

Research Report 1353

EFFECTS OF RANGER TRAINING ON SELECTED MEASURES OF STRENGTH AND CARDIOVASCULAR FITNESS

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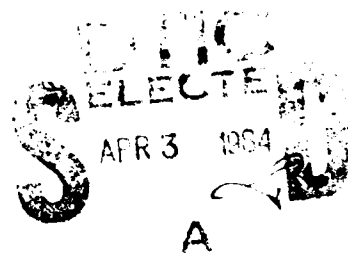
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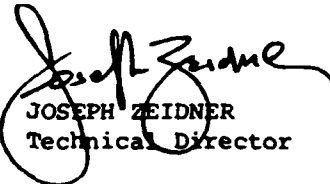
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FOREWORD

Part of the ongoing research program on soldier performance is concerned with the effects of physical fitness of soldiers on their performance in combat situations. This particular effort was completed in support of the U.S. Army Infantry School at Fort Benning, Georgia, which has proponency for physical training. This report describes a pretest-posttest evaluation of the effects of the strenuous two-month long Ranger training program on the physical fitness levels of students in the Ranger Course at Fort Benning. The major finding of this research was that students who successfully completed the course, on average, became stronger and more cardiovascularly fit during the training. These results will be of particular interest to the Ranger Department at Fort Benning and to other military organizations which provide rigorous physical training to their members.



JOSEPH ZEIDNER
Technical Director

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EFFECTS OF RANGER TRAINING ON SELECTED MEASURES OF STRENGTH AND CARDIOVASCULAR FITNESS

BRIEF

Objective:

To establish the effects of Ranger training on the physical fitness levels of Ranger students.

Procedure:

On the day before the beginning of training, students from four classes of the Ranger Course at Fort Benning, Georgia during FY 1979 were given a specially designed physical fitness test consisting of a modified Harvard Step Test and both pushups and chinups. The Harvard Step Test yields measures of cardiovascular fitness in terms of heart rate after exercise. Pushups and chinups are measures of upper-body strength.

Two months later, on the day after the end of training, the members of each class who had successfully completed the course (167 individuals in all) were retested on the same physical fitness test. The changes in the scores from the pretest, at the beginning of the course, to the posttest, at the end, were analyzed by t-Tests for Correlated Means.

Findings:

The results showed that cardiovascular fitness, as measured by the Step Test, had increased significantly over the course of training. Upper-body strength as measured by pushups, had increased also, but strength, measured by chinups, had decreased. All of these changes were statistically significant. It is not clear what the disparity between the two strength measures means; however, the decline in the ability to perform chinups may be the result of lack of practice over the two-month period of training. Pushups, on the other hand, are done frequently during the course and may best represent the individual's state of upper-body strength.

Utilization of Findings:

This research provides a description of the relationships between Ranger training and selected indicators of both strength and cardiovascular fitness. Low fitness trainees who succeeded (many didn't), became more cardiovascularly fit during training. High fitness trainees showed little improvement or declined and were apparently optimally prepared in terms of fitness when they began the training.

These results bear on the selection of students for the Ranger Course. They will provide part of the information necessary to enable the Ranger Department to enroll only those individuals who are fit enough to withstand the physical demands of Ranger training. The results of this research will also be of interest to all other military organizations which provide rigorous physical training to their members.

EFFECTS OF RANGER TRAINING ON SELECTED MEASURES OF STRENGTH AND CARDIOVASCULAR FITNESS

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EFFECTS OF RANGER TRAINING ON SELECTED MEASURES OF STRENGTH AND CARDIOVASCULAR FITNESS

INTRODUCTION

The Ranger Course at Fort Benning, Georgia, is one of the most strenuous and demanding programs of instruction in the U.S. military. As stated in an official Ranger Department publication (Ranger Department, 1980), the purpose of the Ranger School is to develop leadership skills by requiring students "to perform effectively as small unit leaders in a realistic tactical environment, under mental and physical stress approaching that found in combat (p.6)." Farther along in the Ranger Department pamphlet, the prospective student is given fair warning: "The physical condition of the Ranger student, at times approaches near exhaustion (p.6)."

A partial listing of the physical stresses encountered in the course of Ranger training includes heat, cold, hunger, fatigue and extended sleeplessness, leading, as mentioned, to states of near exhaustion. The reported effects of these conditions upon the men who have experienced them range from hallucinations and psychotic-like behavior (Peres, 1959) to falling sound asleep and continuing to walk while in the process of hiking down a road (Elliott, Note 1).

The exact physical toll on the Ranger student of this rigorous, two-month long experience is not known. Subjective reports of weakness and exhaustion are given by many students at the conclusion of training, however, and the inclination of recent graduates of the course to engage in long bouts of eating and sleeping after graduation is well known. It is reasonable, therefore, to conclude from this evidence that Ranger training depletes the students' physical resources and, thereby, lowers his general level of physical fitness. Indeed, the entire program of events in the Ranger Course is purposely designed to bring the individual close to his point of physical breakdown, and then to test him for the qualities of mind and spirit which he must possess to operate as an effective combat leader.

In order to insure that incoming students report to Ranger School in sufficiently high states of physical readiness to meet the demands to be placed on them, there is a need to understand what, in terms of physical fitness, is the effect on the individual of Ranger training. This information will provide part of the input necessary to guide the Ranger Department in setting entry-level criteria for the course. Consequently, this research was undertaken to provide data, in terms of specific physical fitness measures, of the effects of undergoing the prolonged and exacting schedule of events that constitute Ranger training.

OBJECTIVE

The specific objective of this research was to gather evidence of the effects of Ranger training on the physical fitness levels of Ranger students. It was accomplished by administering a specially-designed physical fitness test to incoming Ranger students on the day before the beginning of training and then re-administering that test on the day after the final day of training. Using this pretest-posttest method, data were gathered on changes during training for two measures of upper-body strength - pushups and chinups - and one measure of cardiovascular fitness - changes in heart rate during exercise, as measured by a modified Harvard Step Test.

METHOD

Research Participants

These data were collected from graduates of four classes of Ranger students in FY 1979: Classes 502, 4, 6, and 7. There were a total of 167 men in the sample.

Army Research Institute (ARI) Physical Fitness Test

Cardiovascular Fitness Measure - The Modified Harvard Step Test. The data relating to cardiovascular fitness for this research came from a modified Harvard Step Test. The Step Test procedure used was the modification by Tuxworth and Shahnawaz (1977) which has produced correlations in the high 0.80's between heart rate (adjusted by weight) and physical work capacity max VO₂ (as measured by bicycle ergometry). The modified Step Test consisted of two 5-minute periods of stepping up and down on a 16-inch bench, first at a slow, (15 steps per minute) and then, following an approximate 10-minute rest) once again at a fast cadence (25 steps per minute). The students worked in pairs, with one stepping while the other rested. After each period of stepping, each man sat down on the bench and his heart rate was measured from the carotid artery under the jaw by his paired counterpart. The first measurement was taken 30 seconds after the end of each stepping period, the next measurement 90 seconds after, and the final one 150 seconds later.

Strength Measures - Pushups and Chinups. The upper-body strength measures taken in this research were the number of repetitions of pushups completed in a one-minute period and the number of repetitions of chinups completed in a one-minute period. Following U. S. Army regulations (FM 21-20, 1973), the pushups were to be done in such a manner that the chest of the individual touched the ground in the downward movement and the chinups were to be performed with the palms of the hands facing toward the individual and in such manner that the chin topped the bar at the high point of the chinning maneuver. The Step Test was the first exercise to be done followed by pushups and then the chinups.

Procedure

The first administration of the ARI Physical Fitness Test for each class of students took place on Inprocessing Day, the day before the beginning of actual training. At that time, the men were taken in groups of approximately 32 men each to an enclosure containing two benches for the Step Test and horizontal bars for chinups.

They were then told the purpose of the experiment and asked to volunteer for it. It was explained that the data taken in the experiment would be used to help the Ranger Department decide on the physical fitness level to require of future Ranger students. They were strongly encouraged to do their very best in the test so that the data would represent their true physical fitness levels, rather than their motivation levels, an outcome which would confound the results and make them useless.

The men were then broken down into two smaller groups of approximately 16 men each and every man in one group was assigned a partner in the other group. From then on, each pair worked as a team so that while one man exercised, the other stood by to measure his pulse for the step test and to count the repetitions of chinups and pushups that he performed.

The step test procedure was conducted first and one 16 man group was tested on two benches with approximately 8 men to a bench. The test was conducted for both groups in the manner described earlier.

At the conclusion of the Step Test, the entire 32 man group was given a 3-minute rest and then the 16 man group that had been first to finish the Step Test was asked to perform all the pushups they could in a 1-minute interval. As soon as the first group finished, the second one also completed the pushups.

After a rest of 3 minutes following the last pushups, the group that was first to finish pushups began the chinups. For this exercise only 8 men at a time could perform and each did all the chinups he could in a 1-minute interval. The second 16-man group followed, 8 men at a time.

On the day following the last day of training, the finishers of each class were retested in the same manner as before. At that time, all individuals who were still in the class were asked to volunteer to take the physical fitness test once again. It was reemphasized at this time, that the data collected in these tests would be used to make decisions affecting the success at training and even the health of future Ranger students and that, therefore, their best efforts at the test were absolutely essential.

If, prior to this testing, any individual asked to be excused, claiming injury or illness, he was allowed to forego the test. This insured that all those on whom data were collected were able-bodied enough to perform up to their maximum (no sprained hands or ankles, for example) and also sufficiently motivated to do so.

RESULTS

The data from the 167 individuals who received both administrations of the test are presented in Table 1. The table shows that for all measures except one - chinups - the physical fitness of the retested students was improved. This is indicated, for example, by a decrease in heart rate from an average of 106.6 to an average of 97.8 heart beats per minute, 30 seconds after slow cadence stepping, and a corresponding decrease from 122.4 to 111.2 heart beats per minute, 30 seconds after the fast cadence stepping period. A similar increase in level of physical fitness is indicated by an increase in average number of pushups completed from 45.7 to 48.0. This is to be contrasted with a decline in the ability to produce chinups from an average 10.0 pre-training to an average 8.6 post-training. This outcome would indicate a decrease in physical fitness as measured by the Chinup event. All of these changes are statistically significant as measured by t-Tests for Correlated Means. This means that these results are extremely unlikely (less than one chance in a thousand for most comparisons in Table 1) to have occurred by chance.

Selected portions of the data from Table 1 were then broken down in such manner as to show which individuals had become more fit during training, which had remained essentially the same, in terms of fitness, and which, if any, had become less fit. For cardiovascular fitness, this was done by first grouping all individuals into heart rate categories, from most to least fit, based on their pre-training, 30 second, fast cadence, measurement and then breaking them down within those categories based on the difference between that measurement and their 30 second fast cadence measurement from the post-training Harvard Step Test. The first classification was by categories established by 10 heartbeats per half-minute intervals and the second was by difference scores, pretest minus posttest (consequently, either plus or minus) of 5 heartbeats per half minute. Those data are displayed in Table 2 where, to save space, all those individuals at each level of initial fitness whose difference scores were minus have been collapsed into a general "less fit" category, while all those whose difference scores were plus have been incorporated into a "more fit" category.

The first aspect of the data which should be noted is the Totals row across the bottom of the table. Those data show that 21 individuals, 13% of the total number of men retested, became less fit according to measured heart rate after work; 48 individuals, 29.7% of the total, remained essentially the same in terms of fitness; while the majority, 93 individuals or 57.3%, experienced an increase in fitness during the training.

The uppermost portion of the table breaks out these totals according to the various fitness categories from the pretest described earlier and shows the effect of training on men at different levels of initial fitness. On the left side are the heart rate categories - 49 beats per half minute or less, 50 to 59 beats, 60 to 69, and 70 beats per half minute or more, with the top category representing the most cardiovascularly fit individuals on Inprocessing Day. Each row of the table shows the number and percentage of individuals from that subgroup

Table 1

CHANGES IN PHYSICAL FITNESS DURING RANGER TRAINING
N = 167

Event	Pretest Mean	Posttest Mean	Significance ^c
<u>Cardiovascular Fitness Measures^a</u>			
Step Test, Slow Cadence -			
30 seconds	106.6	97.8	$p < .001$
90 seconds	88.8	82.6	$p < .001$
150 seconds	82.8	77.8	$p < .001$
Step Test, Fast Cadence -			
30 seconds	122.4	111.2	$p < .001$
90 seconds	101.0	91.4	$p < .001$
150 seconds	92.2	86.4	$p < .001$
<u>Strength Measures^b</u>			
Pushups	45.7	48.0	$p = .004$
Chinups	10.0	8.6	$p < .001$

^a Heart rate measured in beats per minute.

^b Number of repetitions per 1-minute interval.

^c t-Test for Correlated Means.

Table 2

NUMBER AND PERCENTAGE OF INDIVIDUALS WHO WERE LESS FIT, THE SAME, OR MORE FIT
AFTER RANGER TRAINING THAN BEFORE FOR EACH HEART RATE CATEGORY FROM
THE 30 SECOND MEASUREMENT OF THE FAST CADENCE PERIOD OF THE
HARVARD STEP TEST ON INPROCESSING DAY

Pretest	Posttest			
Heart Rate (beats/half min.)	Less Fit	Same ^b	More Fit	Totals
49 and Below	6 (33.3%)	6 (33.3%)	6 (33.3%)	18 (100%)
50 to 59	14 (29.2%)	17 (35.4%)	17 (35.4%)	48 (100%)
60 to 69	1 (01.5%)	22 (32.4%)	45 (66.1%)	68 (100%)
70 and Above	0 (00.0%)	3 (11.0%)	25 (89.0%)	28 (100%)
Totals	21 (13.0%) ^a	48 (29.7%)	93 (57.3%)	162 (100%)

^a These are percentages of the total number of men tested that fell into each of the three posttest fitness categories.

^b Individuals were considered to be in the same state of cardiovascular fitness if their heartrates had not changed more than ± 4 beats per minute.

who tested out at the posttest to be either more or less fit or the same as at the pretest.

The data show that the most fit individuals from the pretest (49 and below category) were equally distributed among the three posttest fitness categories. There were 18 individuals in that category and exactly 33.3% of them fell into each category on the posttest measurement. In contrast to that group, the least fit individuals before training - those who fell into the 70 and Above category - were almost all (25 individuals, 89.0%) placed into the more fit category after training with only 3 individuals (11.0%) remaining approximately the same and none becoming less fit. Examination of the two intermediate fitness categories will show an increasing percentage of individuals from each group becoming more cardiovascularly fit during training. The Pearson r correlation coefficient between the fitness categories of the pretest and those of the posttest - scores upon which this table is based - was $r = -0.54$, $p < .001$. This indicates that the relationships shown in this table did not arise by chance alone.

The same breakdowns of the Table 1 data were done for both pushups and chinups and those data are shown in Tables 3 and 4. It is important to note that for both of those tables, contrary to the preceding one, the categories of greater fitness are on the lower rows of the tables.

Table 3 shows the breakdowns for the pushups measure. Considering the population of men as a whole, for slightly more than one quarter of them (28.7%) the ability to do pushups declined, for one quarter (27.5%), it remained the same, and for slightly less than one half (43.7%) it increased. As before with the cardiovascular measure, the least fit categories of men from the initial testing improved the greatest in capacity for pushups during training, whereas the most fit men more often lost some of their ability to do pushups. The statistical relationship between the pre- and posttest categories for this table was $r = 0.35$, $p < .001$.

Table 4 lists the equivalent data for the chinups measure which in Table 1 was shown to have declined significantly on average during the course of training. For this measure most individuals were either less fit (44.3%) or the same (40.1%) while only a few (15.6%) had improved. The table shows that there was some improvement among the least fit individuals - 26.7% and 29.7% of the first two categories were more fit on the posttest but for the most part, the only changes were that individuals who could do 9 or more pushups on Inprocessing Day became less fit during training. The pretest-posttest categories for this table were related with an r of 0.57, $p < .001$.

DISCUSSION

The results of this research indicate that Ranger training has positive effects on measures of cardiovascular fitness and differential effects on measures of strength.

Table 3

NUMBER AND PERCENTAGE OF INDIVIDUALS WHO WERE LESS FIT, THE SAME, OR MORE FIT
AFTER RANGER TRAINING THAN BEFORE FOR EACH CATEGORY OF NUMBER OF
REPETITIONS OF PUSHUPS DONE ON INPROCESSING DAY

Pretest	Posttest			
Pushups (Number of repetitions)	Less Fit	Same ^b	More Fit	Totals
20 to 29	2 (22.2%)	2 (22.2%)	5 (55.5%)	9 (100%)
30 to 39	5 (15.6%)	5 (15.6%)	22 (68.8%)	32 (100%)
40 to 49	18 (25.7%)	21 (30.0%)	31 (44.3%)	70 (100%)
50 to 59	13 (35.1%)	13 (35.1%)	11 (29.7%)	37 (100%)
60 to 69	8 (50.1%)	4 (25.0%)	4 (25.0%)	16 (100%)
70 to 79	2 (66.6%)	1 (33.3%)	0 (00.0%)	3 (100%)
Totals	48 (28.7%) ^a	46 (27.5%)	73 (43.7%)	167 (100%)

^a These are percentages of the total number of men tested that fell into each of the three posttest fitness categories.

^b Individuals were considered to be able to do the same number of pushups if their number of repetitions had not changed more than ± 4 pushups.

Table 4

NUMBER AND PERCENTAGE OF INDIVIDUALS WHO WERE LESS FIT, THE SAME, OR MORE FIT
AFTER RANGER TRAINING THAN BEFORE FOR EACH CATEGORY OF NUMBER OF
REPETITIONS OF CHINUPS DONE ON INPROCESSING DAY

Pretest	Posttest			
Chinups (Number of repetitions)	Less Fit	Same ^b	More Fit	Totals
5 or less	1 (06.7%)	10 (66.6%)	4 (26.7%)	15 (100%)
6 to 8	11 (23.4%)	22 (46.8%)	14 (29.7%)	47 (100%)
9 to 11	23 (43.4%)	23 (43.4%)	7 (13.2%)	53 (100%)
12 to 14	18 (62.1%)	10 (34.5%)	1 (03.4%)	29 (100%)
15 to 17	13 (86.6%)	2 (13.3%)	0 (00.0%)	15 (100%)
18 or more	8 (100%)	0 (00.0%)	0 (00.0%)	8 (100%)
Totals	74 (44.3%) ^a	67 (40.1%)	26 (15.6%)	167 (100%)

^a These are percentages of the total number of men tested that fell into each of the three posttest fitness categories.

^b Individuals were considered to be able to do the same number of chinups if their number of repetitions had not changed more than ± 2 chinups.

Cardiovascular Fitness Measures

Cardiovascular fitness, as measured by heart rate following the Step Test, increased during the course of training. Since cardiovascular fitness is a measure of stamina, or the capacity to sustain exertion over time, it would be expected, under more normal training conditions, to increase during activities of the sort found in Ranger School. The Ranger course features long periods of time during which the men are constantly on the move, up and down hills, bearing heavy loads of equipment and supplies on their backs. However, during the long, fast-moving patrols in this course, which extend over as many as five days, an average of about 2 hours of sleep out of every 24 is not unusual, and the average for other, non-patrol days is only about 4 hours (Elliott, see Note 1). The question in mind at the outset of this research was, does cardiovascular fitness show an increase under the conditions of overexertion and sleep deprivation that characterize this course. The data reported here indicate that it does.

A note of caution must be raised here, however. Heart rate during work is related to amount of work being performed. In the instance of the Step Test, the work involved is stepping up and down on a bench and the amount actually done is determined by the body weight of the individual. Due to the busy schedule of the Ranger classes on both of the days on which they were given the Step Test, it was not possible to weigh the men prior to testing. However, weight measurements on a subsequent, reasonably typical Ranger class indicated that most men probably lost weight between the pretest and the posttest. With an average and most frequently recorded weight loss for that class of 2% of total body weight (after completion of training and much compensatory eating), a slightly lower average heartrate (approximately 2%) would be expected on the posttest based on weight loss alone. It therefore, seems unlikely that changes in heartrate after exercise on the order of an average of 9% that were seen for the 30 second reading after the Fast Cadence exercise period, would result from weight loss alone.

Strength Measures

Strength, as measured by chinups, declined over the course of training, while, as measured by pushups, it increased. It is not clear what this disparity means. It may be attributable to practice effects. Chinup activity is not often engaged in, as such, in Ranger training while pushups, which are assigned in liberal quantities as punishment, are done quite often by most students. Consequently, the ability to perform chinups, which may be cultivated assiduously on the chinup bars as part of a student's preparation for the course, may have declined from simple disuse.

Effects of Ranger Training

It should be recalled that these data were taken from the survivors of each class initially tested and only those among them who were in good enough condition on posttest day to be put through the exercises. Students who couldn't respond to the training with increases in cardiovascular fitness and who didn't have the reservoir of strength necessary to endure the exertions had already been selected out (Burke & Dyer, 1980).

Considered together, the changes described in this research for cardiovascular fitness indicate that the Ranger training program is achieving at least one of its express purposes. The aim of the first two of the three distinct phases of the program is to prepare the student for the greater challenges of the phase to follow, particularly with regard to the physical endurance that will be required. The increase in cardiovascular fitness for most men during training attests to the accomplishment of that goal.

A second purpose of the program is to put the student under physical stresses approaching combat. While stresses of that intensity might reasonably be expected to be degenerative, most of the men in these classes have shown a gain in strength (as measured by pushups) rather than a loss. Since there is no doubt that this training subjects the men to extended periods of strenuous exertions, with little rest, the results of this research seem to indicate that physically fit young men can adapt to increased physical demands with corresponding increases in physical fitness.

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