maximal voluntary contraction) and the time to fatigue increases (2 minutes to hours) more glucose and free-fatty acids (with small amounts of protein) will be utilized. Another way to picture this is that the intensity of muscle contraction is tied along a continuum to the time to fatigue and the energy source used.

d. Components of Physical Fitness: Consolidated Definition

Table 4 shows the common components of physical fitness in the Ability Requirement, Physical Education, and Physiological approaches based on a conceptual understanding of terms, physical measurements used, and the metabolism involved, where possible. Physical measures can be used to quantify individual differences in these fitness components and thus describe levels of fitness. While the approaches use somewhat different terms, the Ability Requirement Approach appears to closely match the Physical Education Approach for all components but body composition. The specific components of fitness described in the three approaches can be grouped into broader generic concepts for the purposes of this paper. The reason for this is that generic terms are more closely linked to the energy systems involved and the terms are more easily understood. The only fitness components measured in studies that examine secular trends in fitness include muscular strength, muscular endurance, and body composition, as will be discussed later.

While it is possible to link physiological energy systems with some components of fitness, this linkage for other components depends on the activity and the length of time the activity is performed. For example, a coordination/agility task requiring individuals to move quickly around a series of obstacles that takes an average of 30 seconds to complete at a maximal effort would involve primarily ATP-CP-glycogen. Longer agility events would recruit glucose and free fatty acids. Flexibility movements through a range of joint motion that takes 1-2 seconds to complete would require energy only from

ATP. If the movement is performed for longer periods of time other energy systems would be recruited.

Table 4. Comparison of Physical Fitness Components in Ability Requirement Approach, Physical Education Approach and Physiological Approach

Generic Term	Human Ability Category	Physical Education	Physical Measure	Energy System
Muscular Strength	Static Strength Explosive Strength	Muscle Strength Power (maximal)	Maximal force/power	ATP[a]
Muscular Endurance	Dynamic Strength Trunk Strength	Muscular Endurance Power (sustained) Speed	Short-term sustained force/power	ATP-CP[b] ATP-CP-Glycogen
Cardiorespiratory Endurance	Stamina	Cardiorespiratory Endurance	Speed/distance or long-term sustained force/power	Glycogen/Glucose/FFA[c]
Coordination	Gross Body Coordination	Agility Coordination	Speed/distance (deviation from desired movement)	[d]
Balance	Gross Body Equilibrium	Balance	Distance (deviation from desired posture)	[d]
Flexibility	Extent Flexibility Dynamic Flexibility	Flexibility	Distance (range of motion)	[d]
Body Composition		Body Composition	Mass (body tissue amount)	(related to tissue type)

[a]ATP= adenosine triphosphate
[b]CP=creatine phosphate
[c]FFA=free fatty acids; minor amounts of protein also used
[d]Varies depending on power output and length of time of movement

4. CONSIDERATIONS AND LIMITATIONS.

Having defined the components of physical fitness we can now look in the literature to see which studies have examined these components in relation to youth or young adult fitness and what databases are available to assist in this effort. However, there are several limitations. In order to examine secular trends it is necessary to have objective measures of the various components of physical fitness over time. Physical fitness testing began in the schools of the United States (U.S.) in the 1880s but testing did not become widespread until the 1950s when the American Alliance for Health, Physical Education and Recreation (AAHPER) established a widely used fitness evaluation. This test included events that measured both athletic and health-related fitness. In the late 1970s and early 1980s physical educators moved away from test events that measured athletic fitness and emphasized events that measured health-related fitness. Athletic fitness events measuring power (standing broad jump, softball throw), speed (50-yard dash), and agility (shuttle run) were deleted from test batteries. Tests that involved more health-related fitness components (e.g., cardiorespiratory endurance, muscle strength, body composition) were increasingly adopted. Individual events to measure these health-related components were sometimes changed as new knowledge developed. The movement towards health-related fitness events was due to an evolution in thinking in the physical education and medical communities that physical activity should be directed away from athletic performance and toward good health and the prevention of medical problems (3,26,107).

The changing of test items over time presents problems when examining secular trends. Even if 2 test items are measuring the same fitness component the 2 items cannot be reasonably compared because different tests produce different performance values. For example, consider the change on the AAHPER test from a 600-yard run on the 1975 test to a 1-mile run on the 1980 test (26). It is obvious that the run times on the 2 tests would be radically different. Attempts could be made to equate the two tests by regression analysis (assuming access to individual data) but this would be subject to some error for physiological (e.g., fatigue, energy systems used) and cognitive/psychological reasons (e.g., pacing, length of the test). The ranking of individuals on one test would not be expected to be exactly the same as the ranking of individuals on the other test. Because of these factors, the use of the regression approach would make detecting subtle temporal differences difficult to accurately assess.

A less serious problem than the changing of test items but a problem that is also important to consider is the elimination of athletic fitness events. In the early test batteries, events measuring athletic fitness components like power, speed, and agility were included. Secular comparisons of these items would have been useful because many of these fitness components are important from a military perspective. Examples of useful eliminated test events include the standing broad jump and the shuttle run. These events were included in the 1958 AAHPER test battery but not the 1980 test battery (107). The standing broad jump measures leg power (the ability of the legs to develop force rapidly). Individuals able to generate more leg power would be expected to propel their bodies higher into the air and thus more easily get over higher walls, a task often required of soldiers. The shuttle run is a measure of agility (the ability to rapidly change the direction of the body quickly and accurately). Soldiers may have to move quickly and nimbly toward an objective across terrain that contains debris or obstacles.

Another limitation of many studies of youth and young adult fitness is that they do not compile information according to age groups that would be of most use to the military. It would be ideal if fitness information were reported on high-school graduates 18 to 21 years of age (Army's prime market). However, studies often collect fitness data on high-school aged individuals (generally 15 to 18 years of age) because this is an easily defined population that can be accessed for fitness testing at high schools located in every community in America. For the purposes of this paper, this represents only the youngest of the Army's prime market and individuals who have not yet achieved their high school diplomas. A few studies have examined adults over age 18 but virtually no study specifically examined the 18 to 21 year old age group. Some studies include age groups that approximate the Army's prime market and other studies provide age groups in 1 year increments. In some cases it was possible to access databases that allowed analyses of military age groups. Where possible, this paper highlights information that approximates the Army's prime market.

5. SECULAR CHANGES IN YOUTH AND YOUNG ADULT FITNESS.

a. Early Secular Trends

The AAHPER youth fitness tests were first introduced in 1957/1958. A comparison of scores on this early test battery to a similar test battery in 1965 showed that test scores were higher in 1965 (26,57). However, this comparison may not have been valid. In 1958 the AAPER test battery appears to have been introduced with little announcement or preparation. By 1965, the test battery was well known and it was possible to prepare students for testing (26,81). Test items in common in 1958 and 1965 included sit-ups (SU) (straight leg), shuttle run, 50-yard dash, long jump, softball throw, 600-yard run/walk, and pulls ups (boys only).

Hunsicker and Reiff (57) evaluated fitness changes in a nationally representative sample of 10 to 17 year olds in 1958, 1965 and 1975. Comparisons with the 1958 test may not have been valid for the reasons cited above. Test items in common in 1965 and 1975 included the 600 yard run, standing long jump, shuttle run, 50-yard dash, pull-ups (boys) and flexed arm hang (girls). For boys, there were no differences between the 1965 and 1975 scores among 40 comparisons (8 age groups and 5 tests) except for a lower score on the long jump for 14-year-old boys. The girl's data showed significant gains in 7 of 40 comparisons including the 600-yard run for 13, 14, 15 and 17 year olds, the long jump for 13 and 14 year olds and flexed arm hang for 14 year olds.

Corbin and Pangrazi (26) expanded the work of Hunsicker and Reiff (57) by performing a historical review of fitness tests administered from 1958 to 1985. Again, comparisons with the 1958 test may not have been valid. Corbin and Pangrazi compared performance on test events from 1975 to 1985. Items in common on the two test dates included a shuttle run, 50-yard dash, long jump, 600-yard run, pulls ups (boys) and flexed arm hang (girls). Scores on the 2 test administrations were similar with only 9 of 64 age and gender comparisons showing significant differences. There were some improvements on some events (shuttle run for 16 and 17 year old boys) and some decrements (50-yd dash for 16 year old girls). Unfortunately, the authors did not provide data on all the test items so changes from 1975 to 1985 could be more closely identified.

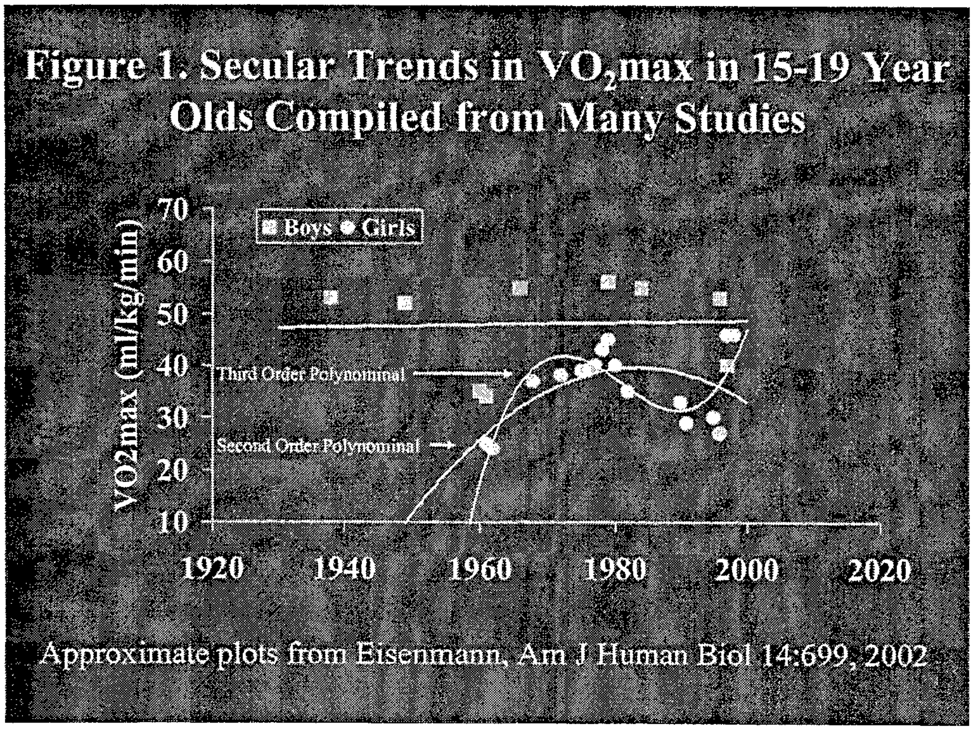
b. Cardiorespiratory Endurance

Maximal oxygen uptake (VO_2max) is the highest rate at which oxygen can be taken up and used by the body during physical activity (12). The faster rate of oxygen usage, the faster the rate of energy production to fuel longer-term physical activity. Oxygen used by the body is directly linked to energy production. One liter of oxygen taken up by the body is the energy equivalent of 4.85 kilocalories produced from fats, carbohydrates, and protein. Thus, VO_2max is a measure of cardiorespiratory endurance because it is a direct measure of the maximal rate at which energy can be supplied to fuel longer-term physical activity (76).

VO_2max can be measured either absolutely as liters of oxygen consumed by the body per minute (L/min) or relative to body weight as liters of oxygen consumed by the body per kg of body weight per minute (L/kg/min). The relative VO_2max provides a measure of how much aerobic capacity an individual has considering his or her body weight. If two individuals have the same absolute VO_2max, the lighter individual would have a higher relative VO_2max. The lighter individual is moving a smaller body mass and would be able to perform more physical activity because the proportion of the aerobic capacity not used to move his or her body weight can be used for external physical activity. When VO_2max is mentioned in this report, the reference is to relative VO_2max.

One study (32) reviewed research papers that had examined changes in VO_2max of boys and girls ages 6 to19 years. The authors only examined direct measures of VO_2max and no predicted data was included in their analyses. Most studies involved treadmill testing but in some cases bicycle ergometer data was used. When bicycle data was used, a correction factor was applied so that the bicycle VO_2max values approximated those of treadmill values. Studies of boys were available from the 1930s to the mid-1990s while studies on girls were available from the 1960s to the mid-1990s. Figure 1 shows the data for 15-19 year old boys and girls replotted from the article. The values in the Figure 1 are approximate because they had to be estimated from a graph in the original article. For boys, VO_2max changed little over the 60 year period. For the girls, the authors of the paper fitted the values to a second order polynomial equation (shown on Figure 1) and suggested that VO_2max of the girls rose from the 1960s into the 1980s then declined after that. However, if the data is fitted to a third order polynomial equation (shown in Figure 1) a different conclusion can be reached. In this case, VO_2max values rose from the 1960s into the 1970s and 1980s, declined again in the late 1980s and early 1990s, but the latest data shows a rise in VO_2max. The r^2 for the second order polynomial was 0.28 while that for the third order equation was 0.63.

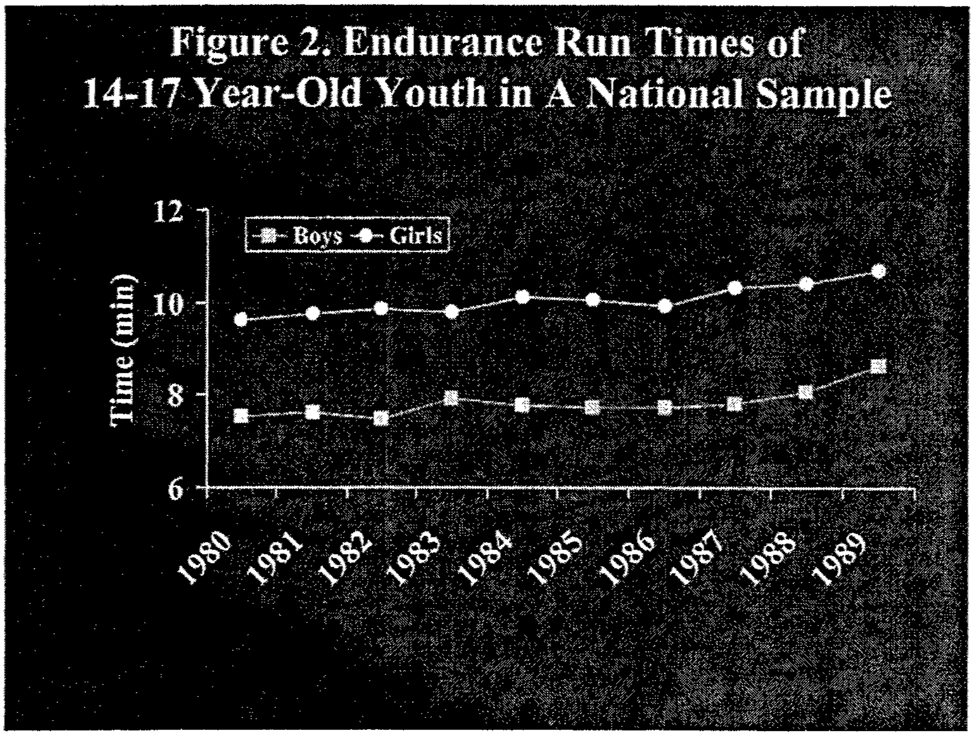
Tomkinson et al. (130) examined secular trends in the performance of the 20-meter shuttle run of children and youth. The 20-meter shuttle run involves running back and forth a distance of 20 meter at a speed established by a metronome. The initial running speed is either 8 km/h (5 mile/hr) or 8.5 km/hr and speed is increased by 0.5 km/hr (0.3 miles/hr) each minute. In reviewing a total of 55 studies from 11 countries, Tomkinson et al. estimated that 20-meter running speed of boys and girls had declined 0.43% per year over a 20 year period (1981-2000). In adolescents (17 and 18 year olds), the rate of decline was 0.75% to 1.0% per year in the same time period.



Updyke (132) reported on "endurance run" times of 10 to 17 year old boys and girls from 1980-1989. Over 12,000 students were sampled each year across the U.S. The distance of the "endurance run" is not clear from the original article but another article indicated that the run was 1 mile in length (81). Figure 2 shows that for 14 to 17 year olds, run times were increasing over the years. Overall changes from 1980 to 1989 are shown in Table 5.

Table 5. One-Mile Run Times of 14 to 17 Year Old Boys and Girls in a National Sample (estimated from Reference Number 132)

Year	Boys	Girls
1980 (min)	7.5	9.7
1989 (min)	8.6	10.7
Change (min)	1.1	1.0
Change (%)	14.7	10.3



c. Muscular Endurance

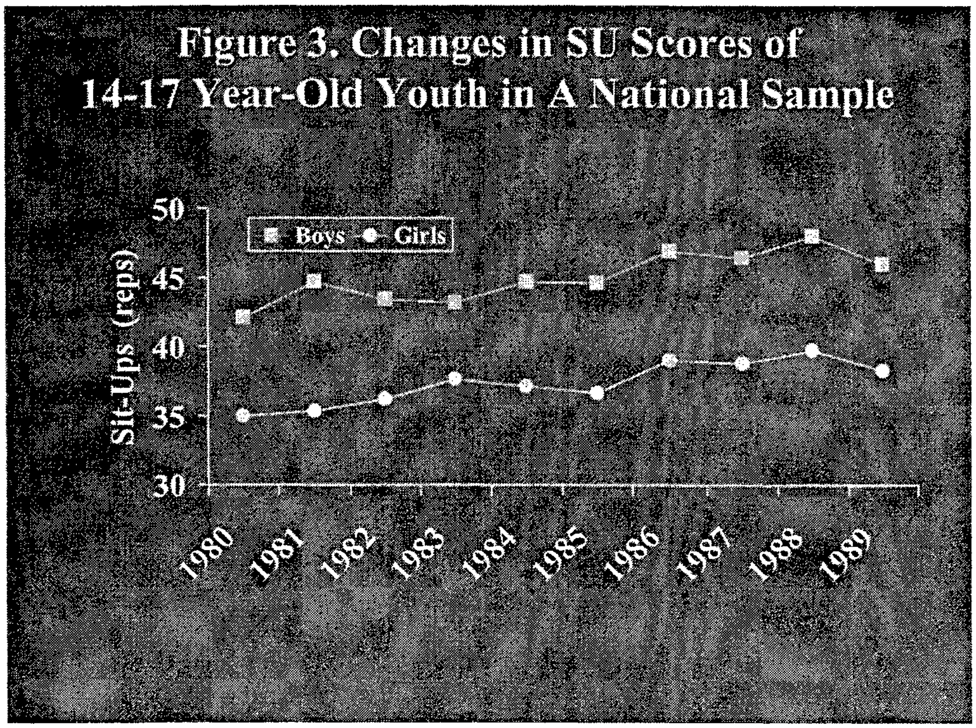
Corbin and Pangrazi (26) compiled data on pull-ups and flexed arm hang from several national tests administered from 1958 to 1985. Table 6 shows the proportion of 16- to 17-year old boys able to complete at least 5 pull-ups and 16- to 17-year old girls able to hold a flexed arm hang for at least 12 seconds. Because early data (1958-1975) was only in 5% increments this is all that could be presented in the table; more precise data was available for 1985. It can be seen that for other than 1958 (where results are questionable as noted above) the general trend from 1965 to 1985 is a greater proportion of boys and girls meeting the criteria.

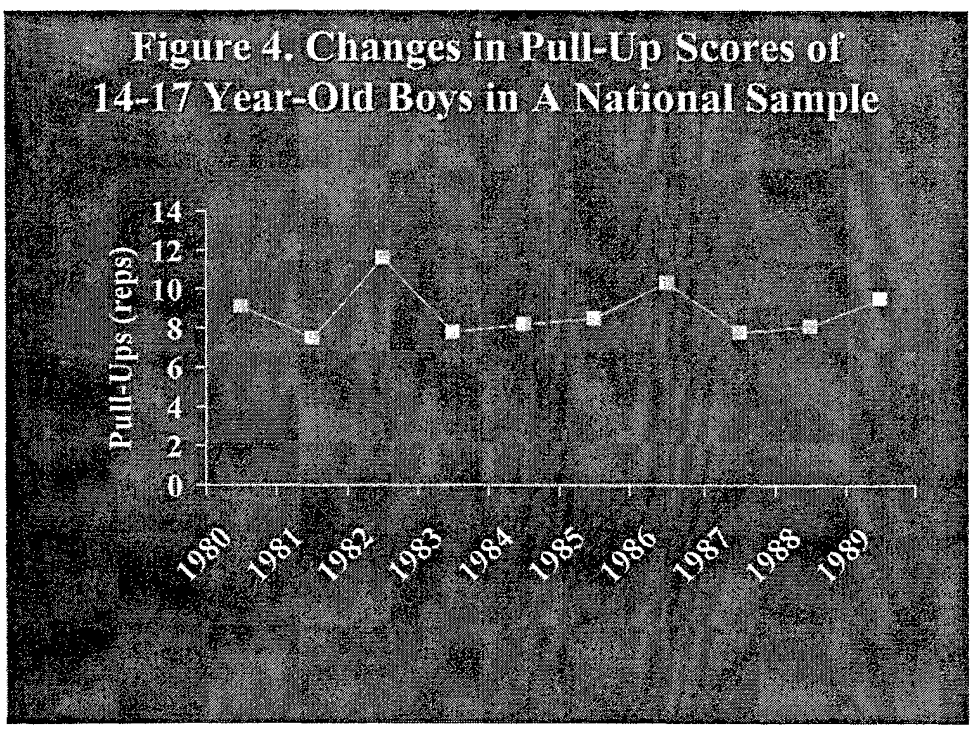
Table 6. Pull-up and Flexed Arm Hang of 16 to 17 Year Olds

	Age(yrs)	1958	1965	1975	1985
Men--Pull Ups	16	55	65	70	72
(% performing 5)	17	60	70	70	76
Women--Flexed Arm	16	[a]	30	30	38
Hang (% holding 12 sec)	17	[a]	30	35	37

[a]No test given this year

Another study (132) examined three measures of muscular endurance among 10 to 17 year olds boys and girls from 1980 to 1989. The measures included SU, pull-ups (boys) and flexed arm hang (girls). The methods used to conduct the test were not specified in the article but the study involved over 12,000 students each year sampled across the nation. Figure 3 shows the SU performance in the years of the tests. The general trend is an increase in performance over time with 9% higher performance in 1989 compared to 1980 for both boys and girls. Figure 4 shows changes in pull-up performance over time. There appears to be little change over time. Finally, Figure 5 shows the performance of the girls on the flexed-arm hang. In 1986 performance rose substantially and then reached a plateau that was maintained into 1989.





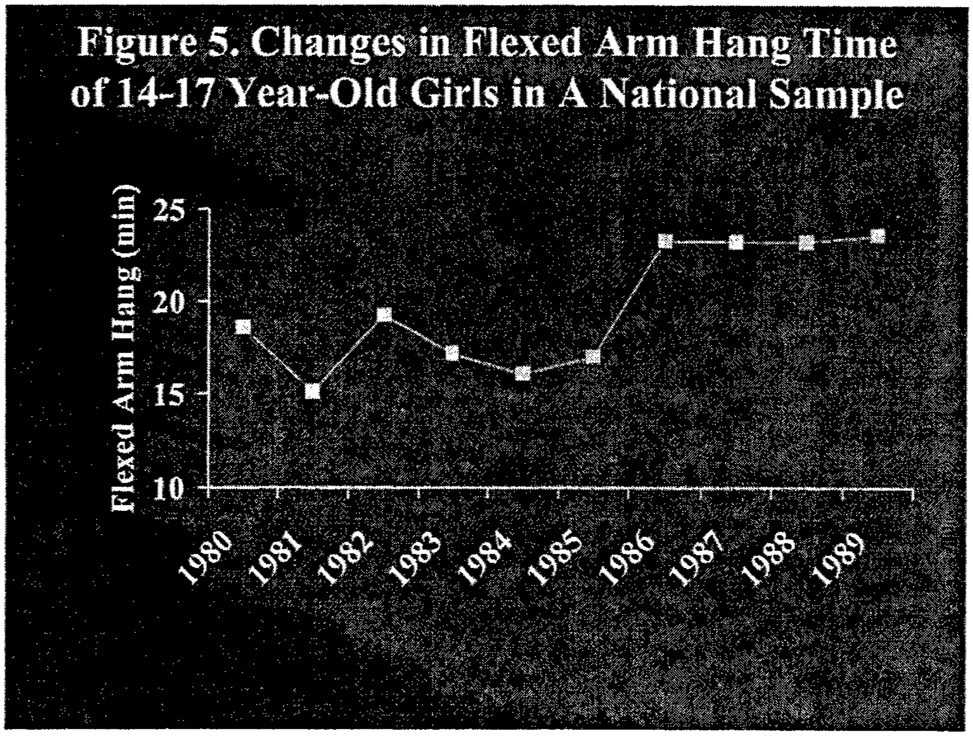


Figure 5. Changes in Flexed Arm Hang Time of 14-17 Year-Old Girls in A National Sample

d. Weight, Body Mass Index, and Body Composition

In contrast to the limited number of studies on secular changes in cardiorespiratory endurance and muscular endurance, there is a plethora of well-designed investigations examining changes in various aspects of body composition. National surveys have been conducted that provide trends in body weight, body mass index (BMI) and, to a limited extent, estimates of body fat. These surveys were conducted by the National Center for Health Statistics and examined samples representative of the U.S. civilian non-institutionalized population. Individuals were selected for examination using a complex, stratified, multistage probability cluster sampling design. Table 7 shows these surveys, approximate sample sizes, age groups examined, and the dates in which the surveys were conducted. The National Health Examination Survey (NHES) was designed to gather data on specific diseases using standard diagnostic criteria. Both interviews and physical examination were conducted to obtain physical and physiological measures including directly measured height and weight (133). The National Health and Nutrition Examination Survey (NHANES) collected health and nutrition data by interview and physical examination and also contains directly measured height and weight. Prior to 1999, NHANES was performed periodically but beginning in 1999, data were collected yearly (36,103; www.cdc.gov/nchs/nhanes.htm).

Table 7. National Health Surveys (from References Numbers 50,103 and CDC website[a])

Survey	Sample Size (approx n)	Ages (years)	Year
NHES I[b]	7800	18-79	1959-1962
NHES II[b]	7400	6-11	1963-1965
NHES III[b]	7500	12-19	1966-1970
NHANES I[c]	32,000	1-74	1971-1974
NHANES II[c]	28,000	0.5-74	1976-1980
NHANES III[c]	34,000	>0.2	1988-1994
NHANES 1999-2000[c]	10,000	[d]	1999-2000

[a]www.cdc.gov/nchs/nhanes.htm
[b]NHES=National Health Examination Survey
[c]NHANES=National Health and Nutrition Examination Survey
[d]No age limit was established

(1) Body Weight and Body Mass Index

There appears to be strong evidence of increasing body weight and BMI in youth and young adults in the published peer-reviewed medical literature using data from NHES and NHANES (23,36,37,38,45,50,103,118). Since the published NCHS studies used the same national surveys it would seem possible to make direct comparisons among studies (36,37,38,103). However, these same investigations used different (though similar) definitions of overweight and obesity. Further, they used different age grouping presenting problems for the present purpose which is to identify fitness trends of individuals in the Army's prime market. Table 8 shows the age groupings and the definitions used for overweight, obesity, and other concepts in the NCHS studies.

Table 8. Definitions of Overweight and Obese Used in NCHS[a] Studies

Study (Reference Number)	Age Groupings (numbers are years of age)	Group	Definition for Group[b]
36	20-29, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80	Overweight or Pre Obese	BMI 25.0-29.9 kg/m^2
		Obese	BMI≥30.0 kg/m^2
		Class 1 Obesity	BMI 30.0-34.9 kg/m^2
		Class 2 Obesity	BMI 35.0-39.9 kg/m^2
		Class 3 Obesity	BMI≥40.0 kg/m^2
38	Every year 6 to 17, then 20-29, 30-39, 40-49, 50-59, 60-69, 70-74	Obese (Adults≥20 years)	BMI≥30.0 kg/m^2
		Overweight (Children and Adolescence)	BMI≥95th percentile for age and gender
37	Varies: 20-74, ≥20, 10 and 20 year groupings	Overweight	BMI ≥25.0 kg/m^2
		Obese	BMI≥30.0 kg/m^2
		Extremely Obese	BMI≥40.0 kg/m^2
103	0.5-2, 2-5, 6-11, 12-19	Overweight	BMI≥95th percentile for age
		At Risk of Overweight	BMI 85th to 95th percentile for age

[a]NCHS=National Center for Health Statistics
[b]BMI=Body Mass Index

Despite the problems mentioned above, it is possible to see broad secular trends. Table 9 shows that there were only minor changes in the prevalence of overweight from 1966 to 1980 for individuals 12 to 19 years of age. However, after 1980 the prevalence of overweight increased (23,103). As Tables 10 and 11 show, the obesity trends for adult men are similar to those of the 12 to 19 year olds; however, there is no increase in the proportion of overweight adult men. Adult female obesity and overweight shows a steady increase in prevalence from 1960 to 2000 but the prevalence of obesity increased more after 1980 than in previous years (36,37). The general picture from these studies is an increase in overweight and obesity that in most cases began after 1980.

Table 9. Secular Trends in the Prevalence (%) of Overweight (BMI≥95th percentile for age) in 12- to 19-Year Olds (From Reference 103)

	NHES III (1966-1970)	NHANES I (1971-1974)	NHANES II (1976-1980)	NHANES III (1988-1994)	NHANES (1999-2000)
Boys	4.5	6.1	4.8	11.3	15.5
Girls	4.7	6.2	5.3	9.7	15.5

Table 10. Secular Trends in Prevalence (%) of Overweight (BMI 25.0-29.9) and Obesity (BMI≥30.0) in 20 to 29 Year Olds (From Reference 36)

BMI Category	Gender	NHES I (1960-1962)	NHANES I (1971-1974)	NHANES II (1976-1980)	NHANES III (1988-1994)
Overweight (BMI=25.0-29.9)	Men	30.8	30.6	28.8	30.6
	Women	10.9	15.0	16.0	18.5
Class 1 Obesity (BMI 30.0-34.9)	Men	6.6	5.9	6.0	8.4
	Women	4.4	4.9	6.0	8.6
Class 2 Obesity (BMI 35.0-39.9)	Men	2.4	1.7	1.8	2.9
	Women	1.0	2.2	1.9	4.3
Class 3 Obesity (BMI ≥40.0)	Men	0.0	0.5	0.3	1.2
	Women	0.7	1.1	1.1	1.8

Table 11. Prevalence (%) of Obesity (BMI≥30.0) in 20 to 39 Year Old Men and Women (37)

	NHES I (1960-1962)	NHANES I (1971-1974)	NHANES II (1976-1980)	NHANES III (1988-1994)	NHANES 1999-2000	Δ (NHANES II to NHANES 1999-2000)	Δ%(NHANES II to NHANES 1999-2000)
Men	9.8	10.2	9.8	14.9	23.7	13.9	141.8
Women	9.3	11.2	12.3	20.6	28.4	16.1	173.1

Flegal and Troiano (38) examined changes in mean BMI and the distribution of BMI for children and adults from NHES II/III to NHANES III. Mean BMI values are shown in Table 12 for ages 17 and 20 to 29 years (relevant to this discussion). It is apparent that mean BMI is increasing in both age groups and both genders during this 29-year period. Prevalence of overweight (BMI≥95th percentile age and gender adjusted) increased 2.9-fold for 15 to 17 year-old boys and 1.7-fold for the same aged girls. An interesting aspect of this study involved plotting of curves that showed differences between the surveys. By doing this, it was demonstrated that among 17-year olds and 20 to 29 year olds, shifts towards higher BMI occurred at most BMI levels. However, by far the largest increases in BMI were at BMI levels indicative of overweight or obesity. This indicated that the most overweight or obese became more overweight or obese.

Table 12. Average BMI in Youth and Adults (From Reference Number 38)

Age (years)	Men				Women			
	NHESIII BMI (kg/m^2) (1966-1970)	NHANESIII BMI (kg/m^2) (1988-1994)	Δ (kg/m^2)	Δ (%)	NHESIII BMI (kg/m^2) (1960-1962)	NHANESIII BMI (kg/m^2) (1988-1994)	Δ (kg/m^2)	Δ (%)
17	22.1	23.4	1.4	6.3	21.7	23.3	1.6	7.4
20-29	24.3	25.2	0.9	3.7	23.1	24.3	1.1	4.8

Another source of height and weight data is the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS involves a national telephone interview that collects self-reported state-specific behavioral risk factor information from adults (ages 18 plus) to assist state health agencies. The survey began in 1984. By 1990 there were 45 states participating and by 1994 all states plus the District of Columbia participated. Questions on self-reported height and weight are included in the survey and the exact questions asked are in Appendix B. It should be noted that when individuals self-report height and weight they tend to overestimate height and underestimate weight; the underestimate in weight increases in proportion to the degree of overweight (98,106,122). These errors are generally not large but they would result in lower BMI values and this error would increase with increasing overweight. Despite these problems, the data are consistent with the published NCHS findings in that BMI appears to be increasing over time. Figure 6 shows data from the BRFSS obtained from the CDC website (https://apps.nccd.gov/brfss/trends). The proportion of 18 to 34 year olds classified as overweight (BMI 25.0-29.9 kg/m^2) or obese (BMI≥30.0 kg/m^2) increased in the 12 year period from 1990 to 2002. Also note that the proportion of those who are obese is increasing at a faster rate than those who are overweight. Consistent with the data of Flegal and Troiano (38), the obese are getting more obese.

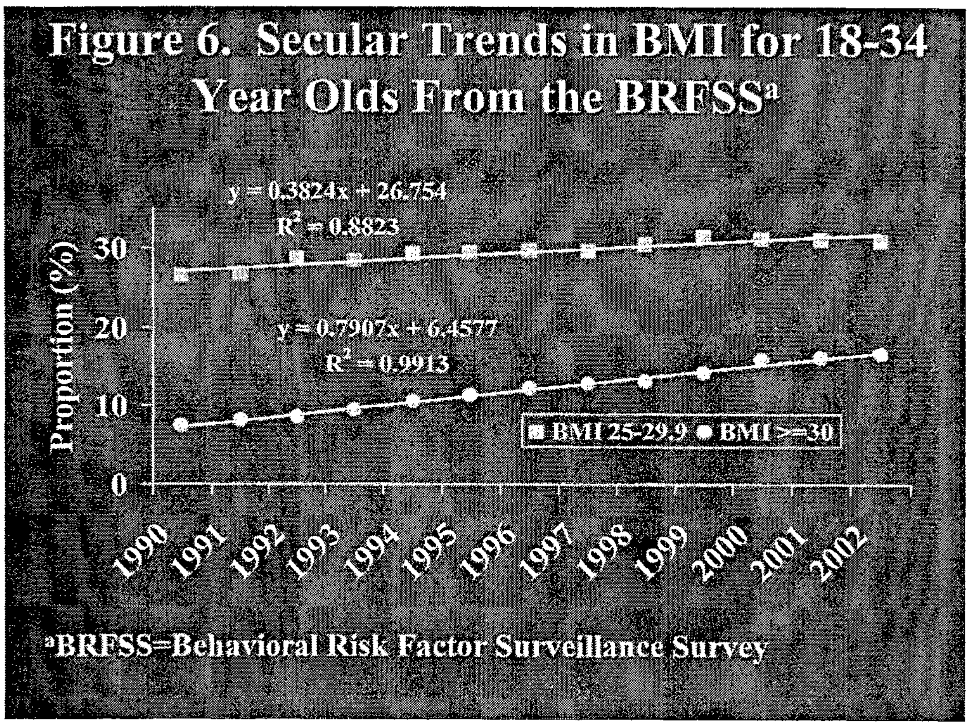


Figure 6. Secular Trends in BMI for 18-34 Year Olds From the BRFSS[a]

[a]BRFSS=Behavioral Risk Factor Surveillance Survey

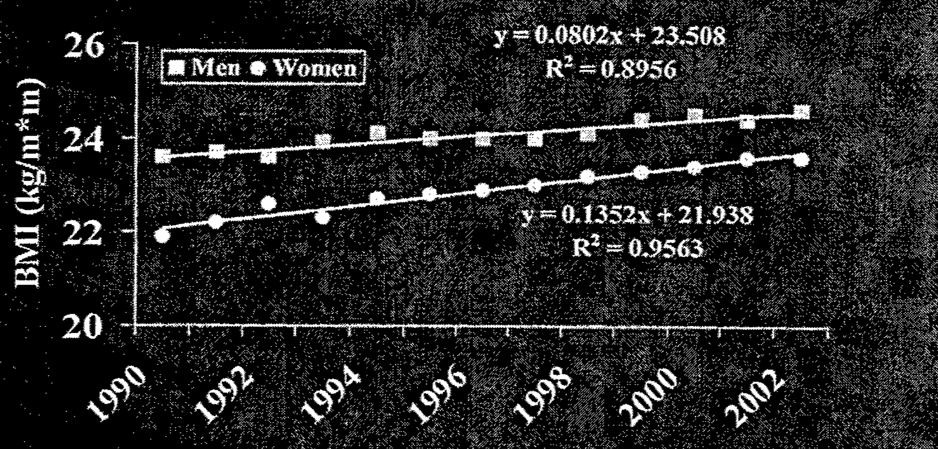
We obtained the raw data from the BRFSS and analyzed trends in BMI for individuals aged 18 to 21 years (those that approximate the Army prime market). Figure 7 shows that the average BMI for this age group was increasing over time. The average BMI of women increased at a faster rate than that of men. Figures 8 and 9 show the trends in the proportion of men and women, respectively that are overweight or obese. In consonance with the CDC data on 18 to 34 year olds, the proportion of overweight and obese young adults were progressively rising for both men and women.

Beside the BRFSS and NCHS studies another study (132) of American youth examined body weight and height of 10 to 17 year olds from 1980 to 1989. The period

1980 to 1989 is critical because it appears to be the years when the prevalence of overweight and obesity began to accelerate. Over 12,000 students were sampled each year across the U.S. Results showed little difference in weight between 1981 and 1983 for 14 to 17 year old boys and girls, but weight steadily increased after this. Over the 10 year period boys gained 5 pounds (a 3% increase) while girls gained 7 pounds (a 6% increase). Figure 10 shows changes in BMI from a secondary analysis of data provided in the article (132). Except for a sharp (presumably anomalous) rise in BMI in 1981, the general trend is a progressive increase in the BMI value for both boys and girls. The BMI difference from 1980 to 1989 was 7% for boys and 6% for girls.

Kuntzleman and Reiff (81) compiled changes in body weight of 6- to 17-year old American youth from reports of the U.S. Department of Agriculture and U.S. Department of Health, Education and Welfare (Public Health Service). Table 13 shows changes over time for 16 and 17 year olds. These data show that from about 1937 to 1987 (50 years) mean body weight of 17 year old boys and girls increased 11%.

Figure 7. Secular Trends in BMI for 18-21 Year Old Men and Women (BRFSS[a])



[a]BRFSS=Behavioral Risk Factor Surveillance Survey

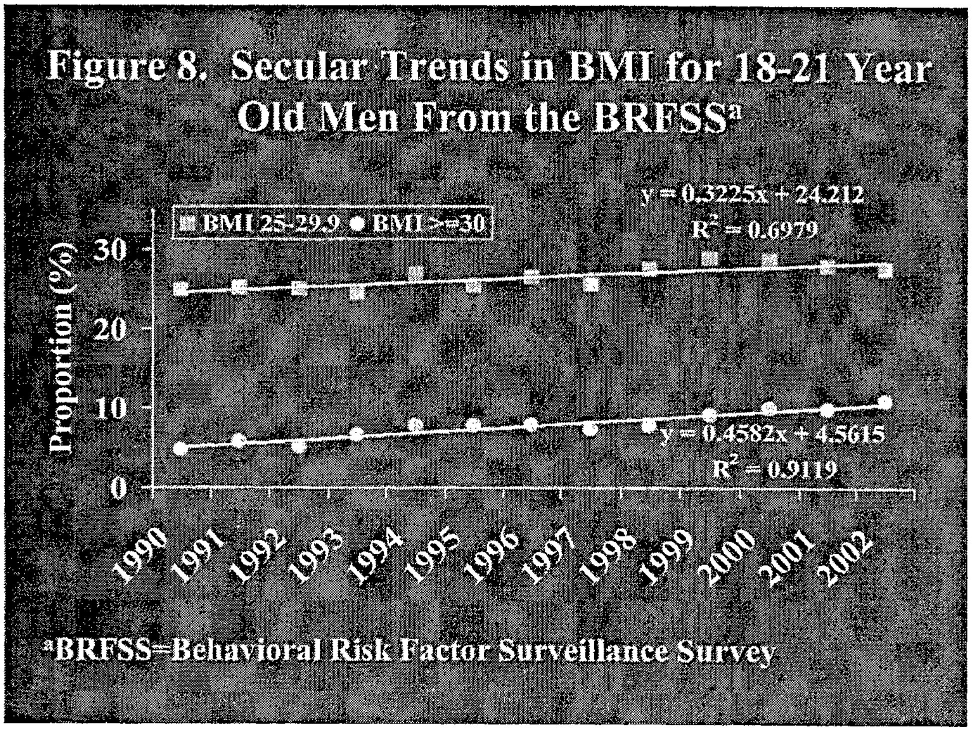


Figure 8. Secular Trends in BMI for 18-21 Year Old Men From the BRFSS[a]
BMI 25-29.9 ● BMI >=30
y = 0.3225x + 24.212
R² = 0.6979
y = 0.4582x + 4.5615
R² = 0.9119
Proportion (%)
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
[a]BRFSS=Behavioral Risk Factor Surveillance Survey

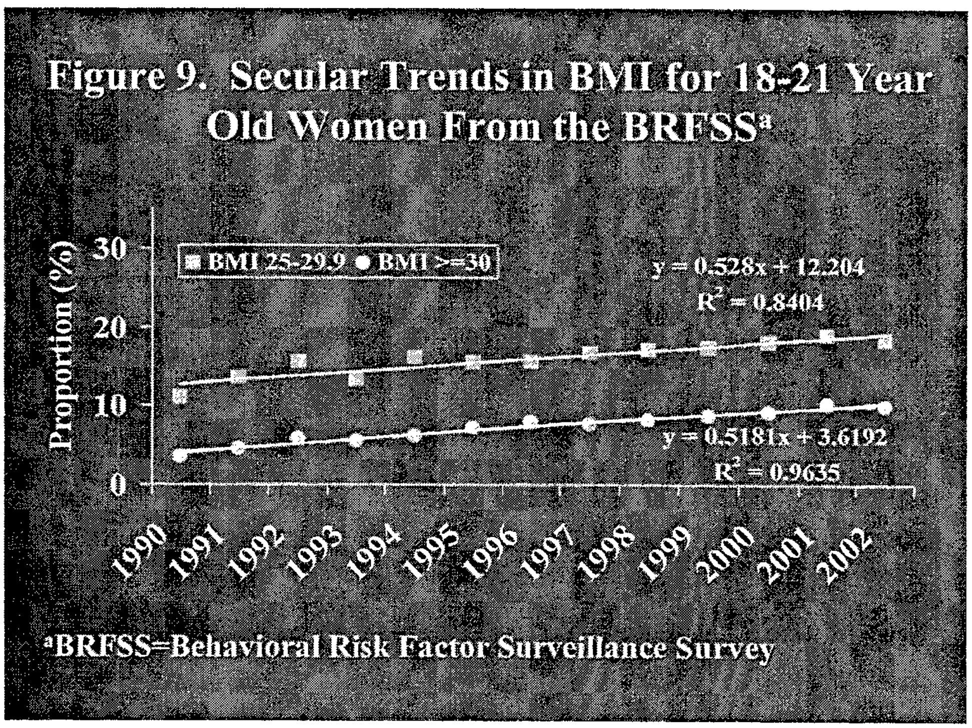


Figure 9. Secular Trends in BMI for 18-21 Year Old Women From the BRFSS[a]
BMI 25-29.9 ● BMI >=30
y = 0.528x + 12.204
R² = 0.8404
y = 0.5181x + 3.6192
R² = 0.9635
Proportion (%)
30
20
10
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
[a]BRFSS=Behavioral Risk Factor Surveillance Survey

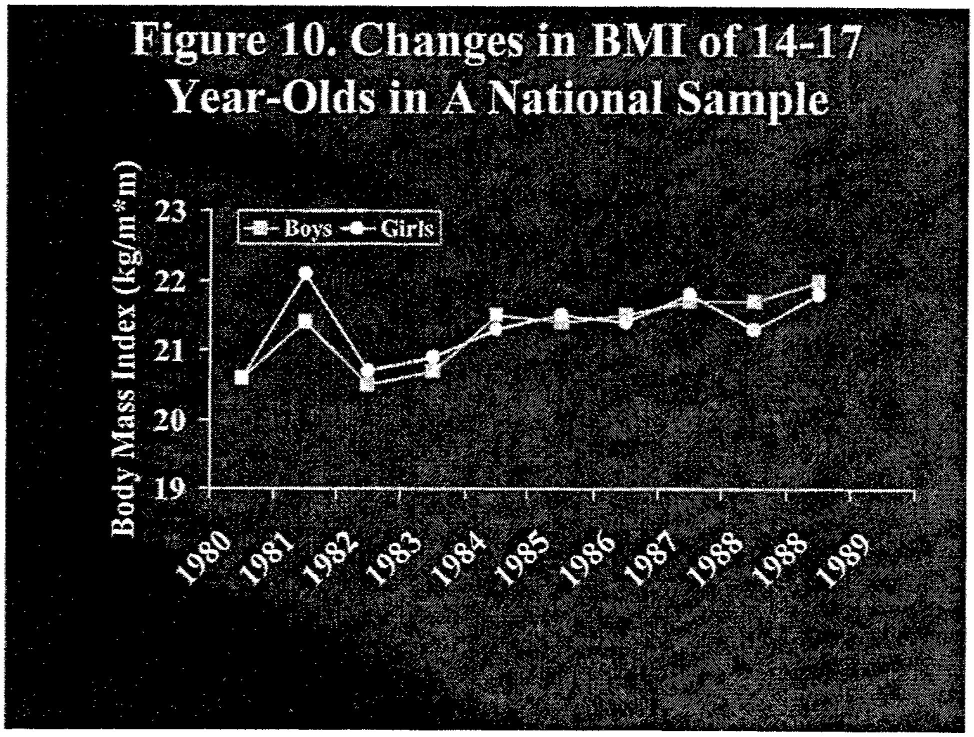


Figure 10. Changes in BMI of 14-17 Year-Olds in A National Sample

Table 13. Secular Changes in Mean Body Weight of 16- and 17-Year Old Boys and Girls from Public Health Service Data (from Reference Number [Kuntzleman, 1992 #1321)

Gender	Age (yrs)	1937-1939 (kg)	1963-1970 (kg)	1985-1987 (kg)
Boys	16	60	65	67
	17	63	68	70
Girls	16	53	58	57
	17	53	57	59

(2) Body Fat

One study (45) has examined temporal trends in triceps skinfold thickness which provides an estimate of body fat (64,142). This study used data from NHES III, NHANES I and NHANES II. Obesity was defined as triceps skinfold >85th percentile in NHES II or III; superobesity was defined as a triceps skinfold ≥95th percentile in NHES II or III[a]. Table 14 shows that among 12 to 17 year olds, the prevalence of obesity by these definitions has been increasing steadily since the 1963 to 1970 period. It should be pointed out that skinfolds can be highly variable and depend on the skill of individuals taking the measures (119).

Table 14. Prevalence (%) of Obesity[a] and Superobesity[b] in 12- to 17-Year Old Boys and Girls (From Reference Number 45)

Concept	Gender	NHESIII (1963-1970)	NHANES I (1971-1974)	NHANES II (1976-1980)
Obesity	Boys	15.5	16.3	18.3
	Girls	16.1	23.9	25.5
Super Obesity	Boys	5.2	7.1	7.3
	Girls	5.8	9.7	10.8

[a]Obesity defined as skinfold ≥85th percentile of age and gender in NHES II or III
[b]Superobesity defined as skinfold ≥95th percentile of age and gender in NHES II or III

[a] There were actually 2 surveys on which the percentile rankings were based. Only 1 is discussed here.

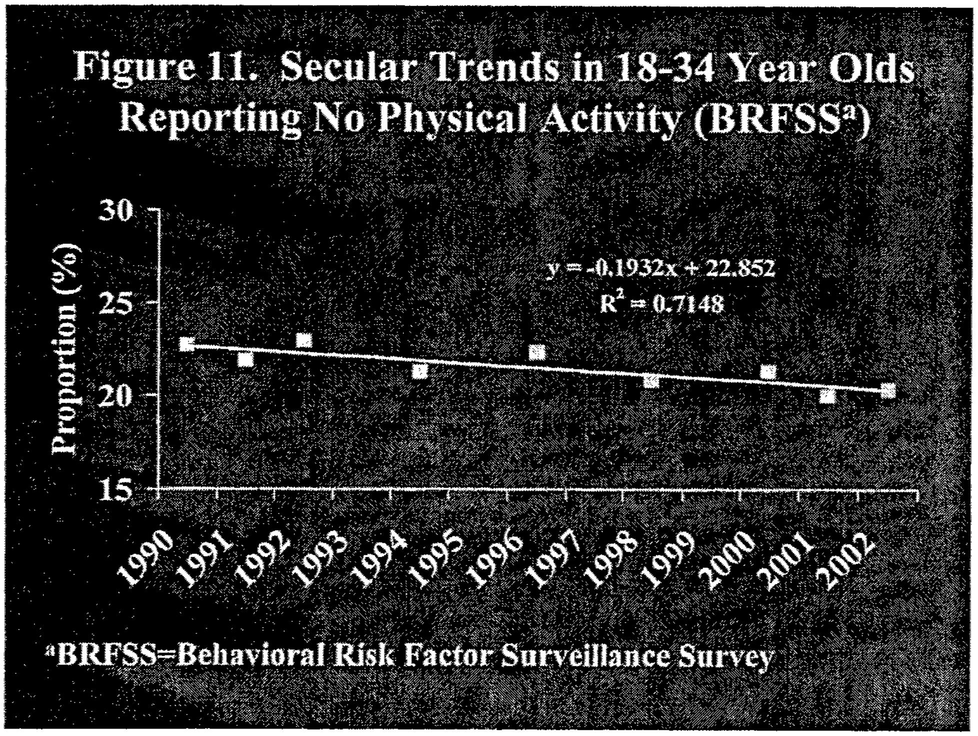
e. Composite Fitness Study

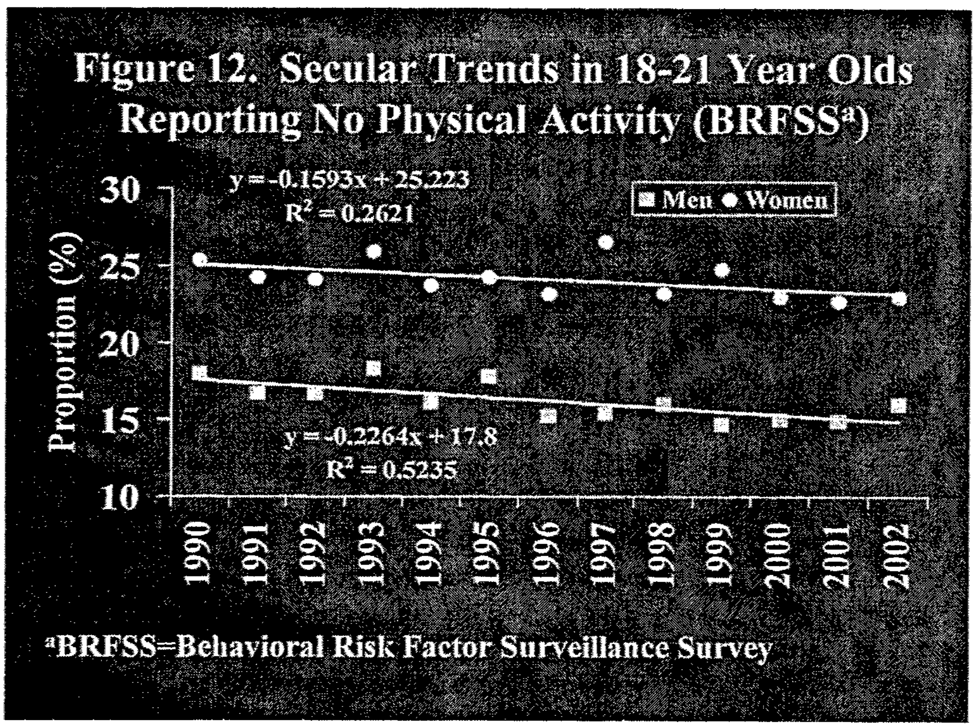
One study (4) performed a cross-sectional analysis of physical fitness in college freshmen in 1987 (n=236) and 1997 (n=257) at a large Southeastern city (presumably Atlanta GA). Participants (average ages 18 to19 years) were enrolled in an introductory health education course. The fitness test score was a composite of health-related fitness components plus resting heart rate and blood pressure. Each test event contributed a varying percentage to the total score as follows: skinfold body fat estimate (25%), grip strength (5%), SU in 1 minute (10%), sit-and-reach flexibility test (10%), resting heart rate (5%), blood pressure (10%), and a 1.5 mile walk-run test (35%). Unfortunately, scores on individual test items were not reported. Scores for each component were based on age- and gender-adjusted norms. Body weight of the men and women increased about 3% from 1987 to 1997. The composite fitness scores of the men did not differ between 1987 and 1997 but the composite fitness score of the women was over 20% higher in 1997.

f. Physical Activity

Physical activity can be defined as "any bodily movement produced by muscular contraction that results in energy expenditure" (16,22). Physical activity of sufficient intensity, duration, frequency and type can increase specific components of physical fitness (35,140). In examining secular trends in fitness, physical activity trends can be a useful adjunct and may assist in interpretation of changes.

The BRFSS and Youth Risk Behavior Survey (YRBS) provide data that can assist in determining trends in youth and young adult physical activity. Figure 11 shows data from the BRFSS obtained from the CDC website (https://apps.nccd.gov/brfss/trends) showing the proportion of 18 to 34 year olds who reported no physical activity in the last month. The questions asked each year on the survey are shown in Appendix B. Figure 11 shows that the proportion of individuals reporting no activity is decreasing.





We obtained the raw data from the BRFSS and analyzed it for the proportion of 18 to 21 year old men and women (the Army prime market) who reported that they had participated in no physical activity in the last month. Figure 12 shows the results. In consonance with the composite data on 18 to 34 year olds (Figure 11), the number of men and women reporting no physical activity in the last month is decreasing over time.

The other national study that can assist in determining trends in youth physical activity is the YRBS. This is a self-administered questionnaire taken by high school students (grades 9 to 12) every 2 years in the spring. The questionnaire asks about six types of health risk behaviors including unintentional injuries and violence, tobacco use, alcohol and drug use, sexual behaviors, diet, and physical activity. During the 6 times the questionnaire has been administered for which there is currently public data, there were a total of 12 questions related to physical activity, although not all questions were asked each year. The activity questions are at Appendix C.

Pratt et al. (113) analyzed some activity data from YRBS. They reported that in 1992, 54% of high school students said they were vigorously active while in 1997, 64% said they were vigorously active. Using data from the 1991 to 1997 YRBS the authors showed that the proportion of students attending daily physical education classes declined from 1991 to 1995, then leveled off in 1997.

Since the publication of the Pratt et al. article (113) more extensive data has been collected from the YRBS. Questionnaire responses are now available from 1991 to 2001. We obtained raw data from the YRBS and analyzed it to get a better picture of changes in youth physical activity. Tables 15 and 16 shows the mean±SD values for all available physical activity questions on the survey for male and female high school students, respectively. It should be noted that some of the questions or response categories changed slightly from one year to the next. For example, on the intense activity question the 1991 survey did not include a time interval but in the 1993 and later surveys the question asked if the intense activity had been for 20 minutes or more (see Appendix C). On the moderate intensity question, the 1999 survey did not include examples of moderate activity but the 2001 survey did include examples (see Appendix C). On the question relating to the amount of time students were active in physical education classes, the response categories were expanded in 2001.

Despite differences in the wording of some questions, there are four questions (Questions 1, 4, 6 and 7 in Tables 15 and 16) that allow an analysis of trends in physical activity from 1991 to 2001. A one-way analysis of variance with a subsequent Tukey Test was used to determine differences among years for the 4 questions included on the survey every year. There was a decline in the number of days of intense activity (Question 1) from 1991 to 1997 for both boys and girls but days of intense activity returned to near 1991 level in 1999 and 2001. The frequency of strengthening exercises (Question 4) was higher in 1999 and 2001 compared to prior years for both boys and girls. The number of days in physical education classes (Question 6) declined in 1995 and 1997 for boys and girls but returned to near 1991 levels in 1999 and 2001. Time spent exercising in physical education class (Question 7) appears to have increased in 2001 compared to other years but this could be due to restructuring of the response categories in 2001 (see footnotes in Tables 15 and 16 and changes to question in Appendix C).

Table 15. Secular Changes in the Activity of Male High-School Students From the Youth Risk Behavior Survey (Mean±SD)

Question	1991	1993	1995	1997	1999	2001
1. How many of past 7 days do intense exercise (days)[a]	4.4±2.4	4.1±2.5	4.0±2.5	3.9±2.5	4.2±2.5	4.3±2.5
2. How many of past 7 days do stretching (days)[a]	3.1±2.6	3.0±2.6	3.0±2.6	3.0±2.6	h	h
3. How many of past 7 days do moderate intensity exercise (days)[a]	h	h	h	h	2.6±2.6	2.7±2.6
4. How many of past 7 days do strengthening exercise (days)[a]	3.1±2.5	3.2±2.5	3.2±2.5	3.2±2.5	3.4±2.5	3.4±2.5
5. Walk/bike 30 minutes in last 7 days (days)[a]	h	2.3±2.6	2.2±2.6	2.3±2.6	h	h
6. Days per week go to physical education classes (days)[b]	2.5±2.4	2.3±2.3	2.1±2.2	2.0±2.3	2.4±2.3	2.4±2.3
7. Time exercise in physical education class[cg]	1.8±1.8	1.9±1.8	1.8±1.7	1.7±1.8	1.9±1.8	2.6±2.7
8. In past 12 months, how many sports teams participate at school (n)[c]	0.9±1.0	0.9±1.0	0.9±1.0	0.9±1.0	h	h
9. In past 12 months, on how many sports teams participate outside of school (n)[d]	0.7±1.0	0.7±0.9	0.7±1.0	0.7±0.9	h	h
10. In past 12 months, how many sports team participate at school or community (n)[d]	h	h	h	h	1.2±1.1	1.1±1.1
11. In past 12 months, how many times injured while playing sports (n)[e]	h	h	h	h	0.8±1.3	1.4±0.8
12. Time watching television per day (hours)[f]	h	h	h	h	4.5±1.8	4.3±1.8

[a]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days, 6=6 days, 7=7 days
[b]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days
[c]Response categories: 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=>30 min
[d]Response categories: 0=no teams, 1=1 team, 2=2 teams, 3=3 or more teams
[e]Response categories: 0=0 times, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times
[f]Response categories: 1=No TV on average school night, 2=<1 hr/day, 3=1 hr/day, 4=2 hr/day, 5=3 hr/day, 6=4 hr/day, 7= 5 or more hr/day
[g]In 2001, response categories restructured to 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=31-40 min, 5=41-50 min, 6=51-60 min, 7=more than 60 min
[h]Question not asked in that year

Table 16. Secular Changes in Activity of Female High-School Students From the Youth Risk Behavior Survey (Mean±SD)

Question	1991	1993	1995	1997	1999	2001
1. How many of past 7 days do intense exercise (days)[a]	3.1±2.4	2.9±2.4	2.7±2.4	2.6±2.4	3.0±2.5	3.1±2.4
2. How many of past 7 days do stretching (days)[a]	2.8±2.5	2.7±2.5	2.7±2.5	2.6±2.5	h	h
3. How many of past 7 days do moderate intensity exercise (days)[a]	h	h	h	h	2.3±2.4	2.4±2.4
4. How many of past 7 days do strengthening exercise (days)[a]	2.0±2.3	2.1±2.4	2.1±2.4	2.1±2.3	2.3±2.3	2.4±2.4
5. Walk/bike 30 minutes in last 7 days (days)[a]	h	2.2±2.5	2.3±2.5	2.3±2.5	h	h
6. Days per week go to physical education classes (days)[b]	2.1±2.4	1.8±2.3	1.8±2.2	1.7±2.2	1.9±2.2	2.0±2.3
7. Time exercise in physical education class[cg]	1.4±1.6	1.4±1.7	1.4±1.6	1.3±1.6	1.4±1.7	1.9±2.3
8. In past 12 months, how many sports teams participate at school (n)[c]	0.5±0.9	0.6±0.9	0.6±0.9	0.6±0.9	h	h
9. In past 12 months, on how many sports teams participate outside of school (n)[d]	0.3±0.7	0.3±0.7	0.3±0.7	0.3±0.7	h	h
10. In past 12 months, how many sports team participate at school or community (n)[d]	h	h	h	h	0.8±1.0	0.8±1.0
11. In past 12 months how many times injured while playing sports (n)[e]	h	h	h	h	0.5±1.0	1.3±0.9
12. Time watching television[f]	h	h	h	h	4.4±1.9	4.1±1.8

[a]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days, 6=6 days, 7=7 days
[b]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days
[c]Response categories: 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=>30 min
[d]Response categories: 0=no teams, 1=1 team, 2=2 teams, 3=3 or more teams
[e]Response categories: 0=0 times, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times
[f]Response categories: 1=No TV on average school night, 2=<1 hr/day, 3=1 hr/day, 4=2 hr/day, 5=3 hr/day, 6=4 hr/day, 7= 5 or more hr/day
[g]In 2001, response categories changed to 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=31-40 min, 5=41-50 min, 6=51-60 min, 7=more than 60 min
[h]Question not asked in that year

Twelfth graders are those closest to military age. We wanted to see if these youth differed from the general population of high school students. Tables 17 and 18 show the mean±SD values for all available physical activity questions on the survey for 12th grade boys and girls, respectively. A one-way analysis of variance with a subsequent Tukey Test was used to determine differences among years for the 4 questions that were on the survey every year. The trends were almost identical to the trends in the larger group of high school students (Tables 15 and 16). Tables 17 and 18 show that there was a decline in the number of days of intense activity (Question 1) from 1991 to 1997 for both boys and girls but days of intense activity returned to the 1991 level in 1999 and 2001. The frequency of strengthening exercises (Question 4) was higher in 1999 and 2001 compared to prior years for both boys and girls. For boys, the number of days in physical education classes (Question 6) declined in 1995 and 1997 for but returned to near 1991 levels in 1999 and 2001; for girls, the decline in 1993 was sustained through 2001. Time spent exercising in physical education class (Question 7) appears to have increased in 2001 compared to other years but this could be due to restructuring of the response categories in 2001 (see footnotes in Tables 17 and 18 and changes to Question 7 in Appendix C).

Table 17. Secular Changes in Youth Activity (12th Grade Boys) From the Youth Risk Behavior Survey (Mean±SD)

Question	1991	1993	1995	1997	1999	2001
1. How many of past 7 days do intense exercise (days)[a]	3.8±2.4	3.7±2.5	3.5±2.5	3.4±2.5	3.8±2.5	3.8±2.5
2. How many of past 7 days do stretching (days)[a]	2.6±2.5	2.8±2.6	2.6±2.6	2.7±2.6	[h]	[h]
3. How many of past 7 days do moderate intensity exercise (days)[a]	[h]	[h]	[h]	[h]	2.7±2.6	2.6±2.5
4. How many of past 7 days do strengthening exercise (days)[a]	2.8±2.5	2.9±2.5	2.8±2.5	2.9±2.5	3.2±2.5	3.2±2.5
5. Walk/bike 30 minutes in last 7 days (days)[a]	[h]	2.0±2.5	2.0±2.5	1.9±2.5	[h]	[h]
6. Days per week go to physical education classes (days)[b]	1.8±2.3	1.8±2.3	1.4±2.0	1.5±2.3	1.7±2.2	1.6±2.2
7. Time exercise in physical education class[cg]	1.3±1.7	1.5±1.8	1.4±1.7	1.4±1.8	1.4±1.7	1.8±2.5
8. In past 12 months, how many sports teams participate at school (n)[c]	0.8±1.0	0.8±1.0	0.9±1.0	0.8±1.0	[h]	[h]
9. In past 12 months, on how many sports teams participate outside of school (n)[d]	0.6±0.9	0.6±0.9	0.7±0.9	0.7±0.9	[h]	[h]
10. In past 12 months, how many sports team participate at school or community (n)[d]	[h]	[h]	[h]	[h]	1.1±1.1	1.0±1.1
11. In past 12 months, how many times injured while playing sports (n)[e]	[h]	[h]	[h]	[h]	0.8±1.2	1.4±0.8
12. Time watching television per day[f]	[h]	[h]	[h]	[h]	4.3±1.8	4.1±1.7

[a]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days, 6=6 days, 7=7 days
[b]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days
[c]Response categories: 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=>30 min
[d]Response categories: 0=no teams, 1=1 team, 2=2 teams, 3=3 or more teams
[e]Response categories: 0=0 times, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times
[f]Response categories: 1=No TV on average school night, 2=<1 hr/day, 3=1 hr/day, 4=2 hr/day, 5=3 hr/day, 6=4 hr/day, 7= 5 or more hr/day
[g]In 2001, response categories restructured to 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=31-40 min, 5=41-50 min, 6=51-60 min, 7=more than 60 min
[h]Question not asked in that year

Table 18. Secular Changes in Youth Activity (12th Grade Girls) From the Youth Risk Behavior Survey (Mean±SD)

Question	1991	1993	1995	1997	1999	2001
1. How many of past 7 days do intense exercise (days)[a]	2.5±2.3	2.3±2.3	2.1±2.3	2.2±2.4	2.6±2.3	2.5±3.2
2. How many of past 7 days do stretching (days)[a]	2.3±2.4	2.3±2.4	2.2±2.3	2.2±2.3	h	h
3. How many of past 7 days do moderate intensity exercise (days)[a]	h	h	h	h	2.2±2.4	2.3±2.4
4. How many of past 7 days do strengthening exercise (days)[a]	1.7±2.2	1.8±2.2	1.7±2.2	1.8±2.3	2.0±2.3	2.0±2.7
5. Walk/bike 30 minutes in last 7 days (days)[a]	h	1.9±2.4	2.0±2.4	2.0±2.5	h	h
6. Days per week go to physical education classes (days)[b]	1.3±2.1	1.1±2.0	1.1±1.9	1.1±2.0	1.1±1.9	1.1±1.9
7. Time exercise in physical education class[cg]	0.9±1.5	0.8±1.4	0.9±1.4	0.9±1.5	0.8±1.4	1.1±2.1
8. In past 12 months, how many sports teams participate at school (n)[c]	0.4±0.8	0.5±0.8	0.5±0.8	0.5±0.8	h	h
9. In past 12 months, on how many sports teams participate outside of school (n)[d]	0.3±0.6	0.3±0.6	0.2±0.6	0.3±0.6	h	h
10. In past 12 months, how many sports team participate at school or community (n)[d]	h	h	h	h	0.6±0.9	0.6±0.8
11. In past 12 months how many times injured while playing sports (n)[e]	h	h	h	h	0.3±0.8	1.2±0.9
12. Time watching television[f]	h	h	h	h	4.1±1.8	3.9±1.8

[a]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days, 6=6 days, 7=7 days
[b]Response categories: 0=0 days, 1=1 day, 2=2 days, 3=3 days, 4=4 days, 5=5 days
[c]Response categories: 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=>30 min
[d]Response categories: 0=no teams, 1=1 team, 2=2 teams, 3=3 or more teams
[e]Response categories: 0=0 times, 1=1 time, 2=2 times, 3=3 times, 4=4 times, 5=5 times
[f]Response categories: 1=No TV on average school night, 2=<1 hr/day, 3=1 hr/day, 4=2 hr/day, 5=3 hr/day, 6=4 hr/day, 7= 5 or more hr/day
[g]In 2001, response categories changed to 0=do not take PE, 1=<10 min, 2=10-20 min, 3=21-30 min, 4=31-40 min, 5=41-50 min, 6=51-60 min, 7=more than 60 min
[h]Question not asked in that year

g. Physical Activity and Health People 2010 Recommendations

Healthy People 2010 (29) recommends that youth engage in vigorous activity that promotes the development and maintenance of cardiorespiratory endurance at least 3 days/week for at least 20 minutes each occasion. Table 19 shows our analysis of the proportion of high school students and 12th graders who reported engaging in 20 minutes of vigorous exercise on 3 of the 7 days prior to administration of the YRBS. The proportion of all high school boys performing the recommended frequency declined slightly up to 1995 then leveled off. The proportion of all high school girls performing the recommended frequency declines from 1993 to 1997 but rises above 1993 levels in 1999 and 2001. Twelfth grade boys performing the recommended frequency decreased up to 1997 then increased in 1999 and 2001 back to 1993 levels. For 12th grade girls, the proportion performing the recommended frequency decreased in 1997 then increased in the 2 following years to exceed 1993 levels.

Table 19. Proportion (%) of High School Students Who Report Performing Recommended Amount of Vigorous Activity

		1991	1993	1995	1997	1999	2001
All Students	Boys	ND[a]	72	70	69	70	69
	Girls	ND[a]	50	47	46	53	54
12th Graders	Boys	ND[a]	65	62	61	66	66
	Girls	ND[a]	40	37	38	46	44

[a]ND=No data; the question in 1991 was not worded properly to answer this question.

Healthy People 2010 (29) recommends that youth engage in moderate physical activity for at least 30 minutes on 5 or more days per week. Table 20 shows our analysis of the proportion of high school students and 12th graders who reported engaging in 20 minutes of moderate activity on 3 of the 7 days prior to administration of the YRBS. Only 2 years of data are available and there is little difference between the two years.

Table 20. Proportion (%) of High School Students Who Report Performing Recommended Amount of Moderate Activity

		1999	2001
All Students	Boys	27	27
	Girls	22	22
12th Graders	Boys	28	26
	Girls	21	21

Healthy People 2010 (29) recommends that youth participate in daily physical education classes. Table 21 shows our analysis of the proportion of high school students and 12th graders who reported engaging in daily physical education classes on an average week in school. For all male high school students and 12th graders, there was a decline in the proportion of students attending daily classes from about 1991 to 1997 but an upward trend in 1999 and 2001. A similar trend was seen for all high school girls but for 12th grade girls there is a decline from 1991 to 1993 that is sustained through 2001.

Table 21. Proportion (%) of High School Students Who Report Participating in Daily Physical Education Classes

		1991	1993	1995	1997	1999	2001
All Students	Boys	45	39	31	32	36	37
	Girls	38	31	27	27	29	31
12th Graders	Boys	28	29	18	23	26	27
	Girls	21	17	14	18	16	16

h. Other Studies Regarding Secular Trends in Physical Activity

Adame et al. (4) performed a cross-sectional analysis of physical fitness in college freshmen in 1987 (n=236) and 1997 (n=257) at a large Southeastern city (presumably Atlanta GA). Participants were an average age of 18 to 19 years and were enrolled in an introductory health education course. Individuals were asked to rate their activity on a 9-point scale and the data were compiled into weekly exercise duration shown in Table 22. There was little difference in the two years for the self-reported activity of men (p=0.35). The women had a significant increase in physical activity (p<0.01) from 1987 to 1997. Secondary analysis showed that the men were more active than women in 1987 (p<0.01) but there were no statistically significant differences in 1997 (p=0.20).

Table 22. Weekly Exercise Duration of College Freshmen in 1987 and 1997 (From Reference Number 4)

Exercise Duration (hrs/wk)	Men (%)		Women (%)	
	1987	1997	1987	1997
<2.0	28	28	52	20
2.0-3.9	35	38	38	48
≥5.0	37	34	11	33

Other studies on secular trends in adult physical activity were found, but the focus of this paper involved youth and young adults so these studies were not included here. A summary of adult studies is in Appendix D.

6. CHANGES IN THE PHYSICAL FITNESS OF U.S. ARMY RECRUITS

A series of military studies performed between 1975 and 2003 allows an examination of both secular changes in the fitness of recruits and an examination of improvements in fitness during BCT. Studies were performed by the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the USACHPPM. USARIEM studies cover specific aspects of fitness including cardiorespiratory endurance, muscle strength, body weight, BMI and body composition. USARIEM has also compiled data on body weight, estimated body fat, and fat-free mass of soldiers as far back as the American Civil War. USACHPPM performed program evaluations that collected data on height, weight, BMI, and performance on PU, SU and the 2-mile run. There are limitations to these data including small sample sizes and the fact that the studies used convenience samples rather than random samples of recruits. However, they are the best available data on recruit fitness. Sharp et al. (124,125) have performed a similar analysis of secular changes in the fitness of recruits.

Studies examining fitness changes during BCT involved a longitudinal experimental design. This means that the same individuals were examined before and after BCT. Studies examining secular changes involved a cross-sectional experimental design. This means that different individuals were examined in different years.

When considering secular changes in BCT it is useful to know critical elements of BCT have changed over time. Men and women have had different types of training over the years. Prior to 1978, men and women had separate BCT programs and different performance standards. In 1978 men and women were still training separately but had similar performance standards (108). By 1995, men and women were training together in gender-integrated platoons with identical training and almost the same performance standards (20). One noteworthy exception is the fact that the criteria to pass the Army Physical Fitness Test (APFT) have always been lower for women than for men (8,9,10,109). BCT was 8 weeks long prior to October 1998 and extended to 9 weeks after this time.

a. Cardiorespiratory Endurance

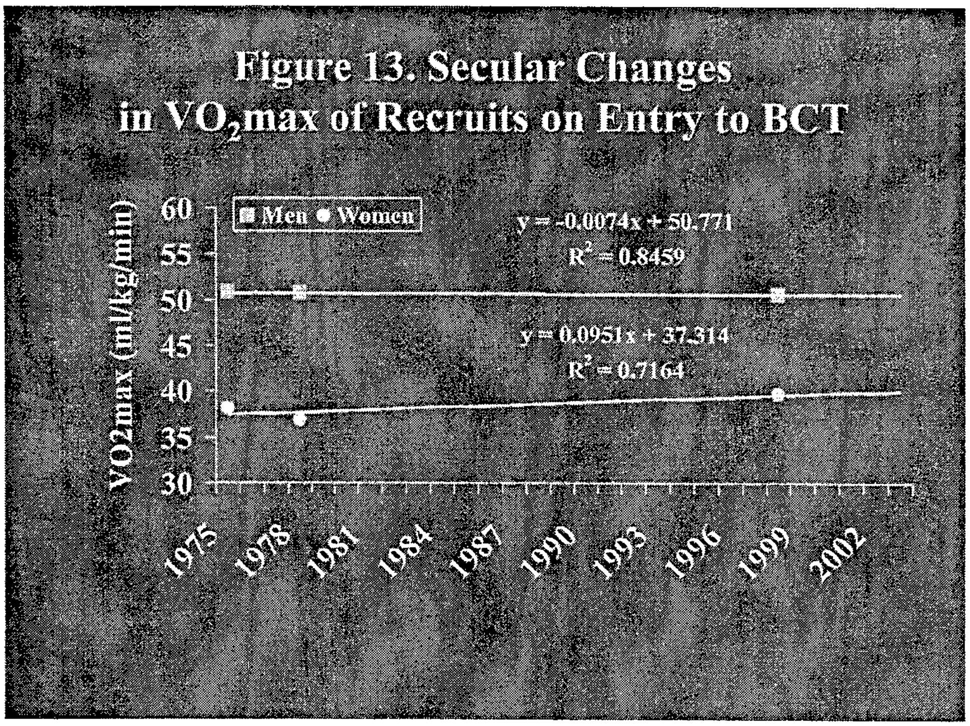
Table 23 shows three studies (108,124,138) that have examined VO_2max before and after Army basic training at three different times. Note that "Post-Basic" in this and subsequent tables actually means the sixth or seventh week of BCT. In all 3 investigations in Table 23, VO_2max was obtained from direct measures of oxygen consumption using a graded running treadmill protocol. Relative and absolute improvements in men's VO_2max during BCT were higher in 1975 compared to 1978 and 1998. Relative and absolute changes in the aerobic capacity of women during were similar in 1978 and 1998 and were greater than the changes in men in the same years.

Figure 13 graphically displays secular trends in the pre-basic training VO_2max data. For men, differences are less than 1% for the pre-basic training values across all three years. For women, the pre-basic 1998 value is 4% higher than the 1975 pre-basic value and 8% higher than the 1978 pre-basic value.

Table 23. Aerobic Capacity (VO_2max) of Recruits Before and After BCT[a] from 1975 to 1998

Year[b]	Study (Reference Number)	Men				Women			
		N	Pre-Basic (Mean±SD in ml/kg/min)	Post-Basic (Mean±SD in ml/kg/min)	Diff[c] (%)	N	Pre-Basic (Mean±SD in ml/kg/min)	Post-Basic (Mean±SD in ml/kg/min)	Diff[c] (%)
1975	138	186	50.8±6.1	54.9[d]	8.1	159	38.1±3.5	[e]	[e]
1978	108	87	50.7±4.7	52.3±3.8	3.1	57	36.9±3.6	39.3±3.5	6.5
1998	124	91	50.6±6.3	52.5±5.6	3.8	80	39.7±5.2	42.2±4.8	6.3

[a]Sixth or seventh week of BCT
[b]Year data collected
[c]Diff=Difference between pre and post basic training calculated as (post-pre/pre)*100%
[d]Estimated from % difference data in article
[e]Data not reported in article



Seven studies (61,62,72,73,74,77,112) have reported 2-mile run times of Army recruits in BCT from 1984 to 2003 (20 year period). However, changes in 2-mile run performance during BCT are only available from 1997 to 2003 (7 year period). In all cases, the 2-mile run was administered by drill sergeants as part of the APFT and run times were obtained from the records of the training companies. The APFT consisted of three events: PU, SU and the 2-mile run, administered in that order. After recruits completed testing on PU and SU they were allowed to rest (10-30 minutes) and were then taken to a measured course for the 2-mile run. Recruits wore a numbered vest or carried a numbered plaque for identification. 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.

Two-mile run times collected in various studies from 1997 to 2003 are shown in Table 24. During BCT, average absolute improvements for men ranged from 1.6 to 2.9 minutes and for women, 2.9 to 3.7 minutes. The average absolute (min) and relative (%) improvements of the women were greater than those of the men.

Figure 14 shows secular changes in the pre-basic training performance of men and women on the 2-mile run. Men ran 11% slower in 2003 compared to 1987 and women ran 6% slower in 2003 compared to 1988.

Table 24. APFT 2-Mile Run Performance of Recruits Before and After BCT[a] from 1987 to 2003

Year Data Collected	Study (Reference Number)	Men				Women			
		N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[b] (%)	N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[b] (%)
1987	62	135	15.6±2.0	[b]	[b]	[b]	[b]	[b]	[b]
1988	61	593	16.4±2.2	[c]	[c]	355	20.3±2.3	[c]	[c]
1989	112	1357	16.0±2.7	14.4±1.4	10.0	[b]	[b]	[b]	[b]
1997	72	389	17.2±2.6	14.8±1.3	13.9	342	21.5±2.8	18.1±1.4	15.8
1998	77	604	17.5±2.9	14.6±1.6	16.6	305	21.5±3.0	17.8±1.6	17.2
2000	74	688	17.0±2.6	14.8±1.3	12.9	446	21.1±2.6	18.2±1.7	13.7
2003	73	656	17.3±2.4	15.5±1.8	10.4	482	21.6±3.0	18.7±1,7	13.4

[a]Sixth or seventh week of BCT
[b]Diff=Difference between pre and post basic training
[c]No data collected post-training in this study

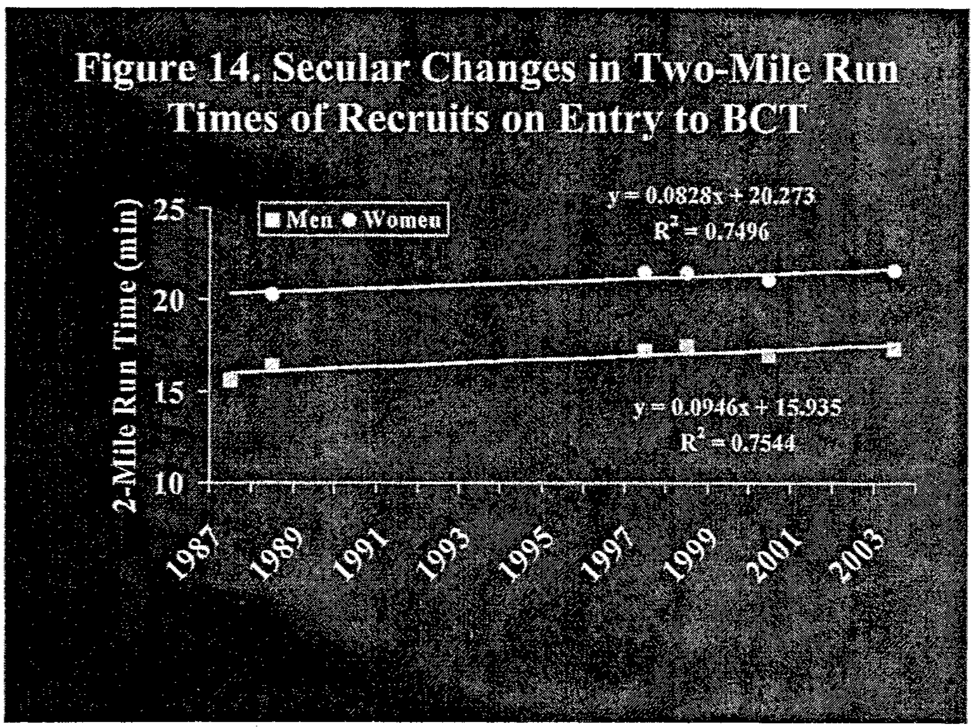


Figure 14. Secular Changes in Two-Mile Run Times of Recruits on Entry to BCT

b. Muscle Strength

Four measures of maximum voluntary strength have been obtained on recruits over periods separated by 15 to 20 years. These measures include isometric Upper Torso (UT) strength, isometric Lower Body (LB) strength, isometric Upright Pull (UP) strength, and isoinertial Incremental Dynamic Lifting (IDL) strength. Studies on these strength measures (79,124,129,141) used the same strength testing devices and same methodology (80,116,129). To measure isometric UT strength, the recruit was securely seated in a chair with a belt around his or her waist. With both hands, the recruit grasped a piece of aluminum tubing such that the recruit's elbow was at a 90° angle with the upper arm parallel to the floor. The recruit pulled downward on the bar exerting as much force as possible and the isometric force was measured on a transducer (116). For LB strength, the recruit was securely seated with feet resting on a bar and knees at a 90° angle. The recruit exerted as much force as possible on the bar performing a motion similar to a leg press. The isometric force was measured on a transducer (116). For the UP, the recruit was standing and grasped with both hands an aluminum bar that was located 38 cm above the ground. Recruit's knees were bent, back straight, and head up. The recruit pulled up vertically on the bar exerting as much force as possible and the isometric force was measured with a transducer (80). The IDL machine consisted of an adjustable stack of weights (weight carriage) attached to 2 handles located 20 cm from the ground. The weight carriage allowed for the progressive stacking of weight to determine maximal lifting strength. The recruit grasped both handles of the device with feet shoulder distance apart, knees bent, back straight, and head up. The recruit lifted the weight carriage to a height of 152 cm. An initial load of 18 kg was progressively increased until the maximal load the recruit could lift safely to the 152 cm height was determined using a 1 repetition maximum procedure (129).

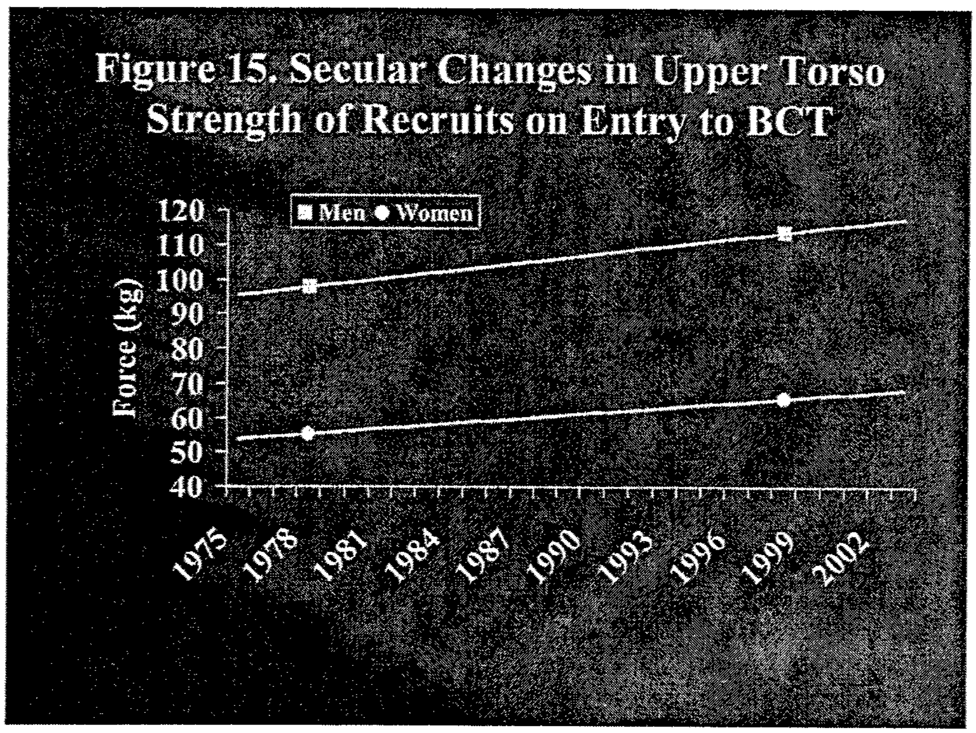
Table 25 shows 5 studies (27,79,124,129,141) that have examined the 4 measures of muscle strength before and near the end of Army BCT. Changes from pre- to post-BCT tend to be greater in 1978 and 1983 compared to changes in 1998. In all cases, relative strength changes after BCT are larger for women than for men.

Figures 15 to 18 graphically depict secular changes in pre-BCT measures of UT, LB, UP and IDL strength, respectively. There are only 2 data points for most variables and a trend line is plotted but the fit of the line is not included because the r^2=1.0 (i.e., a perfect fit) when only 2 points are available (this can be misleading). Male UT and LB strength were respectively 16% and 12% higher in 1998 compared to 1978. Female UT and LB strength were respectively 19% and 4% higher in 1998 compared to 1978 (20 year period). Male UP and IDL strength were respectively 4% and 25% higher in 1998 compared to 1983. Female UP and IDL strength were respectively 3% and 34% higher in 1998 compared to 1983 (15 year period). In general, the secular differences in the strength of muscle groups involving the upper body (UT and IDL) appear to be greater than changes in muscle groups involving the lower body (LB and UP).

Table 25. Muscle Strength of Recruits Before and After BCT from 1978 to 1998

Variable	Year[a]	Study (Reference Number)	Men				Women			
			N	Pre-Basic (Mean±SD in kg)	Post-Basic (Mean±SD in kg)	Diff[b] (%)	N	Pre-Basic (Mean±SD in kg)	Post-Basic (Mean±SD in kg)	Diff[b] (%)
UT[c]	1978	79	733	97.8±18.2	102.1±16.2	4.4	359	55.3±11.8	61.0±9.6	10.3
(kg)	1998	124	98	113.7±17.3	113.7±16.2	0.0	99	65.6±11.4	67.3±11.3	2.6
LB[d]	1978	79	737	143.2±38.4	158.2±41.1	10.5	348	93.4±30.0	106.6±31.1	14.1
(kg)	1998	124	85	160.5±42.6	162.3±39.9	1.1	88	96.7±24.7	103.3±25.6	6.8
UP[e]	1983	129	90	128.4±18.7	142.2±21.4	10.7	113	79.1±10.9	89.0±19.3	12.5
(kg)	1998	124	99	133.3±23.6	133.2±22.0	0.0	99	81.7±19.4	85.3±16.9	4.4
IDL[f]	1983	129	90	61.1±10.0	63.0±9.9	3.1	113	30.4±6.1	34.7±8.2	14.1
(kg)	1987	27	303	71.6±12.1	g	g	g	g	g	g
	1993	141	g	g	g	g	124	40.4±8.8	43.8±9.4	8.4
	1998	124	99	76.5±14.8	73.2±13.6	-4.3	99	40.7±10.6	42.1±9.6	3.4

[a]Year data collected
[b]Diff=Difference between pre- and post-basic training calculated as (post-pre/pre)*100%
[c]UT=Upper Torso Strength
[d]LB=Lower Body Strength
[e]UP=Upright Pull Strength
[f]IDL=Incremental Dynamic Lift Strength
[g]No data collected on these measures



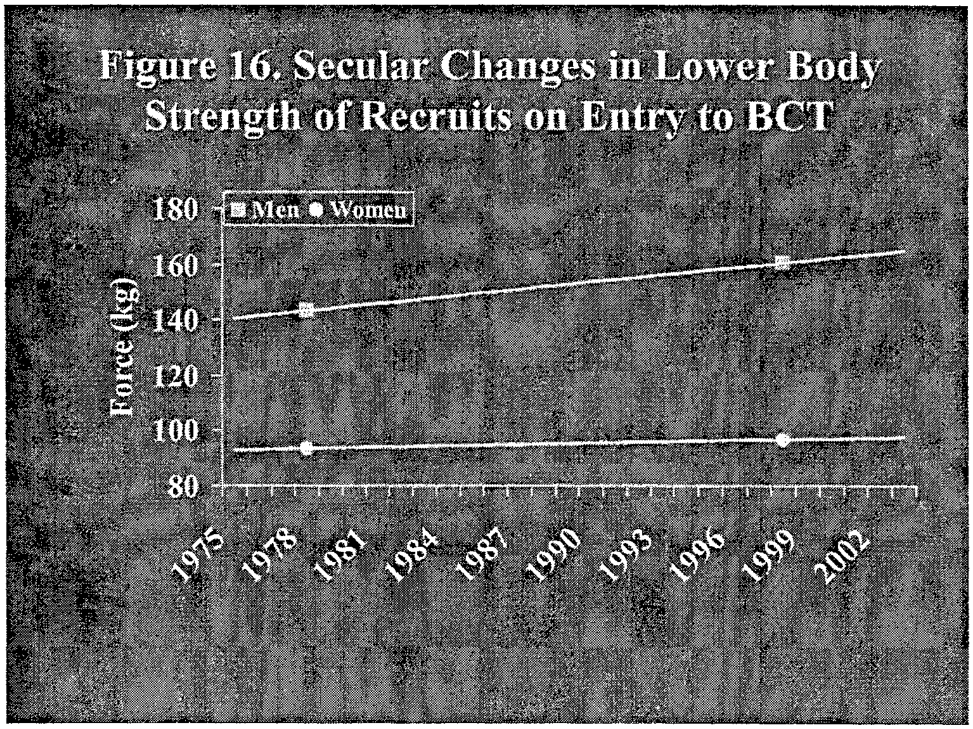


Figure 16. Secular Changes in Lower Body Strength of Recruits on Entry to BCT
Men
Women
Force (kg)
180
160
140
120
100
80
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002

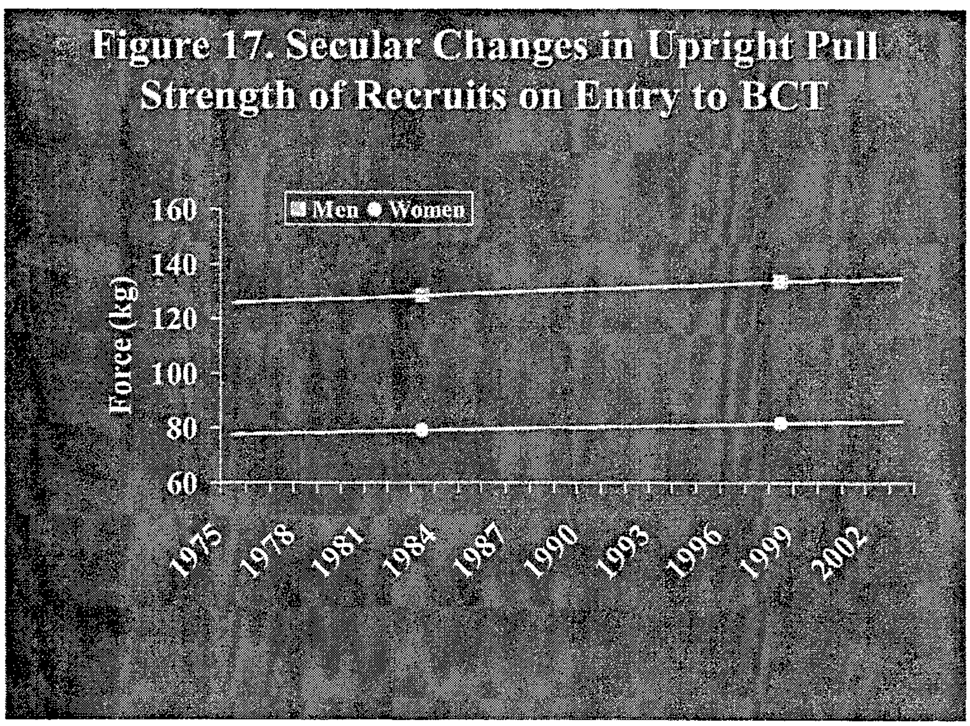
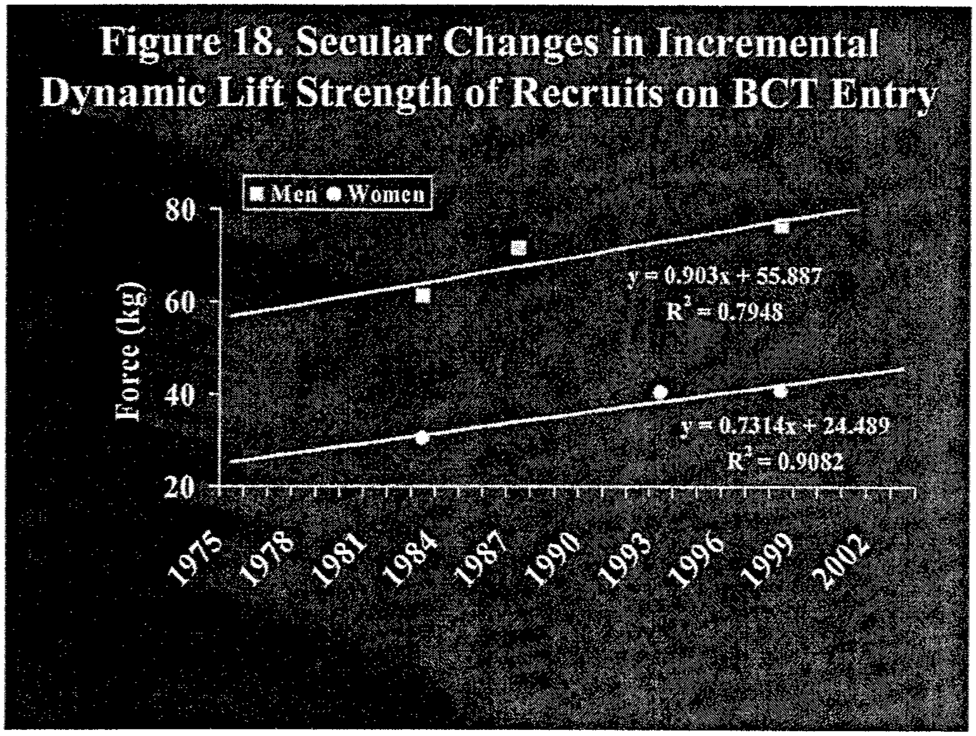


Figure 17. Secular Changes in Upright Pull Strength of Recruits on Entry to BCT
Men
Women
Force (kg)
160
140
120
100
80
60
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002



c. Muscular Endurance

Eight studies (14,61,62,72,73,74,77,112) have reported PU and SU values from 1984 to 2003 (20 year period). However, changes in APFT scores during BCT are only available from 1997 to 2003 (7 year period). In all cases, the tests were administered by drill sergeants as part of the APFT and the data was obtained from the records of the training companies. For PU and SU, recruits generally lined up in 5 to 15 rows and were tested with drill sergeants monitoring individual performances. For the PU, a trainee was required to lower his body in a generally straight line to a point where his or her upper arms were parallel to the ground, and then return to the starting point with elbows fully extended. For the SU, the trainee's knees were bent at a 90° angle, fingers were interlocked behind the head, and a second person held the participant's ankles, keeping his or her heels firmly on the ground. The trainee raised his or her upper body to a vertical position so that the base of the neck was anterior to the base of the spine and then returned to the starting position. Drill sergeants recorded the number PU and SU successfully completed in separate 2-minute periods with a 10-30 minute rest between events.

Table 26 shows PU and SU performance data collected in various studies from 1984 to 2003 (19 year period). During the course of BCT, the average improvements in PU for men ranged from 12 to 19 repetitions and for women, 12 to 22 PU. Average absolute improvements in SU for men ranged from 15 to 19 repetitions and for women, 19 to 30 SU. Relative improvements in PU and SU during BCT are large probably reflecting the fact that trainees are specifically trained for performance on these tasks

(71,74). In all cases, the average relative improvements of the women were greater than those of the men.

Figures 19 and 20 show secular changes in pre-BCT measures of PU and SU performance, respectively. There was a small trend for improved male performance on PU over time but virtually no difference for female PU. There was a weak trend indicating lower performance over time for male SU but little trend in the female SU data.

Table 26. Push-Up and Sit-Up Performance of Recruits Before and After BCT[a] and Over Time

Event	Year	Study (Reference Number)	Men				Women			
			N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[b] (%)	N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[b] (%)
PU	1984	61	97	31±9	c	c	138	12±10	c	c
	1987	62	137	27±11	c	c	c	c	c	c
	1988	61	1357	31±13	c	c	792	10±7	c	c
	1988	14	509	32±12	50±12	56.3	352	11±7	28±10	154.5
	1989	112	1357	37±14	51±13	37.8	c	c	c	c
	1997	72	389	33±15	51±14	54.5	342	10±9	25±10	150.0
	1998	77	604	32±14	47±13	46.7	305	11±10	25±10	127.3
	2000	74	688	33±13	52±13	57.6	446	10±9	32±17	220.0
	2003	73	656	34±13	46±12	35.3	482	12±10	24±10	100.0
SU	1984	61	98	55±14	c	c	163	40±12	c	c
	1987	62	136	38±11	c	c	c	c	c	c
	1988	61	1357	44±12	c	c	902	34±14	c	c
	1988	14	509	44±12	63±10	43.2	352	31±14	61±12	96.8
	1989	112	1357	50±13	63±12	26.0	c	c	c	c
	1997	72	389	40±14	59±10	47.5	342	33±15	55±12	66.7
	1998	77	604	41±13	57±10	39.0	305	35±15	54±12	54.3
	2000	74	688	44±12	60±14	36.4	446	34±14	53±18	55.9
	2003	73	656	46±12	61±11	32.6	482	40±15	59±11	47.5

[a]Sixth or seventh week of BCT
[b]Diff=Difference between pre and post basic training
[c]No data collected in these studies

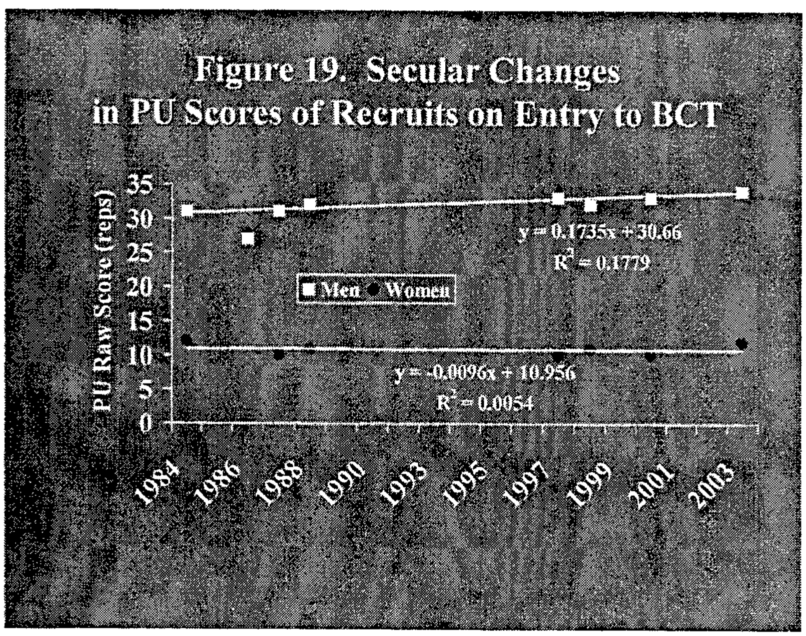


Figure 19. Secular Changes in PU Scores of Recruits on Entry to BCT

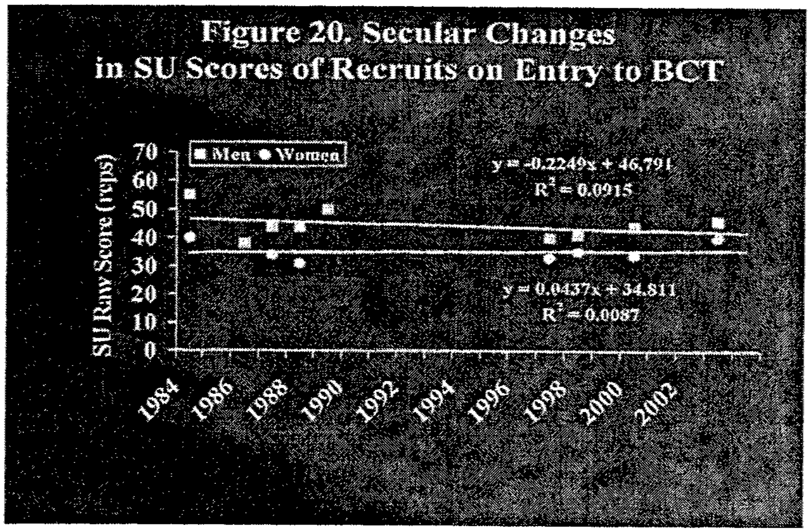


Figure 20. Secular Changes in SU Scores of Recruits on Entry to BCT

d. Height, Weight, Body Mass Index and Body Composition

Several studies have collected weight, BMI, body fat, and/or fat-free mass among basic trainees from 1978 to 2003 (26 year period). In most studies, height and weight were collected directly by the investigators and their teams. Height was measured using an anthropmeter and weight was measured using a digital or balance-type scale (14,61,62,79,112,124,129,141)[b]. In one study, heights and weights were obtained from personnel records (73). BMI was calculated from height and weight in all studies. Most studies (61,79,124,129,141)[b] on body fat have carefully obtained skinfolds and have estimated body fat using the equations of Durnin and Womersley (31). In several studies (14,61,62,112) body fat was estimated from circumferences using the Army equations (137)[c]. Fat-free mass was calculated in these studies by subtracting body fat (kg) from weight (14,61,62,79,112,124,129,141).

Table 27 shows weight, BMI, body fat, and fat-free mass of recruits from 1978 to 2003 both before and at the end of BCT (26 year period). Height was collected only before BCT in all studies. The body weight of men generally showed small changes after BCT but women gained weight, although these weight gains have been smaller more recently. Both men and women generally lose fat and gain fat-free mass during BCT. This gain and loss in men is balanced so that weight changes very little. For women, the weight gain is due to a greater gain in fat-free mass compared to the loss of fat. One notable exception involved the 1998 study (125) in which men lost weight due exclusively to a loss in body fat.

Figures 21 to 25 graphically display the trends in the pre-BCT measures of height, weight, BMI, body fat and fat-free mass, respectively. The relative increase in height, weight, and BMI for men from 1978 to 2003 (25 year period) was 1%, 11%, and 8%, respectively; these values for women were 1%, 6% and 5%, respectively. The relative

[b] Some studies do not specify the exact methods in the article but the personal knowledge of the authors was used to obtain the methods and they are correct as stated.

[c] Information obtained from the author

increase in body fat and fat-free mass from men from 1978 to 1998 (20 year period) was 15% and 6%, respectively; these values for women were 3% and 3%, respectively. A linear trend accounted for most of the variance in these measures. One exception was that a third order polynomial best fit the body fat trend of women (r^2=0.57). However, this added little to conceptually explaining the trend and was probably just due to the wider variance in the data.

Table 27. Physical Characteristics and Body Composition of Recruits Before and After BCT from 1978 to 2003

Variable	Year[a]	Study (Reference Number)	Men				Women			
			N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[c] (%)	N	Pre-Basic (Mean±SD)	Post-Basic (Mean±SD)	Diff[c] (%)
Height (cm)	1978	79	769	174.3±6.6	[b]	[b]	393	162.5±6.8	[b]	[b]
	1983	129	90	175.2±6.1	[b]	[b]	113	162.7±6.2	[b]	[b]
	1984	61	123	175.2±6.6	[b]	[b]	186	163.3±6.6	[b]	[b]
	1987	62	303	175.4±6.4	[b]	[b]	[b]	[b]	[b]	[b]
	1988	61	1053	175.2±7.1	[b]	[b]	895	162.0±6.5	[b]	[b]
	1988	14	509	175.1±7.3	[b]	[b]	352	162.0±6.4	[b]	[b]
	1989	112	1357	175.6±6.7	[b]	[b]	[b]	[b]	[b]	[b]
	1998	124[e]	182	176.5±7.0	[b]	[b]	168	163.0±6.1	[b]	[b]
	2003	73	1174	176.1±7.3	[b]	[b]	898	163.5±6.4	[b]	[b]
Weight (kg)	1978	79	769	70.9±10.6	71.7±8.8	+1.1	393	59.1±7.1	61.3±6.7	+3.7
	1983	129	90	72.9±9.6	73.5±7.6	+0.8	113	58.9±6.5	61.2±6.3	+3.9
	1984	61	124	73.6±10.9	[b]	[b]	186	58.7±5.8	[b]	[b]
	1987	62	303	75.5±11.9	[b]	[b]	[b]	[b]	[b]	[b]
	1988	61	1053	75.7±12	[b]	[b]	895	58.3±6.5	[b]	[b]
	1988	14	509	76.3±12.3	[b]	[b]	352	57.8±6.3	[b]	[b]
	1989	112	1357	75.7±12	[b]	[b]	[b]	[b]	[b]	[b]
	1993	141	[b]	[b]	[b]	[b]	150	62.1±8.7	62.9±8.1	+1.3
	1998	124	99	78.0±12.6	76.8±11.2	-1.5	101	62.0±9.8	62.8±9.4	+1.3
	2003	73	1174	78.5±13.6	[b]	[b]	898	62.7±9.6	[b]	[b]
BMI[c] (kg/m^2)	1978	79	769	23.3[d]	23.6[de]	+1.3	393	22.4[de]	23.2[de]	+3.6
	1983	129	90	23.7[d]	23.9[de]	0.8	113	22.3[de]	23.1[de]	+3.6
	1984	61	123	24.3±3.1	[b]	[b]	186	22.4±2.0	[b]	[b]
	1987	62	303	24.6±3.4	[b]	[b]	[b]	[b]	[b]	[b]
	1988	61	1053	24.6±3.6	[b]	[b]	895	22.2±2.0	[b]	[b]
	1988	14	509	24.9[d]	[b]	[b]	352	22.0[c]	[b]	[b]
	1989	112	1357	24.5±3.4	[b]	[b]	[b]	[b]	[b]	[b]
	1998	124[f]	99	25.2±3.6	24.8±3.0	-1.6	101	23.3±2.9	23.6±2.6	+1.3
	2003	73	1174	25.2±3.9	[b]	[b]	898	23.4±3.0	[b]	[b]
Body Fat (%)	1978	79	769	16.3±5.1	14.5±3.8	-11.0	393	28.0±4.7	26.5±3.7	-5.4
	1983	129	90	16.3±4.7	14.0±3.3	-14.1	113	25.6±3.9	24.3±3.4	-5.0
	1984	61	124	16.9±4.9	[b]	[b]	186	25.2±9.4	[b]	[b]
	1987	62	302	16.9±4.5	[b]	[b]	[b]	[b]	[b]	[b]
	1988	61	1053	16.1±5.8	[b]	[b]	895	22.2±2.0	[b]	[b]
	1988	14	509	16.4±5.6	[b]	[b]	352	26.6±4.0	[b]	[b]
	1989	112	1357	18.4±5.7	[b]	[b]	[b]	[b]	[b]	[b]
	1993	141	[b]	[b]	[b]	[b]	150	31.3±4.5	30.6±4.5	-2.2
	1998	124	99	18.8±4.6	17.7±3.9	-5.9	100	28.9±4.0	27.3±3.4	-5.5
Fat-Free Mass (kg)	1978	79	769	59.3±6.8	61.1±6.4	+3.0	393	42.4±4.3	44.9±4.5	+5.9
	1983	129	90	60.6±5.7	63.0±5.7	+3.9	113	43.6±3.9	46.2±4.1	+6.0
	1984	61	124	61.2[d]	[b]	[b]	186	43.9[c]	[b]	[b]
	1987	62	302	62.7[d]	[b]	[b]	[b]	[b]	[b]	[b]
	1988	61	1053	63.5[d]	[b]	[b]	895	42.7[d]	[b]	[b]
	1988	14	509	63.7[d]	[b]	[b]	352	42.4[d]		
	1989	112	1357	61.8[d]	[b]	[b]	[b]	[b]	[b]	[b]
	1993	141	[b]	[b]	[b]	[b]	150	42.5±4.8	43.5±4.9	+2.4
	1998	124	99	63.0±8.2	63.0±7.9	0.0	100	43.7±5.7	45.3±5.6	+3.7

[a]Year data collected
[b]These data were not collected in these studies
[c]Diff=Difference between pre- and post-basic training calculated as (post-pre/pre)*100%
[d]Calculated from data in study
[e]Assumes same height as pre-basic since post-basic height was not measured
[f]Previously unpublished data from this study

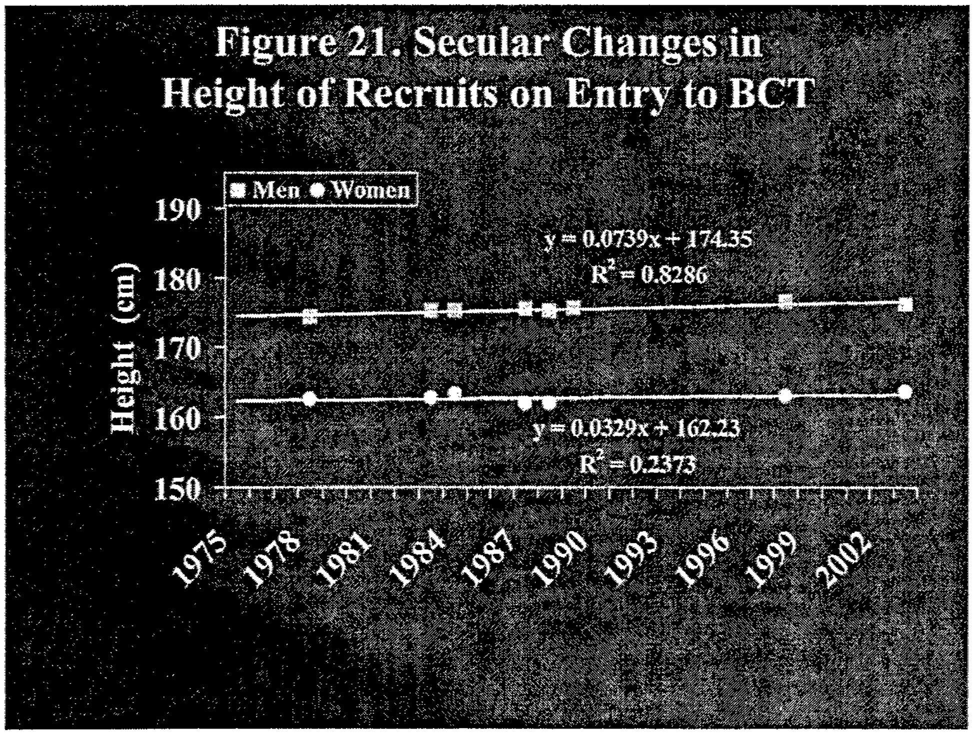


Figure 21. Secular Changes in Height of Recruits on Entry to BCT
■ Men ● Women
Height (cm)
190
180
170
160
150
y = 0.0739x + 174.35
R^2 = 0.8286
y = 0.0329x + 162.23
R^2 = 0.2373
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002

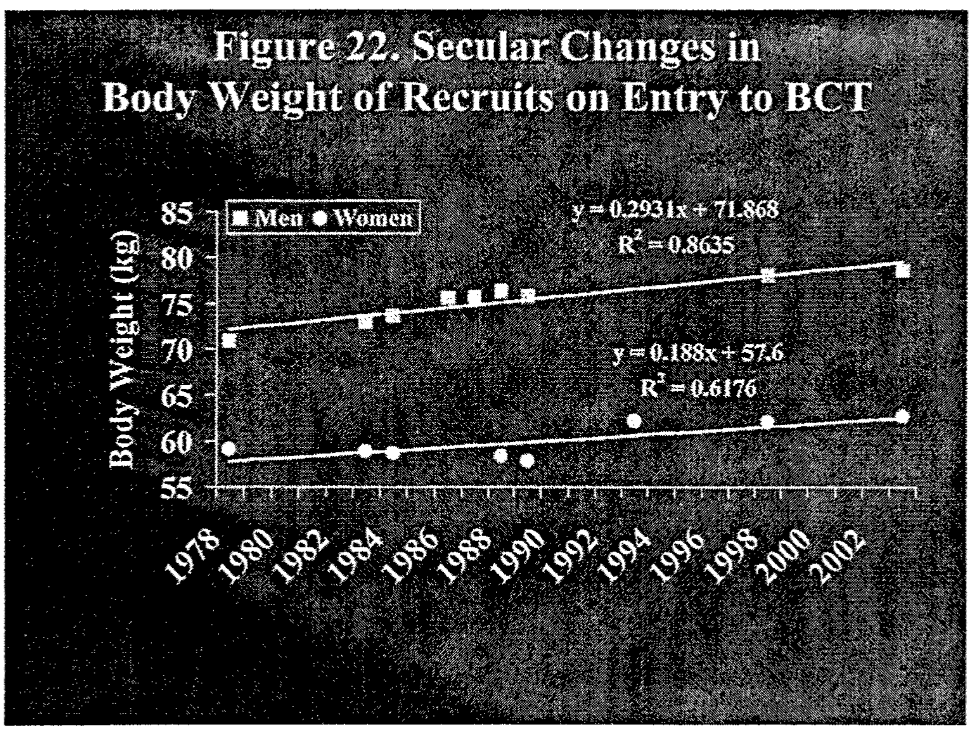


Figure 22. Secular Changes in Body Weight of Recruits on Entry to BCT
■ Men ● Women
Body Weight (kg)
85
80
75
70
65
60
55
y = 0.2931x + 71.868
R^2 = 0.8635
y = 0.188x + 57.6
R^2 = 0.6176
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

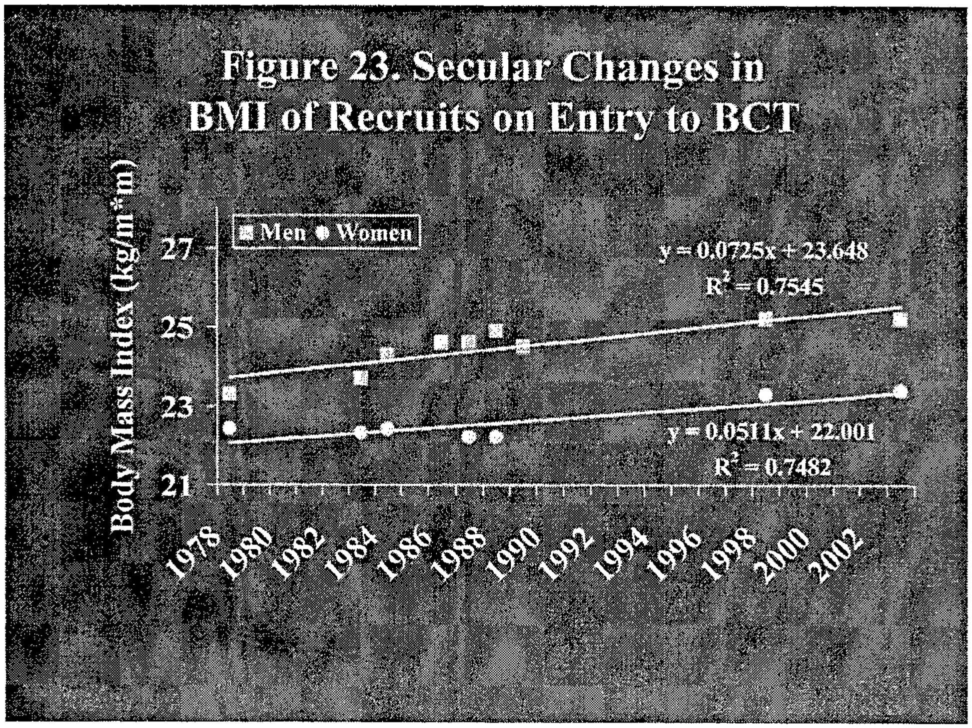


Figure 23. Secular Changes in
BMI of Recruits on Entry to BCT
Body Mass Index (kg/m*m)
Men Women
y = 0.0725x + 23.648
R² = 0.7545
y = 0.0511x + 22.001
R² = 0.7482
27
25
23
21
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

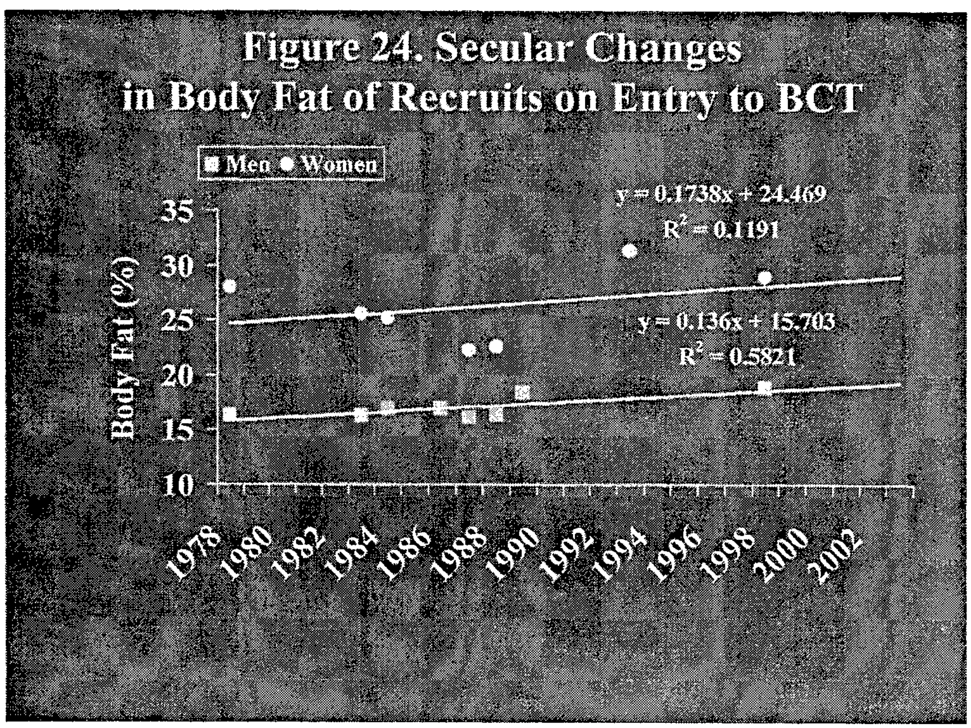


Figure 24. Secular Changes
in Body Fat of Recruits on Entry to BCT
Body Fat (%)
Men Women
y = 0.1738x + 24.469
R² = 0.1191
y = 0.136x + 15.703
R² = 0.5821
35
30
25
20
15
10
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

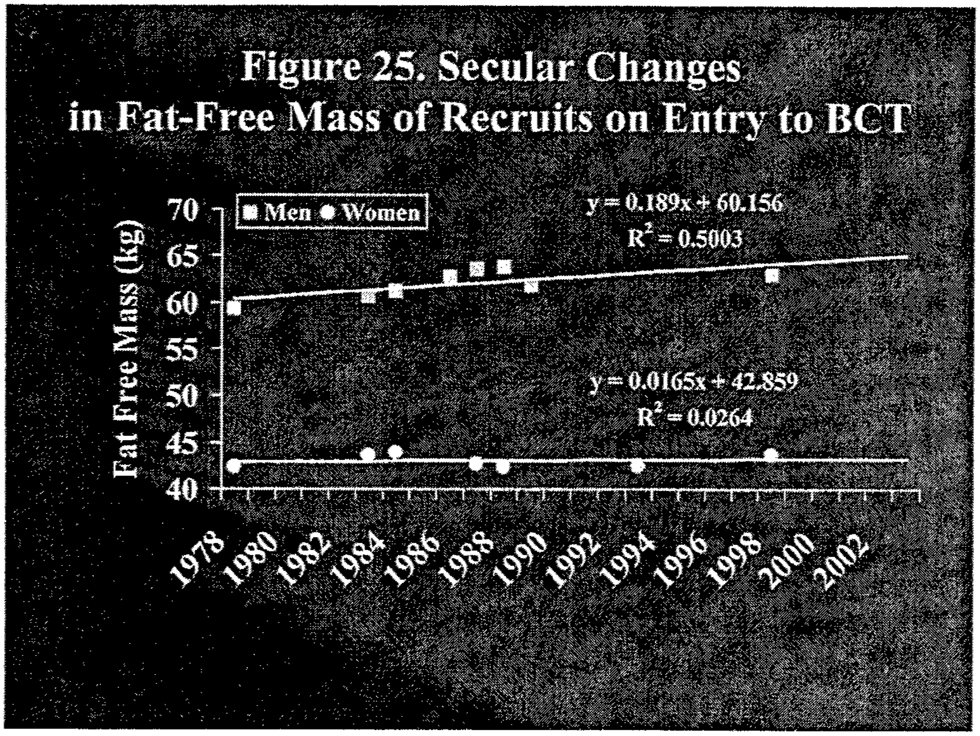


Table 28 shows the absolute (kg) differences in pre-BCT weight, body fat and fat-free mass among recruits in 1978 and 1998. The data indicate that about ½ the difference in body weight is due to fat and about ½ due to fat-free mass.

Table 28. Body Weight and Body Composition Differences of Recruits in 1978 and 1998

Study (Reference Number)	Year	Men			Women		
		Weight (kg)	Body Fat (kg)	Fat-Free Mass (kg)	Weight (kg)	Body Fat (kg)	Fat-Free Mass (kg)
79	1978	70.9	11.6	59.3	59.1	16.7	42.4
125)	1998	78.9	15.2	63.7	62.6	18.7	43.9
Difference (kg)		8.0	3.6	4.4	3.5	2.0	1.5

Table 29 shows historical data compiled by Friedl (42) on weight and body composition of soldiers going back to the Civil War. Added to this are previously unpublished data collected most recently at Ft Jackson, SC among basic trainees (124,125). The 1864 sample is obtained from active duty soldiers but it is not clear exactly who the 1919 and 1946 samples involved. It can be seen that the differences in height between 1864 and 1998 is small (3%) but weight differences are more dramatic (23%). Estimated relative body fat is somewhat variable but it is clear that estimated fat-free mass is increasing over time. Estimated fat-free mass is 23% higher in 1998 compared to 1864.

Table 29. Historical Data on Physical Characteristics of Male Soldiers from 1864 to 1998

	Study Year (n)				
	1864[a] (23624)	1919[a] (99,449)	1946[a] (85,000)	1984[a] (869)	1998[b] (181)
Age (years)	26	25	24	26	22
Height (inches)	67	68	68	69	69
Weight (pounds)	141	145	155	167	174
Waist Girth (inches)	32	31	31	33	34
Estimate Body Fat (%)[c]	16.9	15.7	14.4	17.3	17.0
Estimated Fat-free Mass (pounds)	117	122	133	138	144

[a]Historical data (42)
[b]Previously unpublished data from study of male basic trainees at Ft Jackson South Carolina (124,125)
[c]Body fat is estimated from mean values for height, weight, neck and waist circumference using the circumferential method in Army Regulation 600-9 (7). One exception is the 1984 value which is from hydrostatically determined body fat (34).

e. Physical Activity

Table 30 shows physical activity of basic trainees from 2 surveys. The question asked of recruits was "Over the last month, how often did you exercise or play sports for 15 minutes or more?". There was little difference in the distribution of scores in the two years but the time period between surveys was only 3 years.

Table 30. Physical Activity[a] Among Basic Trainees on Entry to Service

	Men		Women	
	1998 (n=225)	2001 (n=1414)	1998 (n=211)	2001 (n=1166)
1. None (%)	6	7	6	10
2. 1-2 Days/Week (%)	12	13	11	16
3. 3-4 Days/Week (%)	19	17	15	19
4. 5-6 Days/Week (%)	39	37	43	38
5. 7Days/Week (%)	24	26	25	16
Mean±SD (Response #)	3.6±1.2	3.6±1.2	3.6±1.2	3.3±1.3

[a]The question was "Over the last month, how often did you exercise or play sports for 15 minutes or more?"

7. PHYSICAL FITNESS CHANGES DURING BCT

To obtain a more complete picture of improvements in fitness during BCT, we examined progressive changes in APFT scores of recruits during BCT. The database used in this analysis was obtained from the Directorate of Information Management (DOIM) at Ft Jackson. From about 1999 to 2000 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 BCT company completed its training cycle, the DOIM downloaded data from the MTS, including APFT scores and trainee demographics. Demographics described the recruits at the start of training and the APFT data consisted of 4 tests taken by each recruit. Although there was some variation, the 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. For the purposes of this analysis, these were referred to, respectively, as Diagnostic 1 Test, Diagnostic 2 Test, Diagnostic 3 Test, and Final Test. Demographic data included pay grade (rank), race, marital status, educational level and component (active Army, Army Reserve, National Guard). The database spanned the period May 1999 through April 2000. There were a total 14,499 men and 9,595 women although data was not available for all trainees on all variables.

a. Demographic Composition of the Sample

Table 31 shows the demographic composition of the group. Most of the men were single, white, high school graduates in the regular Army. Black men made up about ¼ of the male sample and Army Reserve and National Guard made up about 1/3 of the sample. The demographics of the women were similar. Again, most of the women were White, single, high school graduates in the Regular Army. Black women made up over 1/3 of the female sample and about 40% of the women were in the Army Reserve and National Guard.

Table 31. Demographic Composition of Recruits in APFT Sample

Variable	Level of Variable	Men		Women	
		N	%	N	%
Grade	E1	9,614	66.3	5805	60.5
	E2	2,529	17.4	1844	19.2
	E3	1,747	12.0	1460	15.2
	E4	609	4.2	486	5.1
Race	White	9,651	66.6	5152	53.7
	Black	3,365	23.2	3496	36.4
	Other	1,438	9.9	935	2.8
	Unknown/Missing	45	0.3	12	0.1
Marital Status	Single	12,757	87.9	8245	85.9
	Married	1,741	12.0	1346	14.0
	Unknown/Missing	6	0.0	4	0.0
Educational Level	< High School	874	6.0	553	5.8
	High School Diploma	11,193	77.2	7650	79.7
	GED[a]	1552	10.7	634	6.6
	1-4 years College	420	2.9	398	4.1
	≥College Graduate	458	3.2	358	3.7
	Unknown/Missing	2	0.0	2	0.0
Component	Regular Army	9,220	63.6	5743	59.9
	Army Reserve	2,621	18.1	1937	20.2
	National Guard	2,658	18.3	1915	20.0

[a]GED=General Education Development Certificate

b. Progressive Changes in Fitness During BCT

Table 32 shows the APFT raw scores. The first thing to note is the decline in the number of trainees through the various test periods. This was probably due to soldiers who were discharged, newstarted (recycled) and/or who were on profile (medical prohibition from physical activity) when the tests were administered (73,74,77). Figures 26 to 28 graphically depict the changes in PU, SU, and the 2-mile run, respectively.

Table 32. Changes in Physical Fitness of Recruits During BCT in the APFT Sample

		Men		Women	
		N	Raw Score (reps or min) (mean±SD)	N	Raw Score (reps or min) (mean±SD)
Push-Ups	Diagnostic 1	14,489	32±14	9,591	9±9
	Diagnostic 2	12,836	41±14	8,125	16±11
	Diagnostic 3	11,408	46±14	7,160	22±11
	Final	11,073	50±12	7,177	26±11
Sit-Ups	Diagnostic 1	14,490	43±13	9,591	34±14
	Diagnostic 2	12,842	53±12	8,136	46±14
	Diagnostic 3	11,406	58±12	7,161	54±13
	Final	11,073	63±10	7,179	60±11
2-Mile Run	Diagnostic 1	14,499	17.5±2.6	9,595	21.7±2.8
	Diagnostic 2	12,641	15.7±2.1	7,831	19.7±2.5
	Diagnostic 3	11,282	15.0±1.8	6,955	18.7±2.2
	Final	10,985	14.6±1.3	7,075	17.9±1.7

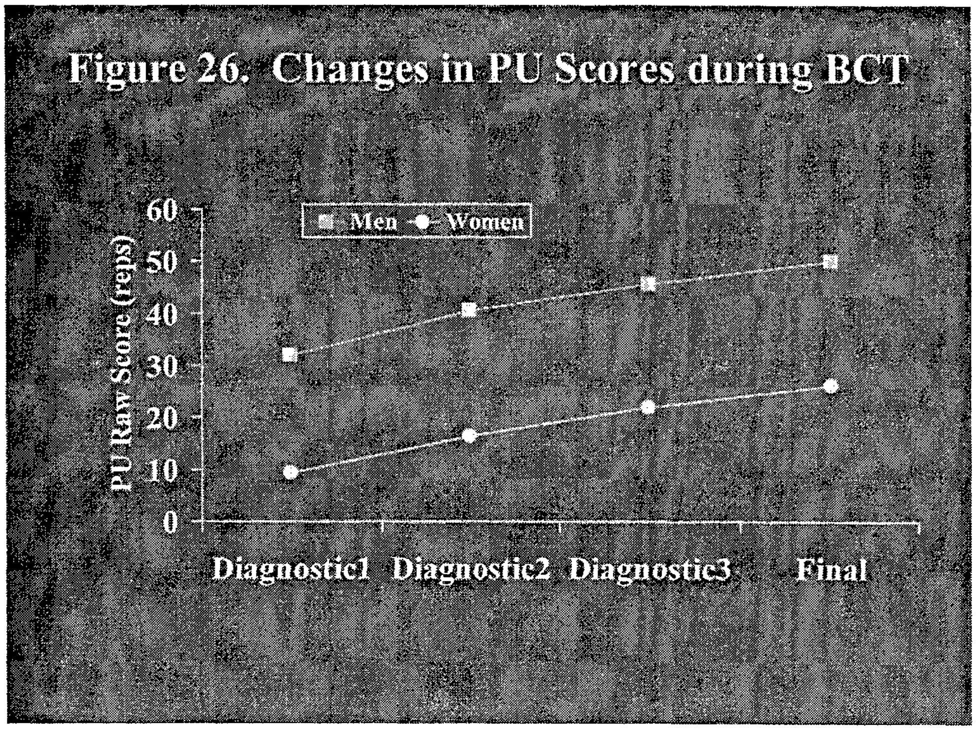


Figure 26. Changes in PU Scores during BCT
Men
Women
PU Raw Score (reps)
60
50
40
30
20
10
0
Diagnostic1
Diagnostic2
Diagnostic3
Final

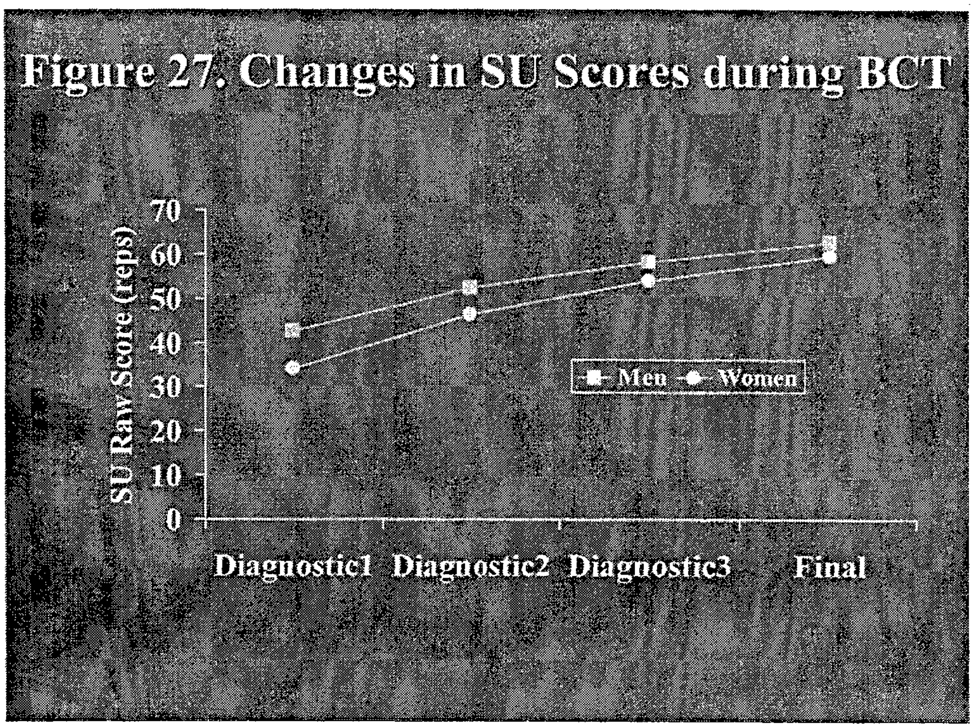


Figure 27. Changes in SU Scores during BCT
Men
Women
SU Raw Score (reps)
70
60
50
40
30
20
10
0
Diagnostic1
Diagnostic2
Diagnostic3
Final

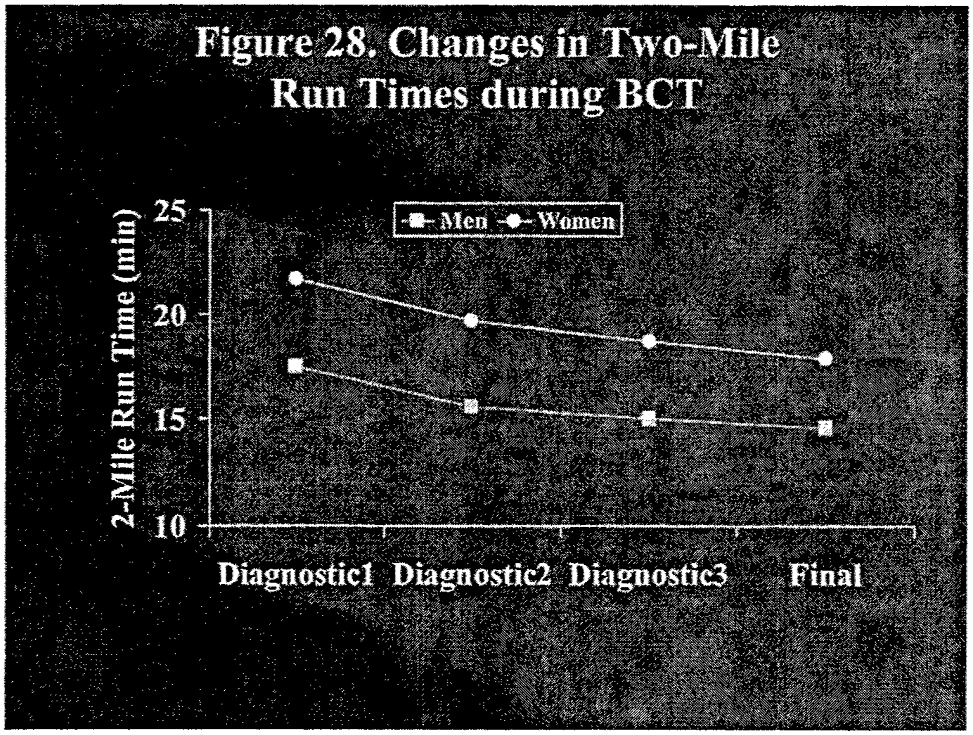


Table 33 shows the absolute and relative changes in the APFT scores from the first diagnostic test to the final test at Week 7. Absolute improvements in PU performance were similar for men and women but women's relative performance was much greater. Absolute and relative improvements in SU and the run were much greater for women.

Table 33. Absolute and Relative Changes in Fitness of Recruits During 7 Weeks of BCT

	Men		Women	
	Score Change (reps or min)	Relative Change (%)	Score Change (reps or min)	Relative Change (%)
Push-Ups	18	56.3	17	188.9
Sit-Ups	20	46.5	26	76.5
2-Mile Run	2.9	16.6	3.8	17.5

The inclusion of all trainees who took the APFT might not provide an accurate picture of improvements in fitness during BCT. This is because trainees who have the lowest fitness level are those most likely to be injured (63) or discharged (70) and consequently least likely to complete all APFTs. The low fitness score of the trainee would be included in the initial score because this is taken very early in training but they would be under-represented in later scores due to injury or discharge. It is not clear how this would affect changes in scores. On one hand, over-representation of low fit in the initial score would tend to lower the initial value; under-representation in the final score might tend to raise the final scores since those of higher fitness would be overrepresented. On the other hand, low fit individuals generally improve their aerobic capacity the most in BCT (108,124). Since they are under-represented in the final score this might lower the final score.

To resolve this issue, trainees who completed all 4 tests on a particular APFT event were examined. Table 34 shows the descriptive statistics for these trainees and Table 35 shows the relative and absolute changes from the first diagnostic test to the final test. The overall effect of including trainees who did not complete training is very small.

Table 34. Changes in Physical Fitness During BCT for Recruits Completed An Event

		Men		Women	
		N	Raw Score (reps or min) (mean±SD)	N	Raw Score (reps or min) (mean±SD)
Push-Ups	Diagnostic 1	9,492	32±13	4,856	12±8
	Diagnostic 2	9,492	41±14	4,856	19±10
	Diagnostic 3	9,492	46±13	4,856	24±10
	Final	9,492	50±12	4,856	28±10
Sit-Ups	Diagnostic 1	9,544	43±13	5,860	35±14
	Diagnostic 2	9,544	53±12	5,860	47±14
	Diagnostic 3	9,544	59±11	5,860	55±12
	Final	9,544	63±10	5,860	60±11
2-Mile Run	Diagnostic 1	9,298	17.4±2.5	5,526	21.5±2.8
	Diagnostic 2	9,298	15.7±2.0	5,526	19.5±2.5
	Diagnostic 3	9,298	15.0±1.7	5,526	18.6±2.1
	Final	9,298	14.6±1.3	5,526	17.9±1.7

Table 35. Absolute and Relative Changes in Fitness of Recruits During 7 Weeks of BCT

	Men		Women	
	Score Change (Reps or Min)	Relative Change (%)	Score Change (Reps or Min)	Relative Change (%)
Push-Ups	18	56.3	16	133.3
Sit-Ups	21	50.0	25	71.4
2-Mile Run	2.7	15.6	3.5	16.4

c. Changes in Fitness Among High School Diploma Graduates

Ages were not available in the DOIM database so it was not possible to examine the Army's prime market as requested by the CAR. However, educational status was available so high school graduates were examined. Table 36 shows changes in APFT raw scores among high school diploma holders and Table 37 shows the relative and absolute changes during BCT. It can be seen that the values are identical in all but a few cases to the entire sample shown in Table 32. This is not surprising since high school graduates made up 77% to 80% of the total sample.

Table 36. Changes in Physical Fitness of High School Diploma Graduate Recruits During BCT

		Men		Women	
		N	Raw Score (reps or min) (mean±SD)	N	Raw Score (reps or min) (mean±SD)
Push-Ups	Diagnostic 1	11,187	32±14	7,646	9±9
	Diagnostic 2	9,956	41±14	6,495	16±11
	Diagnostic 3	8,859	46±14	5,744	22±11
	Final	8,584	50±12	5,733	26±10
Sit-Ups	Diagnostic 1	11,189	43±13	7,646	34±14
	Diagnostic 2	9,964	53±12	6,504	46±14
	Diagnostic 3	8,857	58±12	5,745	54±13
	Final	8,583	63±10	5,735	60±11
2-Mile Run	Diagnostic 1	11,193	17.4±2.6	7,650	21.8±2.8
	Diagnostic 2	9,813	15.7±2.1	6,259	19.7±2.6
	Diagnostic 3	8,768	15.0±1.8	5,573	18.7±2.2
	Final	8,507	14.6±1.3	5,649	18.0±1.7

Table 37. Absolute and Relative Changes in Fitness During 7 Weeks of BCT Among High School Diploma Graduates

	Men		Women	
	Score Change (Reps or Min)	Relative Change (%)	Score Change (Reps or Min)	Relative Change (%)
Push-Ups	18	56.7	17	188.9
Sit-Ups	20	46.5	26	76.4
2-Mile Run	2.8	16.1	3.8	17.4

d. Changes in Fitness by Race

In order to examine racial differences with regard to changes in APFT scores, a 3X4 mixed model ANOVA was performed. The model compared three racial groups (White, Black, Other) as independent measures and the 4 APFT test periods as repeated measures. Where racial main effects were found, differences between races were further analyzed using the Tukey Test. Because repeated measures ANOVA requires complete data, only trainees that completed all 4 tests could be included in the analysis.

There were 6, 3X4 ANOVAs performed. For men and women there were 3 ANOVAs for each APFT event. Each ANOVA had two main effects and one interaction. The two main effects were for test periods and race. The main effect for test period indicated whether or not test scores improved during BCT, regardless of race. As would be expected, in all analyses test scores improved indicating the physical training program was successful in enhancing performance. The main effect of race indicated whether or not there were racial differences regardless of the test periods. This differed depending on gender and race will be discussed below. Finally, the interaction indicates whether or not the pattern of change over the test periods differed by race. Here, too, there were differences which will be discussed. Where racial main effects were found, the Tukey test was used to determine differences between groups.

Table 38 shows APFT raw score by race for the men. Figures 29 to 31 graphically display the changes among the men by race for PU, SU, and the 2-mile run, respectively. On the PU event, there were significant main effects for test periods ($p<0.01$), race ($p<0.01$) and the interaction was significant ($p=0.02$). The Other racial category consistently scored higher than Whites or Blacks ($p<0.01$) and Blacks scored higher than Whites ($p<0.01$). The interaction effect appears to indicate a slightly faster rate of improvement for the Other racial group from Diagnostic Test 1 to Diagnostic Test 2.

For men on the SU event, there were significant main effects for test period ($p<0.01$), race ($p<0.01$) and the interaction was significant ($p<0.01$). The Tukey test on the race main effect indicated that Blacks scored higher than Whites ($p<0.01$) but there were no differences between Blacks and Others ($p=0.64$) or Whites and Others ($p=0.23$). The interaction appears to reflect a slightly faster rate of improvement for those in the Other racial group seen from Diagnostic Test 1 through Diagnostic Test 3.

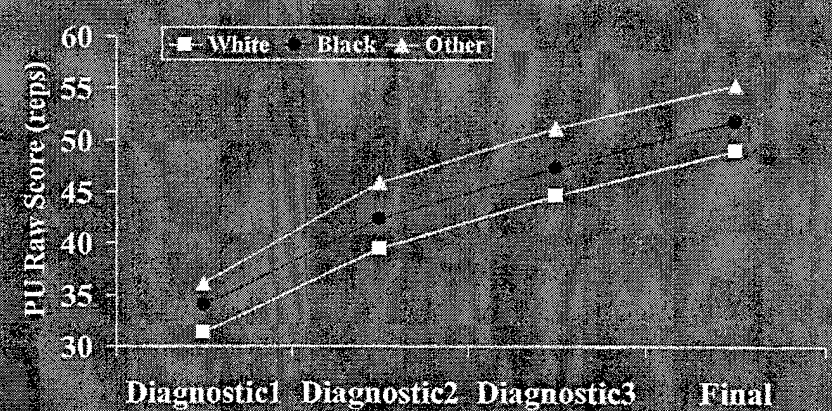
For men on the 2-mile run, there were significant main effects for test period ($p<0.01$) and race ($p<0.01$) but the interaction was not significant ($p=0.21$). The Tukey test on the race main effect indicted that both Blacks ($p=0.02$) and Whites ($p<0.01$) ran faster than the Other racial group but there were no differences between Whites and Blacks (p=0.53). The lack of a significant interaction indicated that all racial groups improved similarly over time.

Table 38. APFT Raw Scores for Male Recruits by Race (Mean±SD)

Test Event	Race	Diagnostic 1 (reps or min)	Diagnostic 2 (reps or min)	Diagnostic 3 (reps or min)	Final (reps or min)	Change[a] (%)
Push-Ups	White	31±13	40±13	45±13	49±12	57.1
	Black	34±14	42±13	47±13	52±12	52.6
	Other	36±14	46±14	51±14	55±13	53.2
Sit-Ups	White	42±13	52±12	58±11	62±10	47.3
	Black	44±12	53±12	59±11	63±10	43.0
	Other	43±12	53±12	59±12	64±11	47.9
2-Mile Run	White	17.3±2.5	15.6±2.0	14.9±1.7	14.5±1.3	16.2
	Black	17.3±2.7	15.7±2.1	15.0±1.8	14.6±1.4	15.6
	Other	17.6±2.4	16.1±2.1	15.2±1.5	14.8±1.3	15.9

[a]Change in score from Diagnostic 1 to Final

Figure 29. Changes in Male PU Scores during BCT by Race



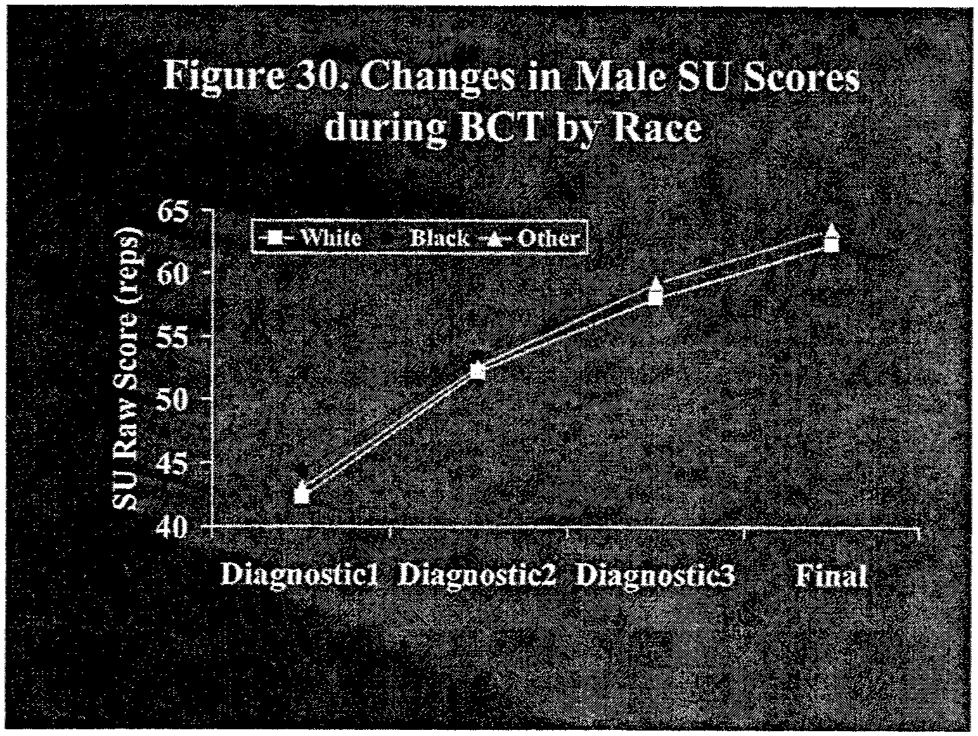


Figure 30. Changes in Male SU Scores during BCT by Race
SU Raw Score (reps)
65
60
55
50
45
40
White
Black
Other
Diagnostic1
Diagnostic2
Diagnostic3
Final

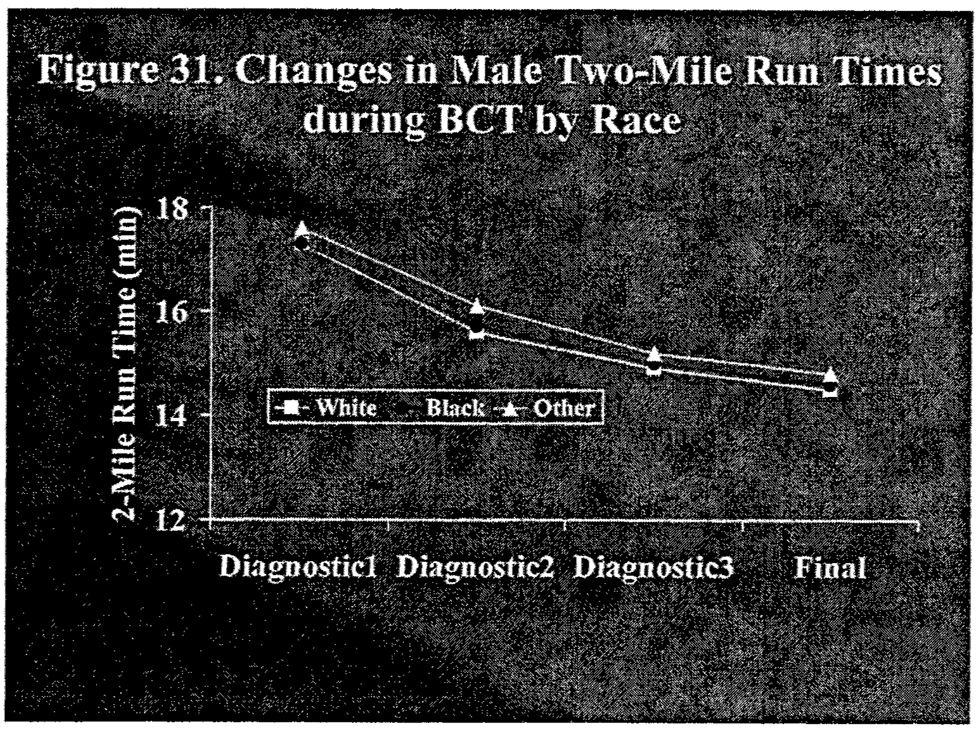


Figure 31. Changes in Male Two-Mile Run Times during BCT by Race
2-Mile Run Time (min)
18
16
14
12
White
Black
Other
Diagnostic1
Diagnostic2
Diagnostic3
Final

Table 39 shows APFT raw scores by race for the women. Figures 32 to 34 graphically display the APFT changes by race for PU, SU, and the 2-mile run, respectively. For women on the PU event, there were significant main effects for test periods ($p<0.01$) and race ($p<0.01$), and the interaction was also significant ($p<0.01$). The Other racial category consistently scored higher than Whites or Blacks ($p<0.01$) and Whites scored higher than Blacks ($p<0.01$). The interaction effect appears to indicate a slightly faster rate of improvement for the Other racial group seen from Diagnostic Test 2 to Diagnostic Test 3.

For women on the SU event, there were significant main effects for test period ($p<0.01$) but not for race ($p=0.18$); the interaction was significant ($p<0.01$). The interaction appears to reflect a slightly faster rate of overall improvement for those in the Other racial group and a slightly slower rate of improvement on the part of Blacks.

For women on the 2-mile run, there were significant main effects for test period ($p<0.01$) and race ($p<0.01$) and the interaction was significant ($p<0.01$). The Whites ran faster than both Blacks ($p<0.01$) and Others ($p<0.01$) while Others ran faster than Blacks ($p<0.01$). Although Blacks demonstrated slower run times overall, the interaction indicated a faster rate of improvement for Blacks.

Table 39. APFT Scores for Female Recruits by Race (Mean±SD)

Test Event	Race	Diagnostic 1 (reps or min)	Diagnostic 2 (reps or min)	Diagnostic 3 (reps or min)	Final (reps or min)	Change[a] (%)
Push-Ups (reps)	White	10±9	17±11	22±12	27±10	167.0
	Black	9±8	16±9	22±10	25±9	171.3
	Other	12±10	18±11	25±11	30±11	156.0
Sit-Ups (reps)	White	34±15	47±14	55±13	60±11	73.9
	Black	35±13	46±13	54±12	60±10	70.0
	Other	33±14	45±15	53±13	59±11	79.7
2-Mile Run (min)	White	21.0±2.8	19.2±2.4	18.3±2.1	17.6±1.6	16.2
	Black	22.2±3.0	20.2±2.5	19.1±2.1	18.3±1.7	17.7
	Other	21.3±2.7	19.7±2.3	18.7±1.9	17.9±1.5	16.0

[a]Change in score from Diagnostic 1 to Final

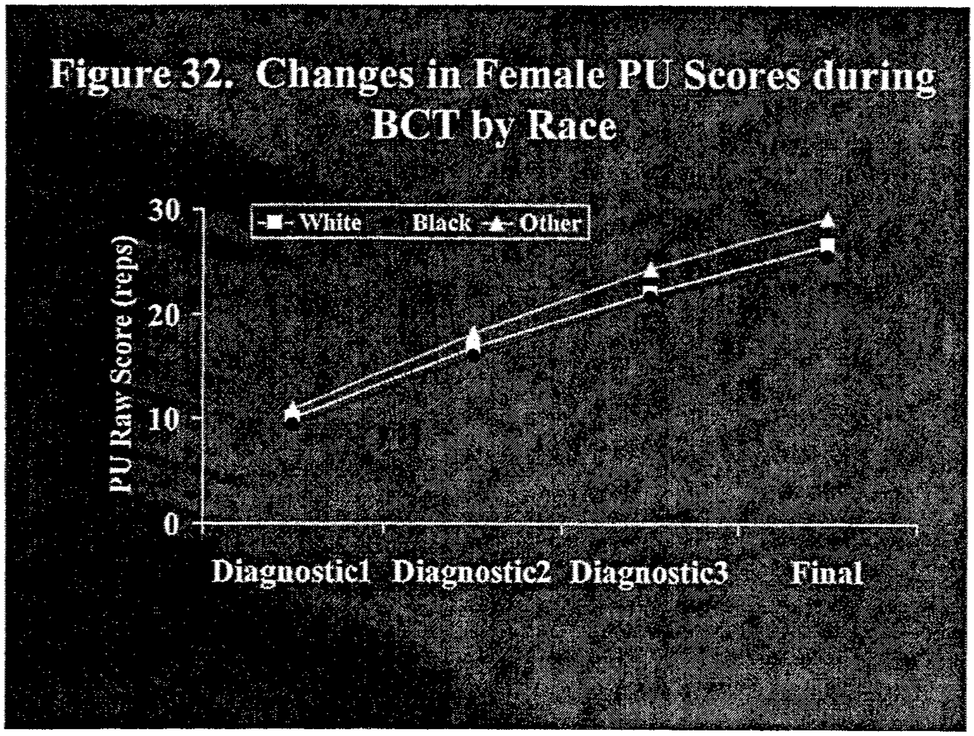


Figure 32. Changes in Female PU Scores during BCT by Race
PU Raw Score (reps)
30
20
10
0
White
Black
Other
Diagnostic1
Diagnostic2
Diagnostic3
Final

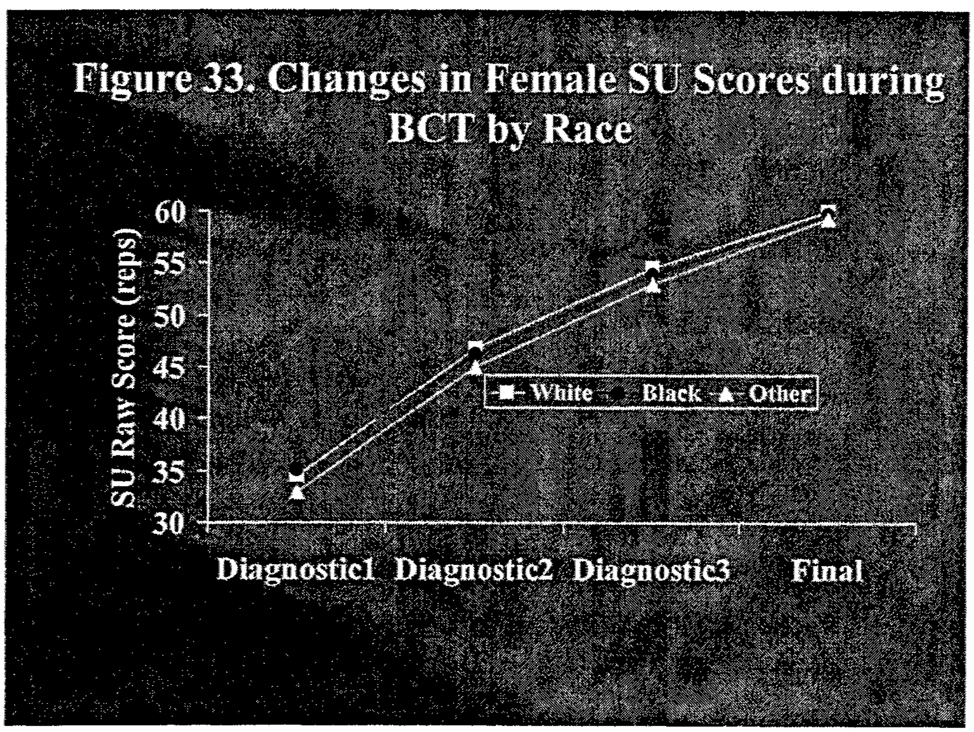
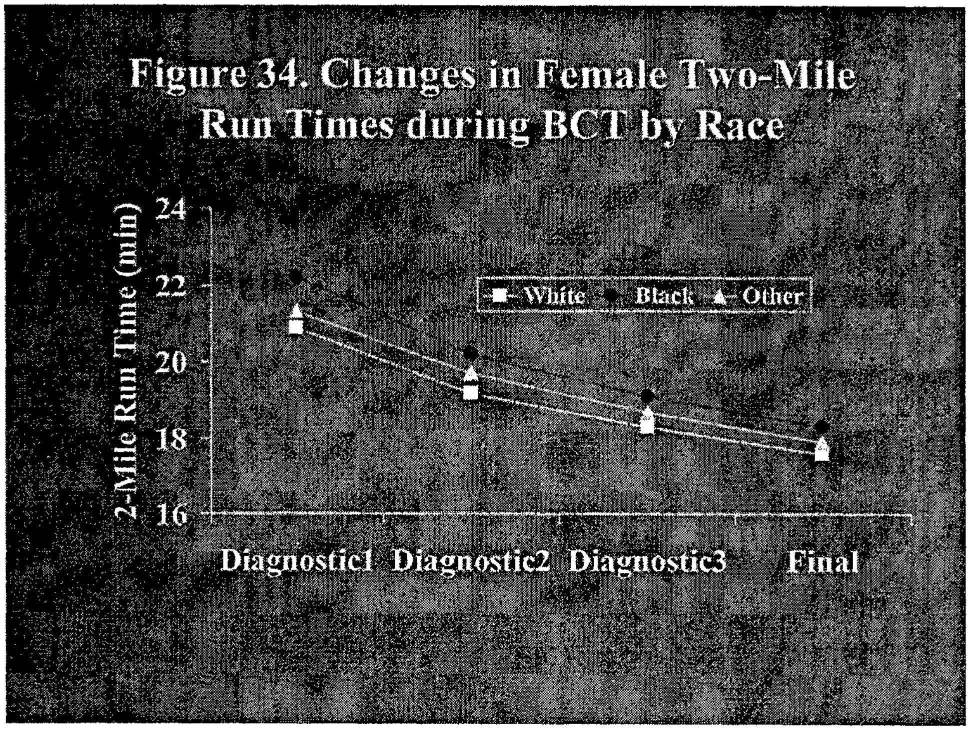


Figure 33. Changes in Female SU Scores during BCT by Race
SU Raw Score (reps)
60
55
50
45
40
35
30
White
Black
Other
Diagnostic1
Diagnostic2
Diagnostic3
Final



8. GENERAL DISCUSSION.

Data on secular trends in the fitness of youth, young adults, and recruits are limited but available information suggests that the situation is more complex than portrayed in the popular press (18,30,92,139). Some components of fitness appear to have degraded over time but other fitness components have not changed and some have actually improved. Cardiorespiratory endurance of male youth, male young adults, and male recruits has apparently not changed over time while there is some indication that that female cardiorespiratory endurance may have improved; however, studies involving endurance runs for time show performance declines for both men and women. Data on the muscle strength of recruits suggests an improvement in strength in the last 20 years. Studies involving muscular endurance suggest there was a small performance increase from 1965 to 1985 among youth while recruit data suggests little or no change in most measures from 1984 to 2003. There is strong evidence that BMI and body weight is increasing in youth, young adults and recruits; however, limited data on recruits suggests that about ½ the gain in body weight is fat mass and about ½ the gain is fat-free mass.

a. Cardiorespiratory Fitness

There has been no change in the VO_2max of 15 to 19 year old boys from the mid 1930s to the 1990s (32) and no change in the VO_2max of male recruits from 1975 to 1998 (125,138). There has been an increase in the VO_2max of girls from the 1960s into the 1990s (32) supported by a higher maximal aerobic capacity of new female recruits in 1998 compared to the 1975 to 1978 period (108,125,138).

In contrast to the data on VO_2max, there has been a decline in the performance of endurance running tasks like the shuttle run and the 1-mile run for both boys and girls up to high school age (81,130,132). Consistent with this is a decline in the 2-mile run times of recruits from 1988 to 2003 (61,72,73,74,77,112). While these data appear to contradict the VO_2max data, a distinction must be made between physiological tests like VO_2max and performance tests involving endurance runs for time. Endurance runs are used as surrogate measures of aerobic capacity because they have a large aerobic component. VO_2max is highly related to 2-mile run times with correlations ranging from -0.76 to -0.91 (67); the correlation between the shuttle run and VO_2max ranges from 0.66 to 0.95 (43,46,85,86,93,105,117,128). Thus, the variance in common to these endurance run tests and VO_2max (i.e., correlation squared) is 44% to 82%. However, this leaves unaccounted for 18% to 56% of the variance. Performance tests can be influenced by factors not directly related to physiological capability such as experience with running (practice, pacing ability, ability to tolerate running discomfort), motivation, and environmental factors (instructions, terrain, weather, slope of the course). Since VO_2max has not changed (males) or improved slightly (females) over time it may be that youth and recruits are not as proficient at applying their physiological capability to performance tasks like runs for time. At any rate, factors other than aerobic capability must account for the decline in run times.

Another factor to explore in the apparent discrepancy between VO_2max and running performance is the increase in body weight. Weight added to the body increases the energy requirement of running and decreases run times without influencing absolute VO_2max (28). There has been an increase in the body weight of youth, young adults and recruits over time (61,73,79,124,129,132,141). One study that measured recruit body composition estimated from skinfolds showed that the additional body weight was due to an increase in both fat mass and fat-free mass in about equal proportions (Table 28, 125). Increased fat mass would be expected to decrease running performance since it merely serves to increase body weight without adding to the oxidative capacity of the body during exercise (28). On the other hand, additional fat-free mass can increase VO_2max in proportion to its contribution as oxidative tissue involved in exercise (136).

Table 40 shows body fat and VO_2max data from two recruit studies in 1978 and 1998 (108,125) and recalculates VO_2max per kg of fat-free mass. For men, VO_2max per unit of fat-free mass was about the same in 1978 and 1998. This suggests that fat-free mass increased in approximate proportion to the increase in aerobic capacity and that the additional fat mass cannot account for the decline in 2-mile run times among male recruits. For women, VO_2max per unit of fat-free mass was higher in 1998 than in 1978, suggesting that VO_2max increased disproportionately to the increase in fat-free mass. The increase in body fat cannot account for the female decline in 2-mile run times since VO_2max actually increased. Thus, factors other than the increased fat mass alone must account for the declines in run times among recruits.

Table 40. VO_2max Data from Two Recruit Studies in 1978 (Refence Number 125) and 1998 (Reference Number 108)

	Men			Women		
	1978	1998	Δ	1978	1998	Δ
VO_2max (L/min)	3.53	3.92	0.39	2.09	2.45	0.36
VO_2max (mL/kg*min)	50.7	50.6	-0.1	36.9	39.2	2.3
VO_2max (mL/kg FFW*min)[a]	61.0	61.5	0.5	51.1	55.8	4.7

[a]FFM=Fat-free weight

Increased participation in sports and exercise may be associated with improvements in female youth VO_2max from 1960 to 1990 and the improvement in female recruit VO_2max from 1975 to 1998. In 1971, girls accounted for only 7% of all high school athletes, but by 2001 that proportion had risen to 42%. In this same time period the number of female collegiate varsity athletes increased 403% while male collegiate varsity athletes rose 23% (114). From 1977 to 1996, the average number of female college sports teams increased from 5.6 per school to 7.5 per school (2). Of course, data on school athletes include only the more highly active individuals. One small study of 18 to 19 year old women at a southeastern university showed that the physical activity of women increased from 1987 to 1997 while that of men did not change (4). Data from the YRBS suggests a decline in physical activity from 1991 to 1997 followed by a recovery back to 1991 levels in subsequent years but this survey covers only a 10 year period. Studies on adult physical activity indicate that women's physical activity has increased from the 1960s into the 1990s (21,49,60,127) and that women increased their activity more than men (21,49,127). Thus, there is some evidence of increased participation in women's sports teams and increased physical activity in the broader female population that exceeds that of men.

b. Muscular Strength

No data was found on secular changes in the muscle strength of youth or young adults in the civilian literature. Data on Army recruits was limited (79,125) but the results were consistent in showing that the strength was higher in 1998 than in 1978 or 1983 for all muscle groups tested. These results are consistent with other findings related to physical activity and estimated increases in muscle mass over the same time period. In the 1999 YRBS there were a greater proportion of high school students and 12th graders who reported performing strengthening exercise than in earlier years (see Tables 15 through 18). There was also an increase in estimated fat-free mass from 1978 to 1998 in the same groups of recruits who took the strength tests (Table 28, 125). About ½ of fat-free mass is muscle mass (91) and the amount of muscle mass is highly correlated with muscle strength (58,59,89). The increase in body fat would not be expected to influence muscle strength because there is little relationship between strength and body fat (66).

c. Muscular Endurance

Civilian data on muscular endurance include information on the PU performance of boys, flexed-arm hang performance of girls and SU performance of both genders. In general, there appears to be a small upward trend such that the PU performance of boys and flexed-arm hang performance increased slightly from 1965 to 1985 (26,132). SU performance of boys and girls increased from 1980 to 1989. Secular data on recruits has little overlap with the civilian data since recruit data covers a period from 1984 to 2003. During this time, there was a small improvement in the PU performance of men but a decline in the performance of SU. For women there was virtually no change in performance on PU or SU during the 19-year period (61,72,73,74,77).

d. Body Weight, Body Mass Index, and Body Fat

Many studies have used BMI as a marker of overweight and obesity (23,36,37,38,50,103,118). There are several advantages to the use of this index. BMI "corrects" body weight for the height of an individual, essentially removing the dependency of weight on height (65). BMI is easy to obtain and the large databases cited above can be used to describe populations and trends. The implicit assumption is that BMI is a marker of body fat and the correlation between body fat and BMI is about 0.7 in both civilian samples (65,121) and in new Army recruits (69). However, a correlation of 0.7 indicates that only about ½ of the variance in BMI is in common with body fat. There is evidence that BMI may be associated with different proportions of body fat in different racial groups and that leg length and body build can affect the association between fat and BMI (83). An individual can have a high BMI because of a high proportion of any tissue in the body, not just fat (e.g., bone, muscle). A good illustration of this fact is the different proportions of body tissues in men and women. Table 41 shows the weight of the total body and various body constituents in a representative 20 to 24 year old man and woman (91). Compared to men, women have more of their total body weight as fat (16% vs. 26%) and less of their body weight as fat-free mass (74% vs. 86%). The density of fat is 0.9 gm/cm^2 while that of fat-free mass is 1.1 gm/cm^2 (91). Since fat-free mass has greater weight per volume (greater density), and men have more fat-free mass, any absolute measure of BMI would tend to show men having higher BMI. This illustration points out a simple fact: BMI is just weight for height and the relative amounts of the various tissues in the body will influence the BMI value.

Table 41. Body Weight and Composition of 20-24 Year Old Reference Man and Woman (From Reference 91)

	Body Weight (kg)	BMI (kg/m^2)	Fat Mass (kg)	Fat-free Mass (kg)	Muscle Mass (kg)	Bone Mass (kg)
Man	70	23.1	11	60	31	10
Woman	57	21.1	15	42	20	7

Army Regulation 40-501 (11) contains a table that prescribes the maximum and minimum body weight for individuals desiring to enter the service. Table 42 shows the entry level weight-for-height tables converted to BMI. BMI ranges from 17.3 to 28.6 kg/m^2 for men and 16.2 to 25.9 kg/m^2 for women. Army Regulation 600-9 (7) prescribes the maximal weight for height for retention in service. Table 43 shows the retention weight-for-height tables converted to BMI values. BMI ranges from 25.7 to 27.6 kg/m^2 for men and from 22.4 to 25.0 kg/m^2 for women. Thus, in no case does maximum allowable BMI exceed 28.6 kg/m^2. However, if an individual exceeds the weight-for-height table, that individual can have his or her body fat estimated using circumferential measures (137). If estimated body fat exceeds the maximum allowable amount shown in Table 44 the individual is not retained in service if he or she cannot reduce their body fat in a reasonable period of time (7,11).

Table 42. Height/Weight Tables for Entry Into the Army Converted to BMI (Recalculated from Reference 11)

Men						Women					
Height (in)	Min BMI	Maximum BMI (kg/m²) by years of age				Height (in)	Min BMI	Maximum BMI (kg/m²) by years of age			
	Any Age[a]	17-20 Years	21-27 Years	28-39 Years	≥40 Years		Any Age[a]	17-20 Years	21-27 Years	28-39 Years	≥40 Years
						58	18.8	23.4	24.1	24.9	25.9
						59	18.5	23.4	24.0	24.8	25.4
60	19.6	27.2	27.6	27.9	28.5	60	18.4	23.4	24.1	24.8	25.4
61	19.3	27.2	27.6	28.0	28.5	61	18.1	23.4	24.0	24.8	25.5
62	18.4	27.1	27.4	28.0	28.5	62	17.9	23.6	24.2	25.0	25.4
63	18.4	27.1	27.4	28.0	28.5	63	17.7	23.6	24.3	25.0	25.5
64	18.0	27.2	27.5	28.0	28.5	64	17.5	23.5	24.2	24.9	25.4
65	17.6	27.1	27.4	27.9	28.4	65	17.3	23.4	24.1	24.8	25.4
66	17.3	27.1	27.4	27.9	28.6	66	17.1	23.6	24.2	24.9	25.5
67	17.3	27.2	27.5	28.0	28.5	67	17.0	23.3	24.1	24.9	25.3
68	17.5	27.2	27.6	28.0	28.5	68	17.0	23.5	24.2	25.0	25.4
69	17.6	27.2	27.5	27.9	28.5	69	17.0	23.4	24.1	24.8	25.4
70	17.7	27.1	27.6	28.0	28.6	70	16.9	23.4	24.1	24.8	25.4
71	17.7	27.1	27.5	28.1	28.5	71	17.0	23.3	24.0	24.7	25.4
72	17.8	27.2	27.6	28.0	28.5	72	17.0	23.4	24.0	24.9	25.5
73	17.8	27.0	27.4	28.0	28.5	73	16.9	23.3	24.0	24.8	25.5
74	17.9	27.1	27.5	28.0	28.5	74	16.7	23.5	24.3	25.0	25.4
75	17.9	27.1	27.5	28.0	28.5	75	16.6	23.5	24.2	25.0	25.5
76	17.9	27.1	27.5	28.0	28.4	76	16.5	23.6	24.3	25.0	25.4
77	17.9	27.1	27.5	27.9	28.4	77	16.5	23.6	24.3	25.0	25.5
78	17.7	27.1	27.5	27.9	28.5	78	16.3	23.5	24.2	25.0	25.4
79	17.9	27.1	27.5	27.9	28.5	79	16.2	23.5	24.2	25.0	25.4
80	18.2	27.1	27.5	28.0	28.5	80	16.2	23.5	24.2	25.0	25.5

[a]Min=Minimum; BMI units are kg/m^2

Table 43. Height/Weight Tables for Retention in Army Converted to BMI (Recalculated from Reference 7)

Height (in)	Men BMI (kg/m²) for Age				Women BMI (kg/m²) for Age			
	17-20 Years	21-27 Years	28-39 Years	≥40 Years	17-20 Years	21-27 Years	28-39 Years	≥40 Years
58					22.8	23.4	24.1	24.9
59					22.8	23.4	24.0	24.8
60	25.8	26.6	27.2	27.6	22.7	23.4	24.1	24.8
61	25.7	26.5	27.2	27.6	22.7	23.4	24.0	24.8
62	25.8	26.3	27.1	27.4	22.9	23.6	24.2	25.0
63	25.7	26.4	27.1	27.5	22.9	23.6	24.3	25.0
64	25.8	26.5	27.2	27.5	22.8	23.5	24.2	24.9
65	25.8	26.4	27.1	27.4	22.7	23.4	24.1	24.8
66	25.8	26.3	27.1	27.4	22.8	23.6	24.2	24.9
67	25.8	26.4	27.2	27.5	22.7	23.3	24.1	24.9
68	25.9	26.5	27.2	27.6	22.8	23.5	24.2	25.0
69	25.9	26.4	27.2	27.5	22.4	23.4	24.1	24.8
70	25.8	26.6	27.1	27.6	22.8	23.4	24.1	24.8
71	25.8	26.4	27.1	27.5	22.7	23.3	24.0	24.7
72	25.8	26.5	27.2	27.6	22.7	23.4	24.0	24.9
73	25.7	26.4	27.0	27.4	22.7	23.3	24.0	24.8
74	25.8	26.5	27.1	27.5	22.9	23.5	24.3	24.9
75	25.7	26.5	27.1	27.5	22.9	23.5	24.2	25.0
76	25.8	26.4	27.1	27.5	23.0	23.6	24.3	25.0
77	25.8	26.4	27.1	27.5	22.8	23.6	24.3	25.0
78	25.8	26.4	27.1	27.5	22.8	23.5	24.2	24.9
79	25.8	26.5	27.1	27.5	22.9	23.5	24.2	25.0
80	25.7	26.4	27.1	27.5	22.8	23.5	24.2	24.9

Table 44. Maximum Body Fat (%) for Entry into the Army and for Retention in the Army (from References 7,11)[a]

	Gender	Age			
		17 to 20 Years	21 to 27 Years	28 to 39 Years	≥40 Years
Entry into Army	Men	24	26	28	30
	Women	30	32	34	36
Retention in Army	Men	20	22	24	26
	Women	28	30	32	34

[a]Body fat is estimated from circumference only if the weight for height tables are exceeded

One might assume that individuals with BMI>30 kg/m^2 would be screened out of the service because of the weight for height tables and the body fat requirement. However, previously unpublished data from 2 studies (73,77) shown in Table 45 indicate that a large proportion of men and a smaller proportion of women who entered service exceeded 30 kg/m^2. It must be assumed that these individuals did not exceed the body fat standards or that they were waivered to enter service. Also interesting is the fact that 2003 had a greater proportion of individuals classified as overweight or obese compared to 1998.

Table 45. Distribution of BMI Values and Average BMI Values in Two Studies

		Year (Reference Number)			
		1998 (77)[a]		2003 (73)[ab]	
		Men	Women	Men	Women
Distribution of BMI Values	BMI <25 kg/m^2 (%)	63	75	50	70
	BMI 25-30 kg/m^2 (%)	28	21	37	29
	BMI >30 kg/m^2 (%)	10	1	13	1
Mean±SD BMI (kg/m^2)		24.2±3.8	23.0±3.2	25.2±3.9	23.4±3.0
N		731	448	1174	898

[a]Previously unpublished data from this study.
[b]Combines information from 2 major groups in the study

Civilian studies show that there was little change in the prevalence of overweight or obesity from 1960 to 1980. However, after 1980 the prevalence of overweight and obesity has progressively increased for both male and female youth and adults (23,36,37,103,132). From 1960 to 1994 the mean BMI of 17 year old boys and girls rose 6% and 7%, respectively while the BMI of 20 to 29 year old men and women rose 4% and 5%, respectively (38). However, this increase in BMI is caused primarily by the most overweight and obese becoming more overweight and obese. The increase in BMI among individuals with values <25 kg/m^2 is much smaller (38) although it is not possible to calculate the change from the data provided in the articles.

Data from military studies on recruits generally support the fact that body weight and BMI are increasing over time. The increase in recruit BMI from 1978 to 2003 (25 year period) was 8% for men and 5% for women. Military studies suggest that the increase in body weight, at least in new recruits, appears to be due to an increase in both estimated fat and estimated fat-free mass, in approximately equal proportions (125). Some caution must be exercised in this interpretation. This finding is based on a single study and the data in both years was estimated from skinfolds for which there could be some degree of error (119). However, in both years the data was collected carefully by trained individuals in a research environment which provides some confidence in the results.

Body weight is regulated by the balance between energy intake and energy output. If food intake is greater than activity output, body weight will increase. If caloric activity output is greater than caloric food input, body weight will decrease. The increase in youth body weight and BMI has been ascribed to a reduction in physical activity coupled with an increase in food intake (36,37,103,118). There is no firm evidence that youth have become less physically active as indicated by the YRBS (Tables 15 and 16), but this survey covers a period only from 1991 to 2001. There is data suggesting that Americans as a whole have become somewhat more active since the 1960s (19,21,60,84,127) (See Appendix D). However, body weight could still increase either if fat-free mass increased or if the increase in activity was not enough to offset an increase in food intake resulting in accumulation of body fat.

Information on food consumption suggest that over the last 20 years or so, caloric intake has increased, different types of foods are being ingested, and places of consumption have changed. NHANES collects dietary information from an interview that asks about food and beverages consumed in the past 24 hours. NHANES data (NHANES I, II, III, and 1999-2000) indicated that from 1971 to 2000 the average energy intake of men increased 7% and that of women 22%. This was attributed to an increase in total calories from carbohydrates for both men and women. With regard to fat, total intake decreased for men while it increased for women (143). However, comparison of total energy intake trends from the NHANES data suffers from several serious methodological problems. These include the fact that different surveys used different methods to collect dietary information and derive nutrient estimates (87,102). In fact, the documented increase in carbohydrates occurred between NHANES II and NHANES III (143) and in NHANES III a different nutrient database was used for analysis (87). Further, underreporting of food consumption is a well documented phenomena and is more common in overweight individuals (53,87). Finally, the published NHANES analyses considers the entire sample (ages 20 years and up), not just the sample of military age which could show different results.

One set of studies (99,100,101) examined individuals surveyed on food intake in 1977 to 1978, 1989 to 1991, and 1994 to 1998 (21 year period). These studies used a single nutrient database providing more comparability across surveys than the NHANES studies. The survey technique differed in the middle year survey but was similar in the two extreme year surveys. These studies indicate that *trends* in food intake were almost identical for youth (12 to 18 year olds), young adults (19 to 29 year olds), and older adults. Estimated total energy consumption increased 10% for youth and 20% for young adults from about 1977 to about 1996. For both youth and young adults, there has been a reduction in the proportion of calories from desserts, milk, milk products, beef and pork. There has been an increase in the proportion of calories from soft drinks, pizza, candy, fruit drinks, french fries, cheeseburgers, and Mexican food. Many more calories were consumed away from home at restaurants and fast food establishments in 1994 to 1998. Portion sizes increased in 8 out of 9 key foods (e.g., salty snacks, soft drinks, hamburgers, etc.) both at home and at fast food establishments.

Taking a different and more global approach, Harnack et al. (53) examined data on food availability in the U.S. as an adjunct to these national dietary surveys. Harnack and colleagues showed that per capita daily *availability* of food was 13.8J in 1970 and 15.9J in 1994, a 15% increase. The greatest per capita availability increases were for carbohydrates and protein resulting in a decrease in energy availability from fat from 42% to 38%. Twenty percent of food dollars were spent away from the home in 1970 and 38% in 1992. It was estimated that restaurants were growing at a rate of 3%/yr while fast food establishments were growing about 7%/yr.

Thus, available evidence suggests that the increase in BMI and body weight are due primarily to an increase in food intake. Physical activity appears to have increased but this increase has apparently not been enough to offset the intake of food. The increase in BMI and body weight must be of concern because high body mass, if not offset by muscle mass, is associated with lower physical capacity for some weight bearing tasks (136). Further, individuals who have a high BMI in adolescence tend also to have high BMI as adults (47,82) making these individuals less appropriate for military service because of the weight for height requirements.

e. Improvements in Fitness During BCT

Regardless of race or gender, recruits were able to substantially improve their physical fitness as measured by the APFT during BCT. The improvements in fitness followed the logarithmatic pattern typically seen in many physical training studies. That is, there was a rapid improvement in cardiorespiratory endurance and muscular endurance early in training followed by less improvement later in training. For men, the absolute improvements during 7 weeks of BCT resulted in an average increase of 17 PU, 20 SU and a 2.9 minute decrease in 2-mile run times. For women, average improvement were 17 PU, 26 SU and a 3.8 minute decrease in average 2-mile run time. Since men and women train together, the generally greater improvement for the women is presumably due to the greater relative training stimulus.

Early improvements in PU and SU performance are probably associated with a fuller activation of the muscles involved in the task and a more effective coordination of motor unit firing (94,123). As training progresses, an increase in muscle mass (hypertrophy) may provide more contractile tissue to perform PU and SU (94,111) provided a portion of the increased muscle mass is in the muscles performing the PU and SU tasks. Whole body fat-free mass has been shown to increase during BCT in most (79,124,129,141) but not all (124) studies (also see Table 27).

Run training, and even walking for low-fit recruits, increases cardiac output and the extraction of oxygen from the blood (97) both of which are probably associated with the improvements in run time and VO_2max seen in BCT. As noted above, fat-free mass has generally been shown to increase during BCT while fat mass decreases (Table 27, 79,124,129,141). The decrease in fat mass may assist in improving running speed by reducing non-oxidative tissue in the body (28). The increase in fat-free mass may provide more oxidative tissue for the run assuming some of the increase in muscle mass is in the active leg muscles.

f. Racial Differences in Fitness During BCT

There were some racial differences in fitness score improvements as can be seen in Figures 29 to 34. Where racial variation occurred it was due to an initial performance difference (a difference on Diagnostic Test 1) that was generally maintained throughout training or somewhat reduced during training. In most cases, racial differences were relatively small and not of much practical significance. However, there were 3 racial differences that were of note.

On male PU, the Other racial group performed 5 more PU than Whites at the start of training and 6 more PU than Whites at Week 7 of training. The Other racial category is vague and includes such subgroups as Hispanics, Asians, and American Indians. Few studies were found on racial difference in muscle strength or muscular endurance and these did not support the present findings. Two studies indicate that the grip strength of Asian men tends to be lower than that of White men (96,144). Further efforts need to be directed at partitioning the Other racial category into appropriate subgroups to determine which racial categories may be displaying higher upper body muscular endurance and why.

Blacks performed an average of 3 more PU and 2 more SU than Whites at the start of training. By the end of training the PU difference remained while Blacks performed only 1 more SU than Whites. One study was found on racial differences between Blacks and Whites in maximal strength and power during sustained leg contractions and this study did not support our finding here. Ama et al. (6) found no Black/White differences in maximal strength or maximum power output. However, on total leg work output, racial differences became progressively larger so that by 90 seconds of leg contractions Whites had produced more total work than Blacks.

The other important racial difference was on the female 2-mile run where Black women ran an average 1.2 minutes slower than White women and an average 0.9 minutes slower than those in the Other racial category. Black women progressively closed this time gap during BCT such that by the 7th week of training the difference between Black and White women was only 0.7 minutes. It has been shown in the literature that Black women (ages 18 to 30 years), Black adolescents (ages 11 to 16 years) and Black children (ages 5 to 10 years) have lower VO_2max than their White counterparts (110,126,131,144). We confirmed this for basic trainees by examining previously unpublished data from another study (125) which is shown in Table 46. Black women have been shown to have greater bone mineral density than White women (33) and we confirmed this for basic trainees as shown in Table 47 again using unpublished information from another study (125). This suggests that the contribution of bone to fat-free mass may be greater in Blacks than in Whites (104) so that the lower VO_2max may be accounted for by less oxidative muscle tissue. However, one study of Black girls showed that the VO_2max differences persisted after correction for soft lean tissue mass (fat-free mass exclusive of bone), leg soft lean tissue mass, fat mass, and total energy expenditure measured from doubly labeled water (131). Black adolescents have been shown to have lower hemoglobin levels than Whites (110) which could account for some of the difference in VO_2max and running performance. In a multivariate analysis greater smoking prevalence, and lower lung capacity (forced expiratory volume in 1 second) accounted for some of the differences between Black and White women (126). Studies of Black men have shown that they have a lower proportion of Type 1 muscle fibers than White men; if Black and White women share this discrepancy this could limit the ability to perform sustained aerobic activity (5).

Table 46. Racial Differences in VO_2max Among Recruits (previously unpublished data from Reference Number 125)

	Men		Women	
	N	VO_2max (ml/kg*min)[a]	N	VO_2max (ml/kg*min)[a]
White	106	50.9±6.5	78	40.5±5.5
Black	38	50.9±5.4	50	36.7±4.6[b]
Other	26	48.5±5.7	28	41.2±4.0
p-value[c]		0.20		<0.01

[a]Mean±SD
[b]Lower than White and Other (p<0.01, Tukey Test))
[c]Difference among all 3 groups (One-Way ANOVA)

Table 47. Racial Differences in Bone Mineral Density (BMD) Among Recruits (previously unpublished data from Reference Number 125)

	Men		Women	
	N	BMD (gm/cm^2)[a]	N	BMD (gm/cm^2)[a]
White	112	1.271±0.087	81	1.178±0.085
Black	42	1.348±0.113[b]	57	1.249±0.075[b]
Other	26	1.258±0.097	30	1.186±0.071
p-value[c]		<0.01		<0.01

[a]Mean±SD
[b]Higher than White and Other (p<0.01, Tukey Test))
[c]Difference among all 3 groups (One-Way ANOVA)

Black women made up 6.1% of the total active duty Army force in 2003 (90). At first glance, the lower initial aerobic capacity of Black women appears to be a matter of some concern. It is known that recruits with slower run times at the start of BCT are more likely to be injured during training and are more likely to attrite from training (63,70,78). However, Black women show lower overall attrition than White women both in BCT and in the first term of service (68). In our analysis, Black women show more rapid improvement in cardiorespiratory endurance during BCT compared to White and Other women. It would be of interest to track fitness differences beyond BCT to see if the fitness gap is further reduced. The rapid improvement in fitness during BCT may assist Black women in overcoming factors related to attrition and may reflect a higher level of motivation toward training.

9. SUMMARY AND CONCLUSIONS.

a. Physical Fitness Trends

Most physical fitness trends involving cardiorespiratory endurance, muscle strength, muscular endurance, body weight, and BMI can be modeled using linear regression. From a mathematical point of view there is little reason to think these trends will not continue into the future. However, actions taken at the national level and supported by data on youth physical activity from the YRBS may suggest factors that may moderate some of these linear trends. The 1996 U.S. Surgeon General's report on physical activity (24) highlighted the fact that many youth, young adults and adults were not getting recommended amounts of physical activity and that enrollment in high school physical education classes had been declining. Increased youth physical activity was seen shortly after the publication of this report and the attention it generated. There was a reversal of the downward trend in the number of days performing vigorous physical activity reported by high school students and 12^{th} graders (Tables 15 through 18). There was a reversal of the downward trend in the number of days attending physical education classes reported by all high school students and 12^{th} grade boys (Tables 15 through 17). There was an increase in the number of days performing strengthening exercises reported by 12^{th} graders and all high school students (Tables 15 through 18).

Available evidence suggests that there has been little change since 1930 in the VO_2max of male youth and no change since 1975 in the VO_2max of male recruits. Female youth and recruit VO_2max appears to have increased in similar time periods. Contrary to these data there has been a decline in endurance run times of youths and recruits. Since male VO_2max has not changed males and female VO2max may have improved slightly it may be that youth and recruits are not as proficient at applying their physiological capability to performance tasks like runs for time. This could be because of factors such as reduced experience with running, motivation, and/or environmental factors. Running economy (energy used per unit of distance run) could also have declined due to decreased experience with running. It cannot be said with certainty if the decline in running performance will continue. One positive finding in this respect is the reversal in the decline in the number of days that youth are performing vigorous physical activity since 1997.

Muscle strength has apparently increased among recruits and this increase in strength is congruent with an increase in fat-free mass and an increase in self-reported strength training among youth. Muscle strength may continue to increase if fat-free mass continues to increase or if a greater proportion of youth perform strength training.

Data on muscular endurance is conflicting and secular trends cannot be easily determined with available data. Between 1965 and 1989 there was an apparent increase in the muscular endurance of youth. From 1984 to 2003, there was a small improvement in the PU performance of men but a decline in the performance of SU. For women there was virtually no change in performance on PU or SU during the same time.

The most consistently demonstrated fitness trend is an increase in body weight and BMI of youth, young adults and recruits since the 1980s. For youth and young adults the increase in BMI is caused largely by an increase in the BMI of the most obese and overweight, although all BMI levels appear to be increasing. Limited data on recruits suggests that the increase in body weight is due to an increase in both estimated fat and estimated fat-free mass, about in equal proportions. Available evidence suggests that the increase in BMI and body weight are due primarily to an increase in food intake. Overall physical activity appears to have increased somewhat but this increase has apparently not been enough to offset the intake of food. In 2001, the U.S. Surgeon General highlighted the trend in overweight and obesity in the publication of a report (134) and associated media attention (15,17,115). This report called for the recognition of overweight and obesity as a major health problem and proposed strategies for developing a public health response in families, schools, health care, the media, and worksites. Whether or not this will influence the trend in overweight and obesity is not known at this point. Data from NHANES and BRFFS studies can be used to track these future trends.

b. Physical Fitness Changes During BCT

For men, the absolute improvements during BCT resulted in an average increase of 17 PU, 20 SU and a 2.9 minute decrease in 2-mile run times. For women, average improvements were 17 PU, 26 SU and a 3.8 minute decrease in average 2-mile run time. Since men and women train together, the generally greater improvement for the women is presumably due to the greater relative training stimulus.

Whites performed fewer PU than Blacks and those of Other Races and Whites performed fewer SU than Blacks. These differences were seen at the start of training and were generally maintained throughout training. Reasons for these differences are not clear. On the 2-mile run test at the start of BCT, female Black recruits ran considerably slower than female White recruits. Previous literature indicates that Black women have a lower VO_2max, lower hemoglobin levels, greater smoking prevalence, and lower lung capacity which may account for at least a portion of this difference. Black women more rapidly improve their run times in BCT compared to their White counterparts and have lower overall attrition than White women. Examination of fitness changes beyond BCT would be useful.

10. RECOMMENDATION.

This review has revealed that except for body weight and BMI, there is a paucity of information on secular changes in the physical fitness of youth, young adults and new Army recruits. Although prevalence data exists on Army recruits these data have still been collected in a spotty and opportunistic manner. Surveillance systems are needed to systematically track the changes in fitness over time. The usefulness of regular, systematic surveillance of fitness components is illustrated by the body weight and BMI data tracked by NHES/NHANES. These surveys identified the increase in body weight and BMI that began in the 1980s and systematically tracked increases into 2003. Extensive parts of this paper are dedicated to the topic of body weight and BMI because of the studies and data that the NHES/NHANES and the BRFSS data made possible. The YRBS allowed tracking of physical activity but it has only been in place for a short period of time.

To determine fitness trends in the Army, the leadership needs to take action to develop an Army-wide surveillance system tracking body weight, height and physical fitness. The APFT is given on a regular basis in BCT and AIT units and twice a year in operational Army units. Databases already exist on many company and battalion-level computers systems that allow tracking individual soldier height, weight, PU score, SU score, and run score. A surveillance system would only involve standardizing these databases. Standardization should be done in a user friendly way so individual units can enter and obtain the information they need (e.g., who is overweight, who failed the APFT, who scored higher on the APFT) while the data enters a broader surveillance system. The broader surveillance system would allow systematic tracking over time of BMI, cardiorespiratory endurance and muscular endurance. There have been episodic movements to make the physical fitness test more combat and MOS relevant but we recommend keeping a core set of test measurements (PU, SU, 2-mile run, height, weight). In this way periodic assessments and historical comparisons can be made.

Appendix A
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Appendix B
Physical Activity Questions on the Youth Risk Behavior Survey

The question number refers to the number on the questionnaire for a particular year

1. 1991 Questions

Question 68. On how many of the past seven days did you exercise or participate in sports activities that made you sweat and breathe hard, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?

Question 69. On how many of the past seven days did you do stretching exercises, such as toe touching, knee bending, or leg stretching?

Question 70. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 71. Yesterday, did you walk or cycle for at least 30 minutes at a time? (Including walking or bicycling to or from school.)

Question 72. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

Question 73. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 74. During the past 12 months, on how many sports teams run by your school did you play? (Do not include PE classes.)

Question 75. During the past 12 months, on how many sports teams run by organizations outside of your school did you play?

2. 1993 Questions

Question 77. On how many of the past 7 days did you exercise or participate in sports activities for at least 20 minutes that made you sweat and breathe hard, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?

Question 78. On how many of the past 7 days did you do stretching exercises, such as toe touching, knee bending, or leg stretching?

Question 79. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 80. On how many of the past 7 days did you walk or bicycle for at least 30 minutes at a time (including walking or bicycling to or from school)?

Question 81. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

Question 82. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 83. During the past 12 months, on how many sports teams run by your school did you play?

Question 84. During the past 12 months, on how many sports teams run by organizations outside of your school did you play?

3. 1995 Questions

Question 77. On how many of the past 7 days did you exercise or participate in sports activities for at least 20 minutes that made you sweat and breathe hard, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?

Question 78. On how many of the past 7 days did you do stretching exercises, such as toe touching, knee bending, or leg stretching?

Question 79. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 80. On how many of the past 7 days did you walk or bicycle for at least 30 minutes at a time (including walking or bicycling to or from school)?

Question 81. In an average week when your are in school, on how many days do you go to physical education (PE) classes?

Question 82. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 83. During the past 12 months, on how many sports teams run by your school did you play? (Do not include PE classes)

Question 84. During the past 12 months, on how many sports teams run by organizations outside of your school did you play?

4. 1997 Questions

Question 77. On how many of the past 7 days did you exercise or participate in sports activities for at least 20 minutes that made you sweat and breathe hard, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?

Question 78. On how many of the past 7 days did you do stretching exercises, such as toe touching, knee bending, or leg stretching?

Question 79. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 80. On how many of the past 7 days did you walk or bicycle for at least 30 minutes at a time (including walking or bicycling to or from school)?

Question 81. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

Question 82. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 83. During the past 12 months, on how many sports teams run by your school did you play? (Do not include PE classes)

Question 84. During the past 12 months, on how many sports teams run by organizations outside of your school did you play?

5. 1999 Questions

Question 79. On how many of the past seven days did you exercise or participate in physical activities for at least 20 minutes that made you sweat and breathe hard?

Question 80. On how many of the past seven days did you participate in a physical activity for at least 30 minutes that did not make you sweat or breathe hard?

Question 81. On how many of the past seven days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 82. On an average school day, how many hours do you watch TV?

Question 83. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

Question 84. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 85. During the past 12 months, on how many sports teams did you play?

Question 86. During the past 12 months, how many times were you injured while exercising, playing sports, or being physically active and had to be treated by a doctor or nurse?

6. 2001 Questions

Question 80. On how many of the past 7 days did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities?

Question 81. On how many of the past 7 days did you participate in physical activity for at least 30 minutes that did not make you sweat or breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors?

Question 82. On how many of the past 7 days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting?

Question 83. On an average school day, how many hours do you watch TV?

Question 84. In an average week when you are in school, on how many days do you go to physical education (PE) classes?

Question 85. During an average physical education (PE) class, how many minutes do you spend actually exercising or playing sports?

Question 86. During the past 12 months, on how many sports teams did you play? (Include any teams run by your school or community groups)

Appendix C

Height, Weight and Physical Activity Questions on the Behavioral Risk Factor Surveillance Survey

The question number is from original questionnaire for a particular year

1. 1991 Questions

Question 6. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

Question 49. About how much do you weigh without shoes?

Question 50. About how tall are you without shoes?

2. 1992 Questions

Question 6. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

Question 49. About how much do you weigh without shoes?

Question 50. About how tall are you without shoes?

3. 1993 Questions

Question 42. About how much do you weigh without shoes?

Question 43. About how tall are you without shoes?

Module 6: Question 1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

4. 1994 Questions

Question 10. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

Question 45. About how much do you weigh without shoes?

Question 47. About how tall are you without shoes?

5. 1995 Questions

Question 40. About how much do you weigh without shoes?

Question 41. About how tall are you without shoes?

Module 4: Question 1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

6. 1996 Questions

Question 15. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

Question 49. About how much do you weigh without shoes?

Question 51. About how tall are you without shoes?

7. 1997 Questions

Question 44. About how much do you weigh without shoes?
Question 45. About how tall are you without shoes?
Module 11: Question 1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

8. 1998 Questions

Question 13. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?
Question 52. About how much do you weigh without shoes?
Question 54. About how tall are you without shoes?

9. 1999 Questions

Question 10.9. About how much do you weigh without shoes?
Question 10.10. About how tall are you without shoes?
Module 11: Question 1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?

10. 2000 Questions

Question 6.1. During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?
Question 10.12. About how much do you weigh without shoes?
Question 10.14. About how tall are you without shoes?

11. 2001 Questions

Question 3.1. During the past 30 days, other than your regular job, did you participate in any physical activities or exercise such as running, calisthenics, golf, gardening, or walking for exercise?
Question 13.10. About how much do you weigh without shoes?
Question 13.11. About how tall are you without shoes?

12. 2002 Questions

Question 3.1. During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?
Question 12.10. About how much do you weigh without shoes?
Question 12.11. About how tall are you without shoes?

Appendix D
Studies on Adult Trends in Physical Activity

Studies of adult trends in physical activity all suggest that physical activity is on the rise from the late 1950s into the 1980s and 1990s. This Appendix provides a brief summary of studies on this topic.

Stephens (127) examined secular data from a number of different sources including population-based surveys (NHES II, NHANES I, BRFSS, Gallup Polls, and other national surveys), smaller studies, overnight stays in National Parks, YMCA memberships, purchasing of sports equipment, and the number of magazines on fitness topics. Although there were methodological problems with many of these comparisons, the data were relatively consistent from all sources. The author concluded that "adult leisure-time physical activity has increased in the last 2 decades" and "women have increased their activity more than men".

Jacobs et al. (60) examined trends in leisure-time physical activity using the Minnesota Leisure-Time Physical Activity Questionnaire administered to an Upper Midwestern population. From 1957 to 1987 there were strong trends indicating that leisure-time physical activity of 25 to 74 year old men had increased. Data on women was available only from 1980 to 1987 but they also showed increased physical activity in this time period.

Brooks (19) compared physical activity data collected in 1981 and 1984 among adults 25 to 64 years of age. Data came from national surveys involving 1) time diaries of physical activity and 2) a marketing survey. After adjusting socially desirable responses, the data indicated that from 1981 to 1984, the number of sedentary individuals stayed the same but there were increases in the amount of heavy intensity (6 to 7 kcals/min) physical activity.

Caspersen and Merritt (21) analyzed activity data from the Behavioral Risk Factor Surveillance System (BRFSS) in 1986 and 1990. They derived a 4-point activity scale (inactive, irregularly active, regularly active, not intense, and regularly active, intense) from self-reported frequencies and duration of activity and intensities estimated from the literature. In the 4 year period, the number of physically inactive men (ages 18 to 29) decreased from 23% to 19% and inactive women changed little (25% to 26%). The number of regularly active, intense men changes little (6% in both surveys) while active-intense women increased from 4% to 5%.

Lee et al. (84) examined energy expenditure in physical activity among male Harvard alumni over three time periods. At each time period questionnaires were sent to alumni that asked about stairs climbed, city blocks walked, and participation in sports or recreation. The authors estimated that energy expenditure in physical activity was approximately 1,500 kcal/week in 1962 to 1966, approximately 2000 kcal/week in 1977 and approximately 2000 kcal/week in 1988.

Appendix E

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