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US ARMY TEST & EVALUATION COMMAND

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MARCHING AND MOVING

FOURTH PARTIAL REPORT OF
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
DEVELOPMENT OF METHODOLOGY FOR MEASURING
EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT
ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS

JUNE 1965

U S ARMY
GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

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U.S. ARMY GENERAL EQUIPMENT TEST ACTIVITY
FORT LEE, VIRGINIA

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MARCHING AND MOVING

Fourth Partial Report of
USATECOM PROJECT NO. 8-3-7700-01, PHASE II
Development of Methodology for Measuring Effects of
Personal Clothing and Equipment on Combat Effectiveness
of Individual Soldiers

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FOREWORD

This report reviews a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) and is the fourth of a series of seven reports presenting the results of Phase II of the contract. (See Appendix C.) The project is a three-phase research effort directed toward the development of a field measurement methodology for evaluating the effects of Quartermaster clothing and protective equipment on the combat effectiveness of the individual soldier.

Earlier portions of the work accomplished under this project have indicated that a major constituent of the effectiveness of an individual infantryman in a combat situation is his level of performance in the individual physical tasks which are most important to battlefield success. A meaningful determination of the effect of clothing and personal equipment on the operating efficiency of an infantryman must therefore include objective measurements of his performance in these critical tasks. A survey of 208 highly qualified veterans of the four most recent operating theaters of the U.S. Army revealed that the ability to move over roads and trails in a combat area was considered an important physical task by combat veterans. The task of moving and marching under combat conditions was considered to include tactical movements and approach marches, but not operations under fire. This report describes the research performed to establish a reliable and sensitive method for measuring performance in this activity over flat and hilly terrain.

The work reported represents a joint effort by Dunlap and Associates, Inc. (D&A), and the Methods Engineering Directorate of the U.S. Army General Equipment Test Activity (GETA). The project team worked together closely throughout all activities but the major effort of D&A was in the development of the measurement scheme, the design of the field trials, interpretation of the data and the preparation of the draft report. GETA prepared the test facilities, planned and conducted the field trials, collected and processed experimental data, and participated in its analysis.

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ABSTRACT

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the fourth of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks performed in combat by the individual infantryman. One of the tasks which were considered by a sample of combat veterans to be important to combat success was the ability to march and move effectively in a combat area. This report describes the work performed to develop a reliable method for measuring soldier performance in this task under conditions considered representative of combat conditions. Procedures were established for measuring performance on flat and hilly terrain and tested for reliability and sensitivity to differences in clothing and equipment using USAGETA Troops. A modified test situation and data collection method is recommended for inclusion in an integrated field course to be evaluated as the next step in the research program.

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MARCHING AND MOVING

I. Review of Research Objectives

The fundamental objective of the research effort was to develop, try out and evaluate a field performance course which measures an infantry soldier's ability to march and move for an extended period of time over roads, trails and hilly terrain. The three main requirements which the course had to satisfy were:

- the test situation had to include a comprehensive sampling of those activities involved in marching and moving;
- the test situation had to be representative of the combat conditions under which individual infantrymen are required to perform these activities;
- the course operating procedures, instrumentation, and measures had to yield data which were sufficiently precise to indicate that the course would be sensitive to the effects of clothing and protective equipment on performance.[1,2]

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[1]The use of the word "sensitive" refers to the ability to detect small performance differences. A sensitive course presupposes reliability in the collection of measurement data.

[2]The validity of the present test situation and the performance measures to be obtained are logical (not statistical) validities. The validity of the combat task, as an important aspect of the criterion, is considered to be demonstrated by the independent judgments of combat veterans (see results from the Further Refinement of Important Combat Tasks). The validity of the test situation in which task performance is being measured must be either accepted or rejected on logical grounds. Either the test setting does or does not represent the essential features of the conditions under which a man will be required to march and move. The validity of the measures must also be accepted or rejected on the basis of logic. That is, the measures either are or are not measures which reflect performance associated with marching and moving.

Another feature, deriving in part from the foregoing, which the course had to satisfy was to permit for the repeated measurement, throughout the distance travelled, of the effects of clothing and protective equipment on an infantryman's ability to march and move. The latter requirement was based on our interest in examining the trend in performance over time, as well as the total performance in this combat activity.

II. Essentials of Test Course as Originally Proposed

The measurement situation originally proposed for research purposes was a group performance test in which an infantry squad (11 men) would move a total distance of 10 miles. Movement was to be both along roads and over cross-country trails. At scheduled periods, the squad was to move at double time.

Within each half hour interval, a signal (such as the firing of a blank pistol) was to occur in a random fashion. When this signal occurred, the squad was to break formation and rapidly take prone positions off the road or trail. There was to be a ten minute break every hour. During this ten minute break, the men would be required to doff and then redon certain specified equipment. At the end of approximately two miles and eight miles, troops were to construct hasty fighting positions on signal starting from their prone positions off the road or trail. At the end of five miles, the troops were to traverse a maneuver course.

Procedurally, it was planned that each squad member would be accompanied by an Observer/Recorder (O/R) who would collect specified performance data. Each group was also to be accompanied by a Senior Controller who would be responsible for initiating tasks according to a predetermined schedule.

III. Description of Actual Test Setting

A. Difficulties with Original Test Setting

While the above test setting and a number of modifications thereof were in fact tried, the final test situation was considerably different. What had appeared to be a reasonably straightforward measurement problem turned out to be fairly complex in the light of our concerns for measurement precision and test sensitivity. There were two main reasons why the original test setting was abandoned:

1) it was not a sensitive test situation; and 2) it was extremely inefficient from the standpoint of usable data per test subject. The lack of measurement sensitivity seemed to stem from the fact that the squad movement situation, while realistic, was actually masking the effects on individuals of the extended movement. That is, the entire squad was paced by the designated squad leader, and he in turn moved his men at a pace that would accommodate the slowest individual so that squad unity could be maintained. Thus, variation in our direct measures of the effects of selected equipments on marching and moving was being confounded and minimized by both the group paced situation and the hourly ten minute rest breaks. The inefficiency from the standpoint of data per subject arose also because we were using a squad test situation. While 11 men were performing, only one direct measure of marching and moving--the group's performance--was being obtained. (Eleven men were providing one data point; whereas 11 men could--for the same time and effort--conceivably provide 11 data points.) The group test situation was thus abandoned in favor of a more controlled, somewhat less realistic, individual test situation. (Appendix B shows photographs of Quartermaster subjects and O/R's using the originally proposed test situation.)

B. March/Move Flat Track

We thus turned to an individual test situation which we subsequently referred to as the "March/Move Flat Track." The test setting was an oval-shaped, level dirt track which measured 2583.7 feet, or .489 miles. Subjects were started individually in a staggered starting sequence. They were required to make 21 traversals of the course--for a distance of just over ten miles--without stopping. It was a self-paced test situation, and the subjects were instructed to complete the 21 laps (or traversals) as quickly as possible. To minimize unconscious pacing, the number of individuals on the track at any one time was limited to four, and two subjects moved in a clockwise rotation about the track while the other two traversed the course in a counterclockwise direction. O/R's were stationed around the periphery of the track to monitor subject conduct and to record the elapsed time for each lap. Figure 1 shows a subject on the course. Figure 2 shows the O/R noting the time at which the subject completed a lap.

C. Hilly Terrain Course

The design of the Hilly Terrain Course was similar to that of the Flat Track. It was an individual test situation located on the steepest

Figure 1. Subject on March/Move Flat Track.

Figure 2. Performance Measurement on Flat Track.

piece of available terrain at Fort Lee, Virginia. The test setting was an approximately rectangular-shaped, dirt track which measures 1046 feet, or .198 miles. The course started with a downgrade for 118 feet, then a steep upgrade for 102 feet, then a level portion for 444 feet, next a steep downgrade for 224 feet, then an upgrade for 148 feet, and finally a level portion for 10 feet. Figures 3 through 8 are photographs of the research course. Figure 3 shows a test subject just starting the first and steepest upgrade (for 102 feet). Figure 4 shows the subject approaching the top of the upgrade. Figure 5 is a side view of this first upgrade. Figure 6 shows the top of the first upgrade. Figure 7 presents the level portion (444 feet) following the first upgrade. Figure 8 shows a portion of the second downgrade (224 feet) and a portion of the second upgrade (148 feet).

As with the Flat Track, subjects were started individually on the course in a staggered starting sequence. They were required to make 51 traversals of the course--for a distance of ten miles--without stopping. As with the Flat Track, this was a self-paced test situation, and the subjects were instructed to complete the 51 laps as quickly as possible. To minimize unconscious pacing, the number of individuals on the track was limited to four--two moving in one direction, and the other two moving in the opposite direction.

IV. Course Operating Procedures

Operation of both courses was controlled by a Senior Controller who scheduled the starting of subjects at different points about the two tracks. The main features of the operating procedure were as follows.

Initially, on their first exposure to the courses, test subjects were read a set of standard instructions (see Appendix A). The standard instructions indicated the purpose of the course and how each subject was to proceed. After this briefing and the answering of any questions, the test subjects were started.

The duties of test personnel were also explained initially using prepared instructions. Samples of the basic O/R Briefings are given in Appendix A. The duties and assignments were as follows.

The Senior Controller, as already explained, was responsible for the overall operation of the course. In particular, he started subjects at different points on the two courses and assigned O/R's to monitor subject conduct and collect performance data.

Figure 3. First Upgrade on Hilly Terrain Course.

Figure 4. Subject Approaching Top of First Upgrade (Hilly Terrain Course).

Figure 5. Side View of First Upgrade on Hilly Terrain Course.

Figure 6. Top of First Upgrade (Hilly Terrain Course).

Figure 7. Level Portion of Course Following First Upgrade (Hilly Terrain Course).

Figure 8. Second Downgrade and Second Upgrade of Hilly Terrain Course.

O/R's were stationed around the periphery of the tracks. There was one O/R for each test subject, and the O/R recorded the time that his assigned subject passed by on each traversal. A line was marked (in the dirt) across the track so that the time measurements could be taken at precisely the same point for each traversal. (While an O/R was assigned to a single subject for the experimental trials, one O/R can probably handle two to four subjects--depending upon the length of the track.)

V. Instrumentation

The only instrumentation used in measuring performance on both events consisted of Meylan 303D stopwatches. Each O/R had his own stopwatch, and the stopwatches were mounted in standard industrial engineering (or time-and-motion study) clipboards.

The type 303D stopwatch has two large hands, as shown in Figure 9. Once the watch is started, both large hands move together and indicate elapsed time on a scale graduated with 100 marks per minute (.01 of a minute or .6 of a second). The useful feature, for our requirement, was that depression of a button on the side of the watch caused one of the large hands to stop--while the watch and the other large hand continued to accumulate time. Thus, an O/R could stop one of the hands of the watch at the instant his subject passed, and then read and record the indicated time; the watch, however, was still accumulating time without interruption. Release of the side button caused the large hand which had been stopped to catch up with the moving hand. As may be seen also in Figure 9, there was a smaller, inner hand on the watch face which accumulated time in minutes up to a total of 30 minutes.

In actual operation, then, O/R's merely noted and recorded the exact time each time their assigned subject passed by. Determination of elapsed time intervals and other data breakdowns were computed later by statistical clerks.

VI. Measures and Test Design

A. Measures

With the instrumentation described in the preceding section, data were collected on the following basic measure for both the Flat Track

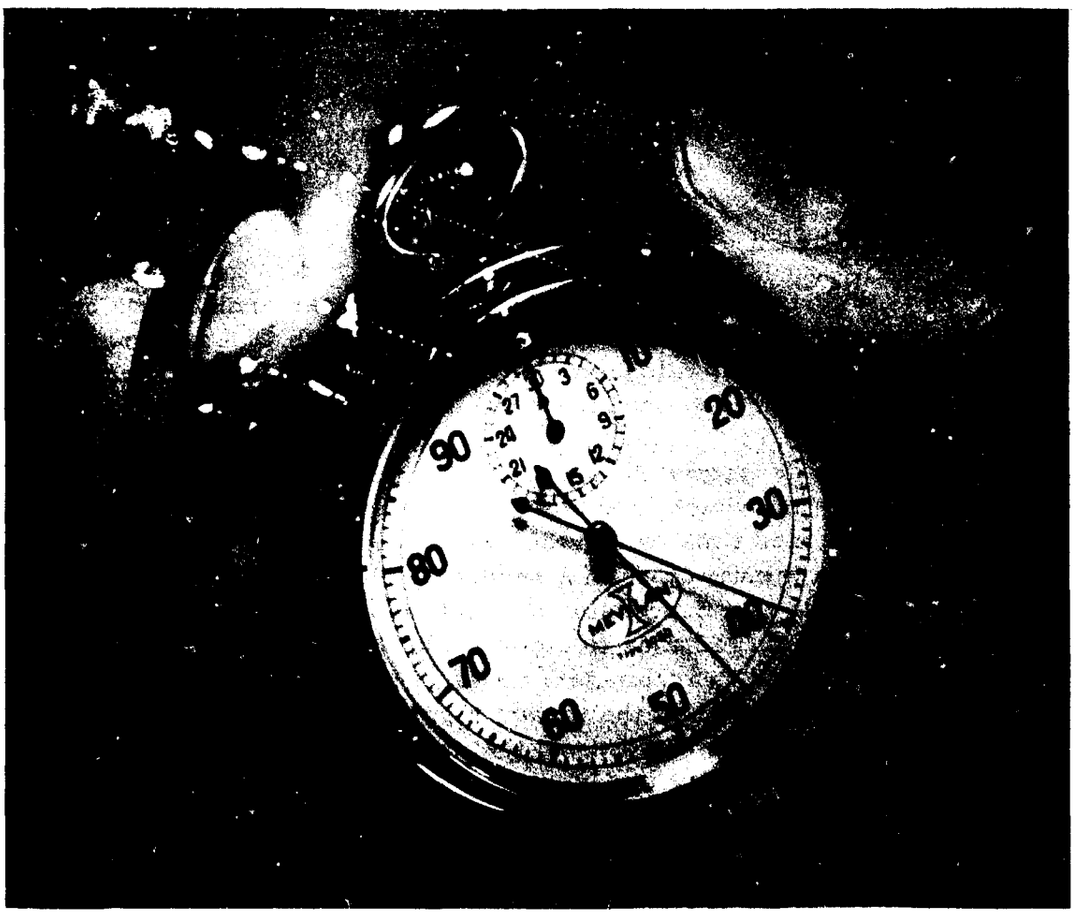


Figure 9. Meylan Type 303D Stopwatch.

and the Hilly Terrain course: time (to nearest .005 minute) to complete each lap.

Reading time to .005 of a minute is probably a conservative estimate of the precision with which the watches were used. While the watches were graduated with 100 marks per minute, it was possible to interpolate between the graduations. O/R's were instructed to read time to the third decimal portion of a minute. (It should be mentioned that O/R's were also given a classroom drill in both the use of the watches and in interpolating, prior to being qualified.)

B. Test Design

The experimental testing was designed to provide information on the following points of interest:

- The feasibility and suitability of the course concept and operating procedures;
- The suitability of the instrumentation concept and equipment;
- The reliability and potential sensitivity of the course.

The reliability of a given test course refers to the precision and accuracy of measurement which the course provides. It can be evaluated in terms of the consistency (i.e., repeatability) of the experimental results obtained from the course over some time period. A measure of reliability, of course, will be obtained from the Phase III testing. However, it appears possible to infer something about course reliability from Phase II results. If a statistically significant difference (at, say, the 5% level of confidence) is obtained between performance measures for a treatment condition (e.g., different combat pack weights), one infers that the obtained difference is not likely to occur by chance. A significant performance difference suggests that, if the test were to be repeated under the same conditions (e.g., with the same treatment conditions, the same procedures, and the same subject population), one might expect to obtain similar results. Thus one can estimate that a course is reasonably reliable if statistically significant performance differences occur. This is the best estimate that can be made on the basis of Phase II results.

The sensitivity of a test course is evaluated in terms of whether the course is able to detect a real performance difference if one exists. If a test course reveals statistically significant differences between performance measures for a treatment condition, then the course can be considered sensitive. Sensitivity and reliability of a test course are interrelated. Accurate and precise measurement will lead to a small within treatment (error) variance. The smaller the within treatment variance, the smaller are the performance differences between treatments that are needed to produce statistical significance. Thus if a test course produces statistically significant performance differences for a treatment condition, it can be assumed to be sensitive and at least minimally reliable.

The March/Move Flat Track and Hilly Terrain Courses were evaluated in repeated measurement test designs in which various weights distributed about the M56 combat pack and harness were the independent variables or treatment conditions. The designs are illustrated in Figure 10.

The rationale underlying the use of these test designs was as follows. If the course is composed of the same marching and moving activities as are required in combat, and if the conditions under which these activities are performed are representative of the combat setting, then the performance data obtained from the course are a valid indication of performance to be expected under combat conditions. Thus, if one finds no significant differences among the performance measures, one might conclude that no differences will exist among the particular clothing and/or equipment items studied in the actual combat setting. It is possible, of course, that uncontrollable sources of variation may be masking small but real performance differences which will become apparent only with a more refined Phase III version of the course. However, the development of this Phase III course is better justified if it can be shown in Phase II that the course will detect real differences if they exist. It is obvious, of course, that a field performance course which fails to differentiate between the clothing and equipment which it was designed to evaluate is of little potential utility to the Army. It was our hope in selecting treatment conditions (the differential weights distributed about the M56 pack) for this Phase II course that some performance differences would occur. It was also our hope in designing the measurement system that the data obtained would be sufficiently accurate and precise to detect real performance differences if they exist.

March/Move Flat Track:

	15# Pack	30# Pack	45# Pack
Subject 1 Subject 2 . . . . Subject n			

Hilly Terrain Course:

	15# Pack	30# Pack
Subject 1 Subject 2 . . . . Subject n		

Figure 10. Test Designs.

Several other points should be mentioned with regard to the foregoing test designs. First, the repeated measurements were used in order to provide sensitivity with respect to the primary independent variable. Second, in implementing the designs, the order in which subjects performed under the various treatment conditions was counterbalanced. The counterbalancing was used to offset any effects that might attend the order of testing. Third, in order to control for longer term learning effects, subjects were tested under the treatment conditions on adjacent test days (counterbalanced)--to the extent possible. Finally, the research testing of the Hilly Terrain Course was limited to a study of the effects of the 15-pound and 30-pound packs based upon the results obtained from testing with the Flat Track. As will be seen in the next section (Results), the Flat Track failed to demonstrate sensitivity in the comparison of the 15-pound versus the 30-pound pack weights. We anticipated that the Hilly Terrain Course would be both more stressful and more sensitive than the Flat Track. It was decided that the comparison of the 15-pound pack versus the 30-pound pack--as the more difficult conditions to discriminate between--would provide the best indication of the sensitivity of the Hilly Terrain Course. Also, by limiting the testing to two conditions, we increased the likelihood that our test subjects would complete the requirements of the experimental design. (If men had trouble with blisters, etc., it was normally on the third day of performance on the Flat Track; the expectation was that the Hilly Terrain event would aggravate such occurrences.)

VII. Results

The data to be presented cover testing sessions which span the period of 3 March 1964 through 21 April 1964. All of the data on the March/Move Flat Track pertain to Quartermaster test subjects. The data on the Hilly Terrain Course include an equal number of Airborne troops and Quartermaster troops as test subjects. For ease of presentation, the data are broken out into three sets of results: 1) testing of the March/Move Flat Track using a ten-mile sample of performance; 2) testing of the Hilly Terrain Course (using a ten-mile sample of performance); and 3) testing of the Flat Track following performance of the Maneuver Course and using a five-mile sample of performance. As will be discussed subsequently, the additional testing of the Flat Track was undertaken in the light of the results obtained from the initial tests with the Flat Track and the Hilly Terrain Course.

A. March/Move Flat Track

The experimental data from the testing of the March/Move Flat Track using a ten-mile sample of performance were collected on 3, 4, 5, 10, 17, 18 and 24 March 1964. Table 1 presents the results obtained with the weighted combat packs. Figures 11, 12 and 13 show graphically the various comparisons indicated in Table 1. (The three graphs are used--Figures 11, 12 and 13--because there are some differences in the sample of people used for the three comparisons. That is, not all subjects completed the experimental design; subjects were included in those comparisons for which their data were appropriate.)

Presented in Table 1 are the size of the samples, the average performance under the indicated conditions, and the results of statistical tests for differences between conditions. In making the statistical tests, a one-tailed t-test using the differences between the related data from each ubject was used.[1] The one-tailed test is the proper one under our hypothesis that, if a difference occurred, it would be in the direction of a decrease in performance as the weight of the combat pack increased.

As may be seen in Table 1, significant performance differences, in the expected direction, occurred between the 30-pound pack versus the 45-pound pack and between the 15-pound pack versus the 45-pound pack. The difference between the 15-pound pack versus the 30-pound pack was small and not statistically significant. In general, the data indicate that, as the weight of the pack was increased, it took subjects longer to make the indicated number of traversals.

With regard to the latter point, it should be noted (as shown in Table 1) that the samples of behavior compared are the average times for the last three miles of the ten-mile total sample. Actually, the data are from laps 15 through 20, which excludes the 21st or last lap. (The last lap was excluded to minimize the effects of any end-spurt on the comparisons.) The last three miles (or final 30% of the total sample of performance) was used because earlier trials had suggested that the effects of the continued marching and moving were usually at a maximum during this period. It was thus decided, in advance of the data

[1] See Walker, Helen M. & Lev, J. Statistical Inference. Holt, New York, 1953, pp. 151-154 concerning the mean of a population of differences between two measures for each subject.

Table 1. Comparison of Weighted Packs[1]

March/Move Flat Track

Data of 3, 4, 5, 10, 17, 18, 24 March 1964

Conditions	N	Average Time for Last 3 Miles (Mins.)			Significance of Difference
15# Pack vs. 30# Pack	9	49.5	vs.	50.3	N.S.
30# Pack vs. 45# Pack	7	50.0	vs.	55.1	*
15# Pack vs. 45# Pack	8	48.0	vs.	55.4	**

* = $p < .05$
** = $p < .01$

[1] Based on data from laps 15 through 20 (or last three miles, excluding last lap).

Figure 11. Average Performance Per Lap, 15# Pack vs. 30# Pack

Data of 3, 4, 9, 10, 17, 18, 24 March 1964

N=9

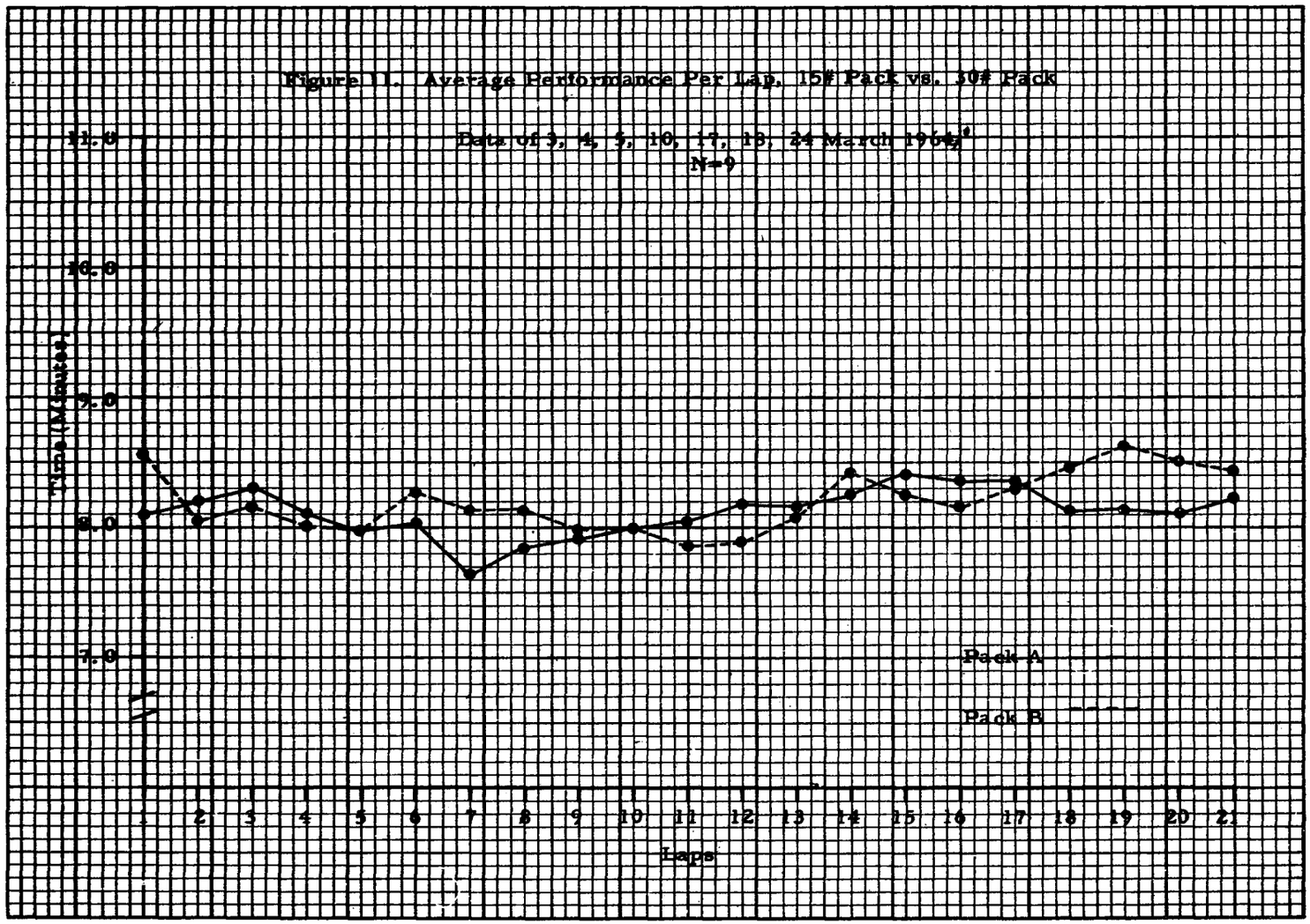


Figure 12. Average Performance Per Lap, 15# Pack vs. 45# Pack

Data of 3, 4, 5, 10, 17, 18, 24 March 1964
N=8

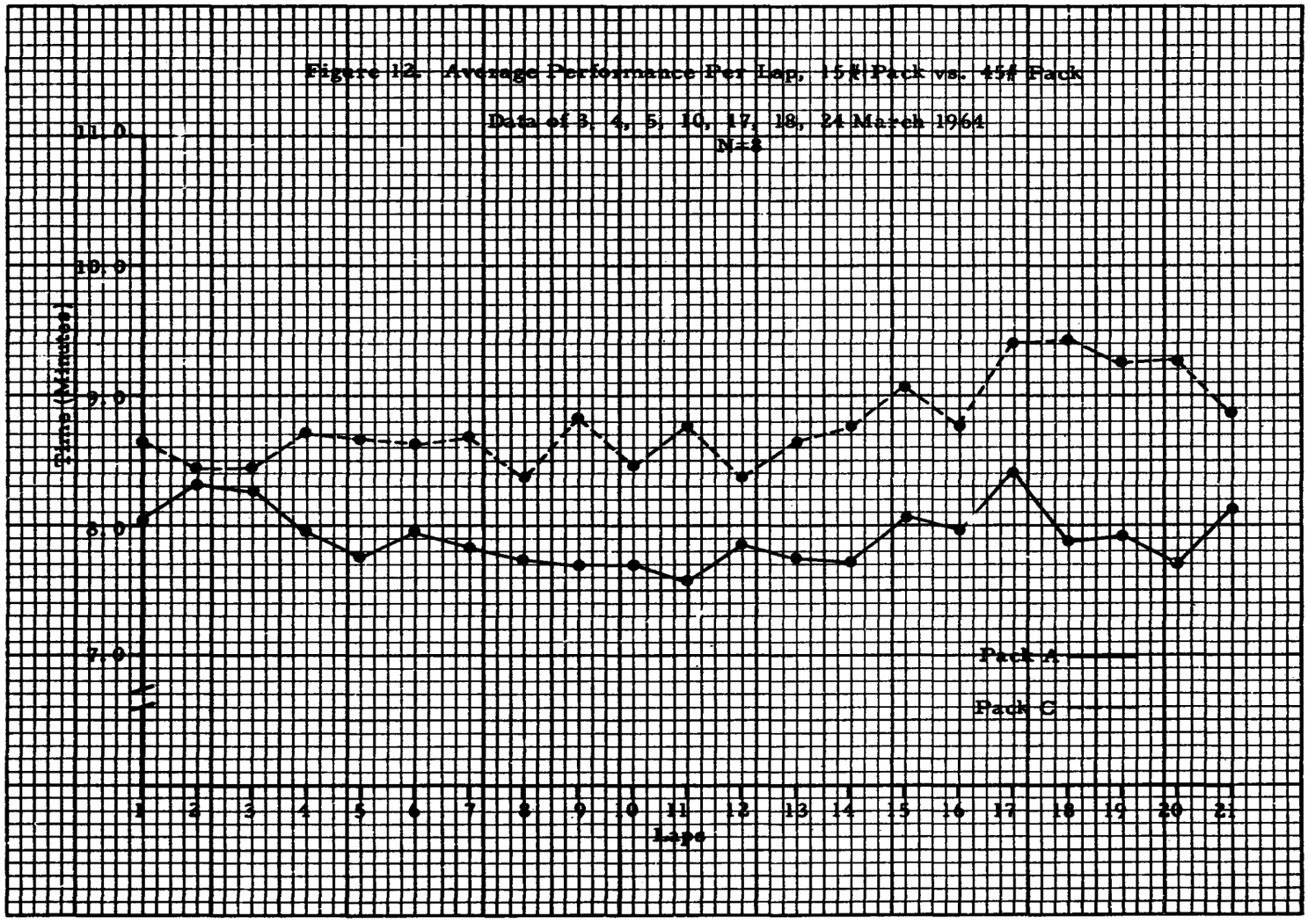
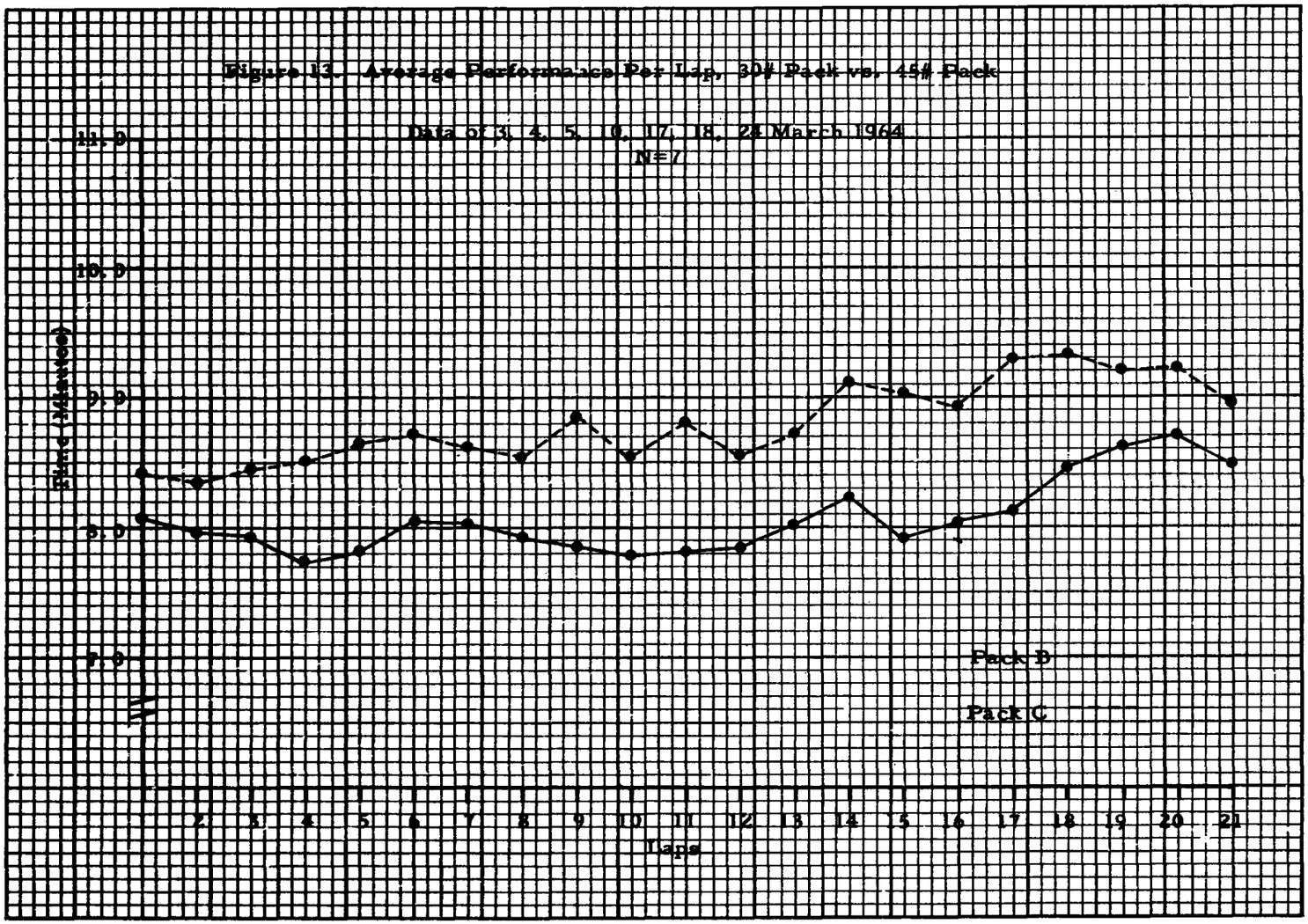


Figure 13. Average Performance Per Lap, 30# Pack vs. 45# Pack

Data of 3, 4, 5, 6, 17, 18, 24 March 1964
N=7



presented in Table 1 and Figures 11, 12 and 13, to use the last three miles of performance as the primary sample of data. (As with our experience in other courses, the initial portion of the event seemed to act as a prestressor leading to the differential effects which subsequently appeared in the continued performance.)

B. Hilly Terrain Course

The experimental data from the research testing of the Hilly Terrain Course were collected on 25, 27, 31 March and 1, 2, 3, 8, 9, 10, 13, 14, 15, 16, 20, 21 April 1964. As already stated, the subjects used were both Airborne (N = 10) and Quartermaster (N = 10). Table 2 presents the results from the comparison of the 15-pound pack versus the 30-pound pack. Shown also are the results of a statistical test on the significance of the obtained difference. As discussed for the results from the Flat Track, the statistical test used was a one-tailed t-test for differences between repeated measures on the same subjects.

Figure 14 shows graphically the average performance, by groups of three laps, under each of the weighted pack conditions.

As shown in Table 2, a significant performance difference, in the expected direction, occurred between the 15-pound pack versus the 30-pound pack. It took test subjects an average of 58.1 minutes to complete the last 3.5 miles of the Hilly Terrain Course while wearing the 15-pound pack. These same subjects required an average of 61.9 minutes to cover the same distance while wearing the 30-pound pack. (The last three and one-half miles of performance were used as the primary sample for the same reasons as presented in the preceding section concerning the March/Move Flat Track.)

C. Flat Track Following Maneuver Course

In the course of conducting the foregoing experimental trials, the thought occurred that perhaps a shorter march/move distance could be used (without loss of test sensitivity) if the marching and moving were preceded by some type of prestressor. From the standpoint of the integrated test course planned for Phase III, it seemed desirable to conserve available daily testing time to the extent possible--if each of the individual courses was to become part of the daily regimen. In the light of our experience with the Maneuver Course--where dashes performed subsequent to the original Maneuver Course were discriminating for some comparisons--we decided to evaluate the combination of the

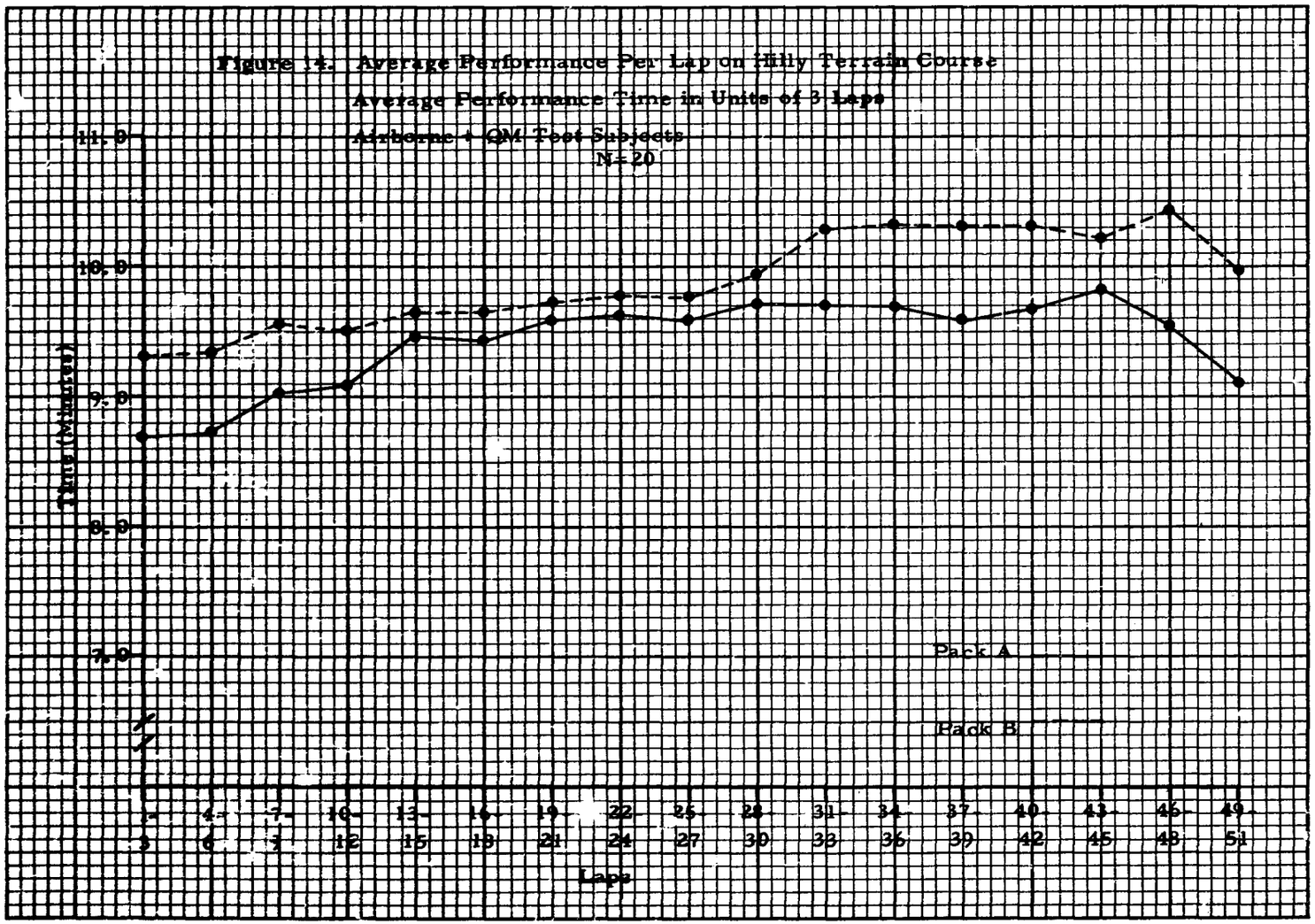


Figure 14. Average Performance Per Lap on Hilly Terrain Course
Average Performance Time in Units of 3 Laps
Airborne + QM Test Subjects
N = 20
11.0
10.0
9.0
8.0
7.0
Time (Minutes)
Pack A
Pack B
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
46-48
49-51
Laps

Table 2. Comparison of Weighted Packs[1]

Hilly Terrain Course

Data of 25, 27, 31 March 1964 and
1, 2, 3, 8, 9, 10, 13, 14, 15, 16, 20, 21, April 1964;

N = 20
(10 Airborne Subjects and 10 QM Subjects)

Condition	Average Performance (Mins.)		Significance of Difference
	Pack A	Pack B	
15# Pack vs. 30# Pack	58.10	61.93	*

* = $p < .05$

[1] Based on data from laps 31-48 (or last 3.5 miles excluding last three laps.)

entire Maneuver Course followed by five miles on the Flat Track. The data were collected on 1, 2, 13, 14, 15, 16, 20, 21 April 1964 and pertain to Quartermaster test subjects. Table 3 presents the results obtained with the weighted combat packs. Figures 15 and 16 show graphically the average performance for the 15-pound pack versus the 30-pound pack and for the 30-pound pack versus the 45-pound pack, respectively.

As shown in Table 3, the comparisons resulted in statistically significant differences in the expected direction.[1] Most gratifying was the fact that the 15-pound pack versus the 30-pound pack resulted in a significant difference. (The straight ten mile Flat Track had not previously discriminated between these conditions--see Table 1.) Thus, not only was the Maneuver Course plus five miles on the Flat Track a sensitive substitute for ten miles on the Flat Track, but it appeared that the integration of events provided a more sensitive situation than the individual ten-mile event. (The latter finding also seemed to portend well for the sensitivity of the integration of courses planned for Phase III.)

VIII. Interpretation of Results

The following conclusions are made in reference to the results presented in the preceding section:

- The magnitude of the differences detected as significant with the weighted combat packs is interpreted to indicate that both the March/Move Flat Track and the Hilly Terrain Course are sensitive test situations which will differentiate among clothing and protective equipment to a practically useful extent.

- The magnitude of the differences detected as significant using five miles on the Flat Track following the Maneuver Course is interpreted to indicate that this integration of the two courses provides sensitivity equal to or greater than that for ten miles on the Flat Track alone. The combination of the Maneuver Course plus five miles on the Flat Track requires substantially less testing time per subject than the ten mile test procedure. The expectation is that a similar procedure

[1] Again, as in the preceding sections, the statistical tests used a one-tailed t-test for differences between repeated measures on the same subjects.

Table 3. Comparison of Weighted Packs[1, 2]

Flat Track Following Maneuver Course

Data of 1, 2, 13, 14, 15, 16, 20, 21 April 1964

Conditions	N	Average Time for Last 3 Miles (Mins.)	Significance of Difference
15# Pack vs. 30# Pack	10	61.6 vs. 64.4	*
30# Pack vs. 45# Pack	13	63.2 vs. 67.4	**

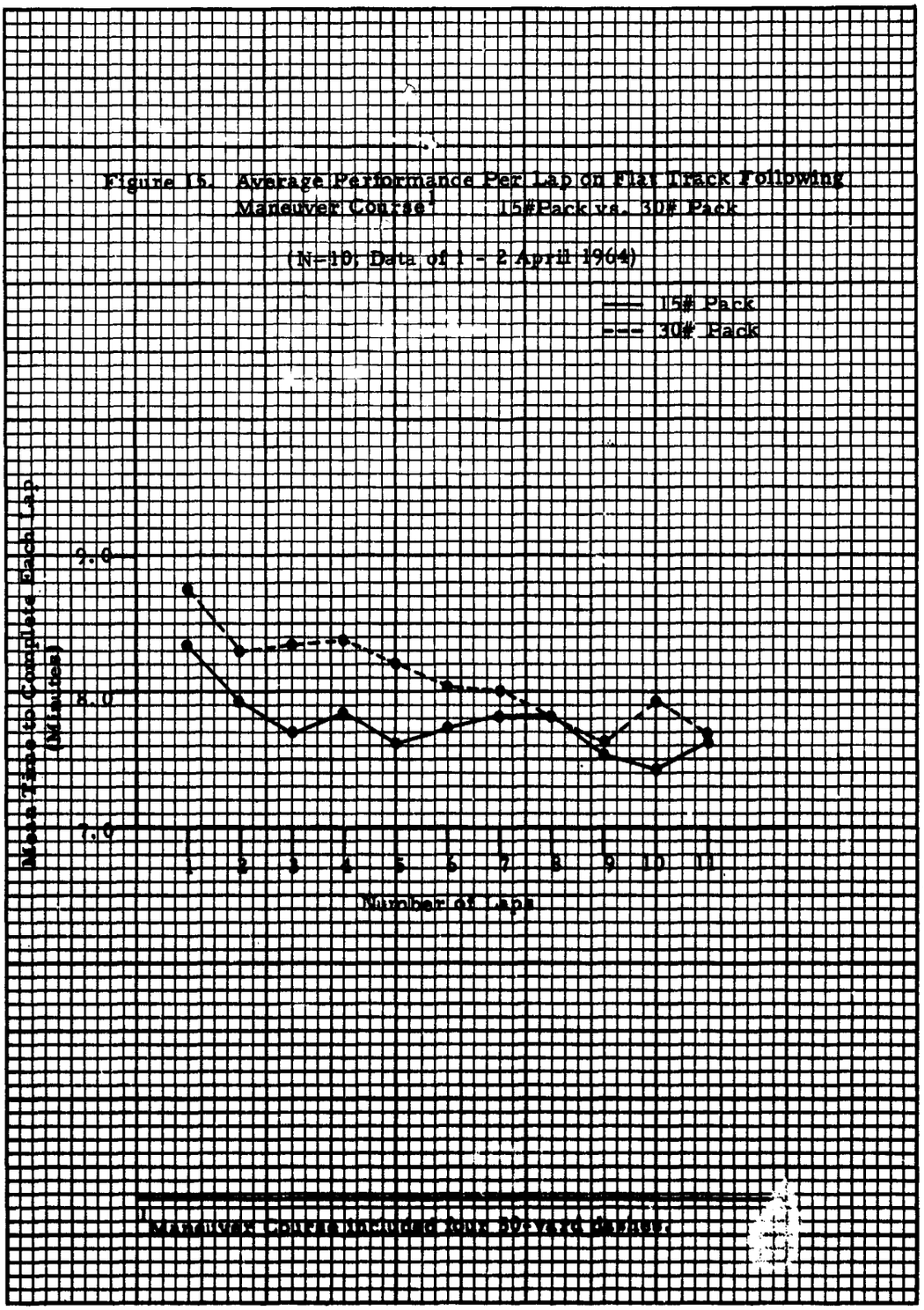
* = $p < .05$
** = $p < .01$

[1] Based on data from laps 3-10 of 11 laps following Maneuver Course + Two Dashes

[2] Since the groups of subjects for the two sets of data were different, no comparison was made between the 15-pound versus the 45-pound pack.

Figure 15. Average Performance Per Lap on Flat Track Following Maneuver Course[1] 15#Pack vs. 30# Pack

(N=10; Data of 1 - 2 April 1964)



[1] Maneuver Course included four 30-yard dashes.

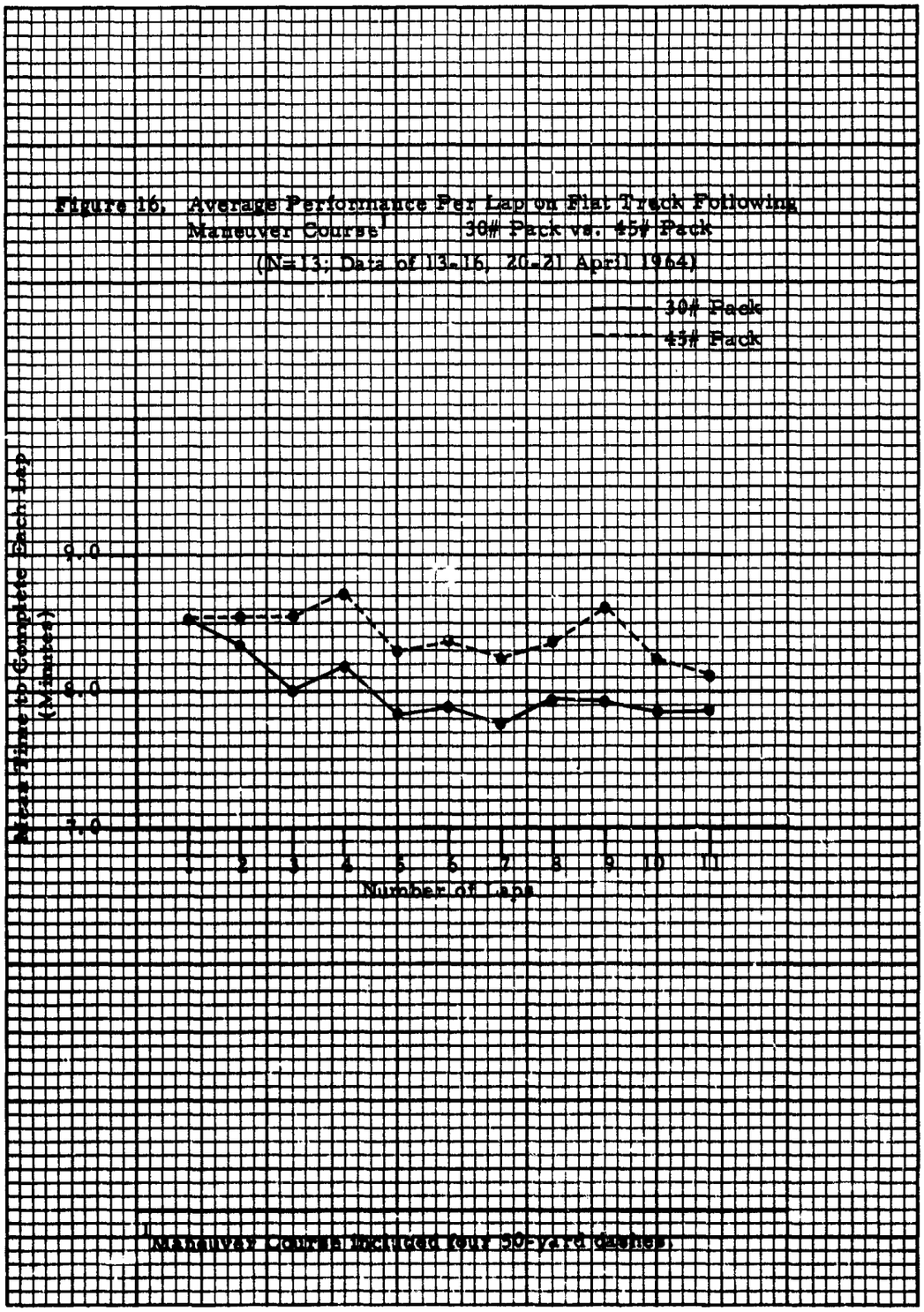


Figure 16. Average Performance Per Lap on Flat Track Following Maneuver Course: 30# Pack vs. 45# Pack
(N=13; Data of 13-16, 20-21 April 1964)

(Maneuver Course + Five Miles) will be an effective substitute for the ten miles on the Hilly Terrain Course.

- The results obtained support the theory of eliminating start-up and end-spurt data from the analysis.

IX. Recommendations for Final Test Course

Based upon all of the experiences gained in the tryout of the Phase II courses, the following recommendations have merit for the design and operation of the Phase III Flat Track and Hilly Terrain Course. The recommendations presuppose that the test setting will be essentially similar to the Phase II course except where changes are specifically stated.

- It is recommended that both the March/Move Flat Track and the Hilly Terrain Course be preceded by the Maneuver Course and reduced to five miles of performance in Phase III.

- A second primary recommendation is that the lap length be increased. Increasing lap length will further minimize unconscious pacing and also allow a greater number of individuals to be tested simultaneously. Ideally, the nature of the foliage and ground cover at the Phase III test site, the way the track is laid out, and the increased length of the tracks will all combine to minimize the opportunity for test subjects to see each other on the course. A "track" that is one mile in length is probably a minimum.

- From the standpoint of data collection with the five miles of performance, it is necessary to measure only the total elapsed time to cover the middle four miles of performance. That is, the first half mile and the last half mile of performance--because of warm-up and end-spurt effects--may be omitted. Further, individual lap times or points within the central four miles are not strictly necessary. Only total time for the four central miles is required based upon the Phase II results. (While the profile of performance may have use diagnostically, the collection of the individual lap times cannot be considered necessary from the standpoint of a primary, overall, direct measure of marching and moving.) The requirement for measuring only the total time to perform the central

four miles, if implemented, will reduce somewhat the number of data collectors required to support operation of the two courses.

- The experiences of Phase II, the proposed longer tracks (resulting in longer elapsed times for each subject to reappear over a designated point on the course), plus the requirement for measuring only two time points should all combine to reduce the number of O/R's needed to operate the courses. A reasonable expectation is that one O/R will be able to monitor the performance of three test subjects.

- Finally, consideration should be given to automating the data collection and refining the instrumentation. With regard to the latter, the resolution of the Meylan stopwatches used in Phase II was certainly adequate. There were occasions, however, when the watches (under field use) failed after a subject had been started. There were also isolated instances when the watches were misread. A desirable alternative would be a timing device which, when triggered, prints out the exact time (in minutes and hundredths of a minute) without losing count. (A less expensive version of the instrumentation under consideration for the Phase III Fire and Reload Weapon and Maneuver Courses should be considered.) The duties of an O/R would thus no longer involve reading a watch; rather, they would consist of either writing--on the printout paper--the name of the subject to whom the time point pertained, or merely copying the printed time onto a prepared data sheet.

  With regard to automating the data collection, we have in mind the use of photo-cell sensors which, when interrupted, would trigger the timing device to print. Thus, the movement of each subject--either about the course, or at the selected points necessary to measure the total elapsed time--would be collected without involving the judgment of the O/R as to when the subject was directly over the line marking the point at which the time should be recorded and without including also the reaction time of the O/R in stopping the watch.

APPENDIX A

March/Move Flat Track

O/R Briefing
Troop Briefing

Hilly Terrain Course

O/R Briefing
Troop Briefing

March/Move Flat Track

O/R Briefing

I. Purpose of the Course

The purpose of the March/Move Course is to study the effects of Quartermaster clothing and equipment on the infantryman's ability to march and move over roads and trails for an extended period of time. This course is one of a series of courses which are being developed to measure performance in the tasks that are most important in combat.

II. Course Description

The present course is a preliminary one and consists of 21 traversals of the flat track located in the General Equipment Test Activity's exposure area. Subjects will walk the course individually and will be controlled by the assigned Observer-Recorder. Subjects are to move at their own pace, nonstop, and will be timed on how quickly they complete each traversal of the track as well as how quickly they complete the 21 traversals.

III. Observer-Recorder Tasks

O/R's will be assigned a subject by the Senior Controller. The O/R will be responsible for the subject's performance while he is participating on the course. Basic uniform for the subject will be fatigue jacket and trousers, combat boots, and fatigue hat. All subjects will carry the M-1 rifle. Subjects may be issued special clothing and/or equipment by the Senior Controller prior to performing on the course.

After insuring that the subject is in the proper basic uniform, carrying the M-1 rifle, and properly wearing or carrying the designated special clothing or equipment, the O/R will start the subject on the course. Subjects will start from predesignated lines on the course and will walk in either a clockwise or counterclockwise direction as specified by the Senior Controller. All performance measures will be taken as the subject crosses this predesignated line at the end of each traversal. Performance measures, taken by the O/R will be the time taken to complete each traversal as well as the time taken to complete all 21 traversals (to nearest 1000th of a minute).

The O/R is to observe the subject at all times that he is performing on the course. He will insure that the subject stays within the limits of the track and does not stop at any time. He will record, in the remarks section of the data collection sheet, any critical event(s) which may influence the performance of the subject and the traversal(s) in which such event(s) occurred. (Examples of such events would be rain, slippery terrain, walking with another subject, etc.) The O/R will furnish, upon request, a canteen of water to the subject. The canteen will be given to the subject as he completes a traversal and taken back from the subject as he completes the next traversal.

IV. Preliminary Checks

Prior to starting the subject, the O/R will:

a) Insure that his stopwatch is reset and in proper working condition. (Two watches may be used per subject.)

b) Insure that the subject is in the proper basic uniform.

c) Insure that the subject is carrying the M-1 rifle.

d) Insure that the subject is properly wearing and/or carrying the special clothing and/or equipment designated by the Senior Controller.

e) Verify the starting position to be utilized and the direction (clockwise/counterclockwise) the subject is to walk with the Senior Controller.

f) Have a fresh canteen of water available for the subject.

V. O/R Data Collection Form

(Review form with O/R and answer any questions.)

March/Move Flat Track

Troop Briefing

I. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today, and for the next few days, we will be evaluating our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to march and move over roads and trails for an extended period of time.

II. Course Procedures

The March/Move Course consists of 21 traversals around the flat track located in the General Equipment Test Activity's exposure area. You will perform the course individually. The uniform will be the standard fatigue jacket, trousers, combat boots, and hard hat. You will start on signal from the Observer-Recorder who is assigned to supervise your activities. You will walk at your own rate and you will walk nonstop. You may be issued additional equipment to wear or carry by the O/R. At all times, you will carry the M-1 rifle.

In review then, this course consists of 21 traversals of the flat track located in the GETA exposure area. You will be told when and from what point to start by the O/R assign d to supervise your activities. He will also tell you in which direction you are to walk. You are to complete each lap as quickly as possible. Your uniform will be the standard fatigue uniform with combat boots, and hard hat. You will also carry the M-1 rifle. You will not wear a field jacket. You may wear additional clothing or equipment which will be issued to you by the appropriate O/R. You will walk around the course at your own pace but at no time will you be allowed to stop. Since there will be more than just yourself on the course, it is requested that you walk as rapidly as possible and if you should meet with another subject on the course, do

not keep pace with him but pass the individual and keep on walking at your own pace. Do not let other test subject's rate of walk influence your normal rate. Finally, if you need water while on the course request the O/R supervising you to furnish the canteen available for this purpose. Remember that you are not to stop but will pick up the canteen while passing the O/R and return it to him on your next trip around the track.

Are there any questions?

Hilly Terrain Course

O/R Briefing

I. Purpose of the Course

The purpose of the Hilly Terrain Course is to study the effects of Quartermaster clothing and protective equipment on the infantryman's ability to move over rough and hilly terrain. This course, like the Flat Track, Hasty Fighting Positions, and Maneuver Courses, is one of a series of courses being developed to measure performance in the most important combat tasks of line infantrymen.

II. Course Description

The Hilly Terrain Course consists of 51 traversals of the hilly terrain track located in the GETA test area along State Highway 630. The length of the track is approximately 1050 feet, 350 feet of which is uphill, 450 feet downhill, and 250 feet level terrain. Subjects will walk the course individually under the supervision of an Observer-Recorder. Subjects will be instructed to walk at their own rate and to finish the 51 traversals as rapidly as possible. Subjects will not be allowed to stop at any time during the test. Performance measures, taken by the O/R, will be the time to complete each traversal and the time to complete the required 51 traversals (to the nearest 1000th of a minute).

III. Observer-Recorder Procedures

O/R's will be assigned a test subject by the Senior Controller. The O/R is responsible for the subject's actions while he is participating on the course. The O/R will insure that the subject is in the proper basic uniform, i.e., fatigue jacket and trousers, combat boots, and fatigue hat and that he is carrying the M-1 rifle. The O/R will also determine by personal check with the Senior Controller what special clothing and/or equipment the subject is to wear and/or carry.

O/R's will start subjects from designated starting lines previously placed on the course. All performance measures will be taken as the subject crosses this line at the finish of each traversal (i.e., the O/R will record on the data collection form the time taken to complete each traversal to the nearest 1000th of a minute). O/R's will also record in the remarks section of the data collection form any critical events which

occur which could influence the subject's performance, e.g., rain, high wind, slippery terrain, subject tripping or falling, etc.

O/R's will insure that subjects properly complete each traversal, i.e., stay within the confines of the designated track. O/R's will further insure that subjects walk nonstop and at their own rate. Subjects will have been instructed not to walk together or to let another subject's performance influence their rate of march; however, if such occurs, the O/R will record same on the data sheet and indicate which traversals were affected. O/R's will have available a fresh canteen of water which will be furnished to the subject upon request. Since the subject is not allowed to stop, the canteen will be handed to him as he completes a traversal and will be taken back as he completes the next traversal.

IV. Preliminary Checks

Prior to starting the subject, the O/R will:

a) Insure that the subject is wearing the proper basic uniform.

b) Insure that the subject is properly wearing and/or carrying the special clothing and/or equipment designated by the Senior Controller.

c) Insure that the subject is carrying the M-1 rifle.

d) Have a fresh canteen of water available.

e) Insure the stopwatch is reset and in proper working order. (Two watches may be used for each subject.)

V. O/R Data Collection Form

Review the data collection form and answer any questions the O/R's may have.

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Hilly Terrain Course

Troop Briefing

I. Purpose of the Course

You are serving in research experiments that will eventually lead to a standard course on which to evaluate the effects of Quartermaster clothing and equipment on a soldier's ability to perform important combat tasks. This is a serious and expensive undertaking. Everyone wants the American soldier to have the best clothing and equipment. The best clothing and equipment may save lives.

Today, and for the next few days, we will be evaluating our preliminary concepts for a course designed to reveal the effects of Quartermaster clothing and equipment on the infantry soldier's ability to move over hilly and rough type terrain.

II. Course Procedure

The Hilly Terrain Course consists of 51 traversals of the hilly terrain track located in the GETA test area along State Highway 630. You will perform the course under the supervision of a trained Observer-Recorder. The uniform will be the fatigue jacket and trousers, combat boots, and fatigue hat. The M-1 rifle will be carried at all times. Field jackets will not be worn. You may be issued additional equipment to wear or carry by the O/R. When you are told to start by the O/R, you are to walk at your own speed for the 51 traversals of the track. At no time will you be allowed to stop. Should you need water, request your O/R to furnish you the canteen which he has available. Again, you will not be allowed to stop, but will pick up the canteen when you pass the O/R point and return it to the O/R on your next time around the course.

Test procedures call for several subjects to be on the track at the same time. It is important that you walk at your own speed and not be influenced by any other subject's rate of march. If you catch up with another man on the track, pass him and keep on at your own rate of speed.

Remember, 51 traversals of the course, as rapidly as possible, walking at your own rate. At no time will you be allowed to stop. Do

not be influenced by another subject's rate of march. If you should catch up with another subject on the course, pass him, and continue as quickly as you can. We are interested in how quickly you can complete each lap and how quickly you can complete the entire distance of 51 laps.

Are there any questions?

APPENDIX B

Photographs of Original Squad Test Situation

Figure 17. Fire Team and Observers on Trail.

Figure 18. Subjects Taking Prone Positions.

APPENDIX C

Project Reports

C-1

PROJECT REPORTS

I. Report of Phase I, USATECOM Project No. 8-3-7700-01, Development of a Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of the Individual Field Soldier, U.S. Army QM R&E Field Evaluation Agency (now U.S. Army General Equipment Test Activity), February 1964.

II. Reports of Phase II, USATECOM Project No. 8-3-7700-01, Development of Methodology for Measuring Effects of Personal Clothing and Equipment on Combat Effectiveness of Individual Soldiers (U.S. Army General Equipment Test Activity):

1. Identification of Important Tasks of Combat Infantry--Report of Results from a Further Refinement, November 1964.

2. Development of a Methodology for Measuring Infantry Performance in Rifle Firing and Reloading, June 1965.

3. Development of a Methodology for Measuring Infantry Performance in Maneuverability, June 1965.

4. Development of a Methodology for Measuring Infantry Performance in Marching and Moving, June 1965.

5. Development of a Methodology for Measuring Infantry Performance in Grenade Throwing, June 1965.

6. Development of a Methodology for Measuring Infantry Performance in Digging Hasty Fighting Positions, June 1965.

7. Final Report, Phase II, December 1964.

AD Accession No.

U. S. Army General Equipment Test Activity, Fort Lee, Virginia

DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MARCHING AND MOVING, FOURTH PARTIAL REPORT OF USATECOM PROJECT NO. 8-3-7700-01, PHASE II, DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS, by A. Gruber, J. Wm. Dunlap, G. DeNittis, Dunlap and Associates, Inc., Darien, Connecticut and J. L. Sanders, V. W. Perry, B. D. Dixon, U.S.A. General Equipment Test Activity, Fort Lee, Virginia, June 1965, 51 p. 18 Figures, 3 Tables.
(TECOM 8-3-7700-01) Unclassified Report

A three-phase research effort is underway to develop field methodology for measuring the effects of experimental clothing and equipment on the combat effectiveness of individual infantrymen. This report covers a portion of the work performed under Contract DA 19-129-QM-2068 (OI 6141) by Dunlap and Associates, Inc., and is the fourth of a series of seven reports presenting the results of Phase II of the study.

The first partial report in this series reported work performed to identify and rank the relative importance of the physical tasks

UNCLASSIFIED

1. Infantry combat tasks
2. Combat effectiveness
3. Clothing--Effects
4. Protective equipment--Effects
5. Human engineering
6. Measurement methodology
I. Gruber, A.
II. Dunlap, J. Wm.
III. DeNittis, G.
IV. Sanders, J. L.
V. Perry, V. W.
VI. Dixon, B. D.
VII. Title
VIII. TECOM Project No. 8-3-7700-01 (Contract DA 19-129-QM-2068)

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DEVELOPMENT OF A METHODOLOGY FOR MEASURING INFANTRY PERFORMANCE IN MARCHING AND MOVING, FOURTH PARTIAL REPORT OF USATECOM PROJECT NO. 8-3-7700-01, PHASE II, DEVELOPMENT OF METHODOLOGY FOR MEASURING EFFECTS OF PERSONAL CLOTHING AND EQUIPMENT ON COMBAT EFFECTIVENESS OF INDIVIDUAL SOLDIERS, by A. Gruber, J. Wm. Dunlap, G. DeNittis, Dunlap and Associates, Inc., Darien, Connecticut, and J. L. Sanders, V. W. Perry, B. D. Dixon, U.S.A. General Equipment Test Activity, Fort Lee, Virginia, June 1965, 51 p. 18 Figures, 3 Tables.
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