AD__________

REPORT NO. T13-90

FREQUENCY OF LOADED ROAD MARCH TRAINING AND PERFORMANCE ON A LOADED ROAD MARCH

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

and

U S ARMY FITNESS SCHOOL
Ft Harrison, Indiana

UNITED STATES ARMY
MEDICAL RESEARCH & DEVELOPMENT COMMAND

Human subjects participated in this study after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION U.S. Army Research Institute of Environmental Medicine

6b. OFFICE SYMBOL (If applicable) SGRD-UE-PH

7a. NAME OF MONITORING ORGANIZATION Same as 6a.

6c. ADDRESS (City, State, and ZIP Code)

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING / SPONSORING ORGANIZATION USARIEM, Natick, MA 01760-5007

8b. OFFICE SYMBOL (If applicable) SGRD-UE-PH

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
	3E162787A879		134

11. TITLE (Include Security Classification) Frequency of Loaded Road March Training and Performance on a Loaded Road March

12. PERSONAL AUTHOR(S) Joseph Knapik, Michael Bahrke, Jeffery Staab, Katy Reynolds, James Vogel, John O'Connor

13a. TYPE OF REPORT Technical Report

13b. TIME COVERED FROM April 89 TO Feb 90

14. DATE OF REPORT (Year, Month, Day) April 1990

15. PAGE COUNT 50

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Road March, Load Carriage, Heart rate, Injuries, Training, Marksmanship, Grenade, Muscle soreness

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Four groups of soldiers (N=137) participated in a 9 week physical training program that was similar except for the amount of loaded road march training. Group 0 (GP0) did not perform any road marching; Group 1 (GP1) road marched once a month; Group 2 (GP2) road marched twice a month; Group 4 (GP4) road marched 4 times a month. The training program involved progressive increases in running, resistance training and interval training and some calistenic exercises. Before and after training soldiers performed a maximal effort 20 km road march while carrying a 46 kg total load. Some soldiers were monitored for heart rate during both road marches. Results showed that post-training road march times were significantly longer than pre-training times presumably because of (a) longer voluntary rest breaks and (b) higher environmental temperature. There were no significant differences in road march times among the 4 groups on the pre-test. On the post-test, GP4 and GP2 had significant faster road march times than GP1 and GP0. There were no significant differences between GP2 and GP4. After both road marches decrements were found in marksmanship and maximum grenade throwing

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL

22b. TELEPHONE (Include Area Code)

22c. OFFICE SYMBOL

DD Form 1473, JUN 86 — *Previous editions are obsolete* — SECURITY CLASSIFICATION OF THIS PAGE distance. These data suggest that twice monthly road marching as part of a progressive physical training program results in 20 km road march times equivalent to road march training 4 times per month. A strenuous road march can significantly impair some aspects of military performance.

CONTENTS

LIST OF FIGURES AND TABLES

FOREWORD

Since at least 1948 the U.S. Army has been concerned with the loads soldiers carry during road marching. The U.S. Army Field Board No. 3 (1948-1950), the U.S. Army Combat Developments Agency (1962-1964) and the U.S. Army Development and Employment Agency (ADEA, 1986-1988) conducted major studies to examine various aspects of loaded road marching (23). All of these groups have agreed that soldier loads are excessive and methods to reduce loads must be developed.

In October 1986 the U.S. Army Research Institute of Environmental Medicine (USARIEM) and U.S. Army Fitness School (USAFS) attended a "lightening the load" conference held at ADEA, Ft. Lewis, WA. ADEA requested assistance in the development of effective physical training programs to properly condition soldiers for loaded road marching.

In December 1987 the USAFS held a conference to review current knowledge on loaded road marching. This meeting identified several areas where information was lacking. A key gap in knowledge was an optimal method of physical training to enhance loaded road marching performance. USARIEM and USAFS agreed to develop a plan to study this issue.

In February 1988 another conference was held at USAFS for two purposes: (a) to finalize interim guidance to field units on how to physically train to improve road marching based on our current knowledge, and (b) to design a study to develop practical methods of improving road marching through physical training.

Continuing communication between USARIEM and USAFS resulted in a protocol to study (a) the weekly frequency of road march training for optimal improvements in road march performance, (b) soldier performance following loaded road marching and (c) physiological factors related to loaded road marching. In early 1989 the USARIEM and MRDC Human Use Committees approved the study for implementation. In February, 1989 USAFS and USARIEM briefed the Commander, 6th Infantry Division, Ft Richardson, AK, on the study design. He approved execution of the study and tasked the 2/17th Infantry to provide support. This report presents some of the results of this study.

ACKNOWLEDGEMENTS

The authors would like to thank the soldiers of the 2/17th Infantry, 6th Infantry Division, Ft. Richardson, AK without whom this study would not have been conducted. We also gratefully acknowledge the cooperation of LTC Masteas, LTC Richie, the staff of the 2/17 Infantry. CPT Charles Gillis and CPT Ike Muril of the Battle Simulation Center, Ft Richardson provided outstanding administrative support. Expert technical assistance was given by the following individuals: Mr. Peter Frykman, SPC Scott Gordon, SPC Wendi Robison, SSG Calvin Witt, Mr. Robert Mello, MAJ Tim Cory, Ms. Marilyn Sharp, SPC John Kasaba, SGT Matthew Bovee and SPC Brian Boutiler, Ms Laurie Trad, SPC Mike Johnson and SGT Jaime Perez.

EXECUTIVE SUMMARY

Four groups of soldiers (N=137) participated in a 9 week physical training program that was similar except for the amount of loaded road march training. Group 0 (GP0) did not perform any road marching; Group 1 (GP1) road marched once a month; Group 2 (GP2) road marched twice a month; Group 4 (GP4) road marched 4 times a month. The training program involved progressive increases in running, resistance training and interval training and some calisthenic exercises. Before and after training soldiers performed a maximal effort 20 km road march while carrying a 46 kg total load. Some soldiers were monitored for heart rate during both road marches. Results showed that post-training road march times were significantly longer than pre-training times presumably because of (a) longer voluntary rest breaks and (b) higher environmental temperature. There were no significant differences in road march times among the 4 groups on the pre-test. On the post-test, GP4 and GP2 had significant faster road march times than GP1 and GP0. There were no significant differences between GP2 and GP4. After both road marches decrements were found in marksmanship and maximum grenade throwing distance. These data suggest that twice monthly road marching as part of a progressive physical training program results in 20 km road march times equivalent to road march training 4 times per month. A strenuous road march can significantly impair some aspects of military performance.

INTRODUCTION

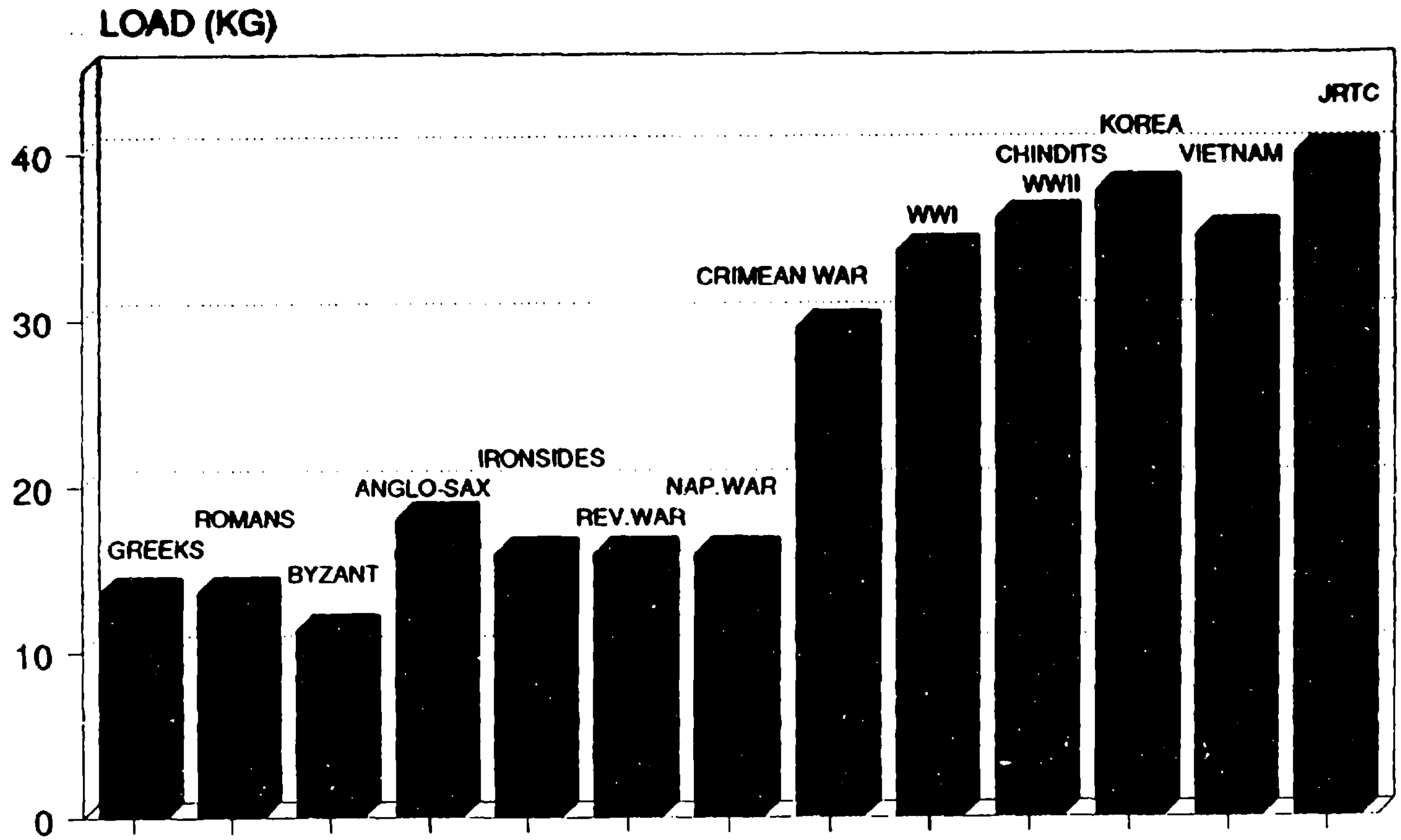
The development of new weapons and other equipment has increased the firepower and protection of the individual soldier (40). However, this has come at a price. The modern day infantryman carries almost twice the load of his counterparts in ages past. This trend is graphically depicted in Figure 1.

The Army Development and Employment Agency (ADEA) has proposed a number of methods to reduce loads carried by soldiers. These include (a) the use of light weight equipment, (b) use of special load handling devices, (c) reevaluation of current doctrine, and (d) better load planning (1). A fifth approach is to physically condition the soldier to better tolerate heavy loads (1). Current Army physical fitness programs focus on calisthenics, running and resistance training (10). Calisthenic activities may improve muscle strength in the first few weeks of the program but without adequate overload, further improvements may be minimal. Running and other forms of long-term submaximal exercise improves aerobic capacity (49), allows soldiers to perform the same exercise at a lower relative exercise intensity (49) and allows more rapid recovery following the exercise (19). Resistance training increases lean body mass and strength (50).

However, past experience suggests that these traditional Army physical training programs may not be sufficient to improve the soldier's ability to march with heavy loads. In Grenada, soldiers had extreme difficulty carrying their approach march loads (13). In a study of soldiers during a 5 day simulated combat scenario participants experienced problems carrying their combat load despite the fact they were judged physically fit as measured by the Army Physical Fitness Test (22).

There have been few systematic attempts to improve loaded road marching ability through physical training. Kraemer et al. (28) demonstrated that load carriage time over a 3.2 km distance could be improved by a combination of aerobic training, resistance training and interval training. Rudzki (48) showed that marching with progressively increasing loads (combined with other military training) could increase the predicted VO_2max of basic trainees. Correlational studies have suggested that aerobic capacity and lower body strength (14, 36) are related to load carriage performance.

FIGURE 1. LOADS CARRIED (0N THE MARCH) BY VARIOUS ARMIES OR AT VARIOUS TIMES



From: Lothian (32), Holmes (20) and
Joint Readiness Training Center 1988

A key question in developing optimal physical training programs for units with a major load carriage missions is the amount of road marching to include into the total program. Some road marching is probably needed to meet specificity requirements (35) while excessive marching may be costly in terms of training time and increased risk of injury (27, 33). Thus, the purpose of the present study was to examine the monthly frequency of load carriage training needed to improve performance on a strenuous road march. A secondary purpose was to examine marksmanship and indices of muscular performance after the road march.

METHODS

SUBJECTS

Subjects were 137 soldiers assigned to the 2d battalion, 17th Infantry, 6th Infantry Division (Light). First Sergeants from each of the 4 companies in the battalion were asked to identify soldiers who might be available for the duration of the study. Soldiers were briefed in a single large group regarding the purposes and risks of the study. Those who volunteered to participate gave their written informed consent.

DESIGN

The study involved a 9 week physical fitness training program with a criterion 20 km road march before (pre-training) and after (post-training) training. Initial assignment of soldiers to 1 of 4 training groups was random although First Sergeants changed some assignments prior to the start of the training. The physical fitness program was essentially identical for all 4 groups with the exception of the amount of road marching performed. Group 0 (GP0) performed no road marching; Group 1 (GP1) road marched once per month; Group 2 (GP2) road marched twice each month; and Group 4 (GP4) road marched 4 times a month.

Measurements of marksmanship, vertical jumping ability and a grenade throw for distance were performed a few days before and immediately after both criterion road marches.

ROAD MARCH

Soldiers marched on a precisely measured 20 km course. The first 10 km had little elevation change and all but 2 km was on paved roads. Between 10 and 15 km the course was paved but had rolling hills with elevation changes as much as 15 vertical meters. The last 5 km was flat with about 1.5 km on dirt roads.

Soldiers carried total loads of approximently 46 kg. A 3 kg rucksack held two sand bags, one weighing 14 kg and the other 18 kg for a total rucksack load of 35 kg. The uniform (BDU's), weapon (M-16), and helmet were estimated to weigh 5.0 kg (45). Load carrying equipment (LCE) of many soldiers was weighed at the end of each road march and averaged (+_SD) 5.9+_2.0 kg on the pre-test (N=92) and 6.9+_2.2 kg (N=101) on the post-test. Some soldiers had grenade launchers attached to their weapons which added an additional 1.2 kg.

Marches were conducted over 2 days for both the pre- and post-training tests. Soldiers began the march in groups of about 10-20 individuals with each group separated by about 10 min. Soldiers were allowed to rest at their own discretion but told that their mission was to complete the road march as rapidly as possible. It was emphasized that this was an individual best effort. At 5 km checkpoints soldiers' times were recorded and the soldiers could secure food and water. The road march ended at a small arms range were their final road march times were obtained and sand bags and LCE's were weighed. Soldiers were also asked to estimate 1) their total number of rest stops and 2) total time spent in resting.

Medics, a physician and a physician assistant walked and/or drove the road march course to provide medical coverage. Medics were also assigned to the 5 km checkpoints. Medical personnel recorded problems on the form shown in Appendix A. Soldiers were also followed-up for 10 days after the march by screening medical record in the battalion aid station for road march related problems.

QUESTIONNAIRES

At the conclusion of the pre-training road march soldiers were interviewed regarding soreness, pain and discomfort in different body regions. A modification of the technique of Corlett and Bishop (7) was used to assess pain, soreness and discomfort. Soldiers were shown the questionnaire in Appendix B and a technician recorded their responses on each body part.

Immediately prior to the post-training road march soldiers were administered the Self Motivation Inventory developed by Dishman et al. (11). This was given indoors in comfortable conditions with the soldiers wearing only their uniform and LCE. The Self Motivation Inventory consists of 19 positively keyed items and 21 negatively keyed items. The possible range of scores is from 40 to 200, with a high score indicative of higher self-motivation. A typical statement is "When I take on a difficult task I make a point of sticking with it until it is completed." Possible responses include "extremely uncharacteristic of me", "somewhat uncharacteristic of me", "somewhat characteristic of me", "extremely characteristic of me".

PERFORMANCE TESTS

Within 5 min of completing the road march, soldiers removed their rucksacks and performed a standard rifle firing task from the foxhole supported position. They fired 3 shots to confirm that their M-16 was zeroed. They then had 20 seconds to fire 10 rounds, 2 at each of 5 identical silhouettes. The number of hits and linear distance of each shot from the centroid of the silhouette was recorded.

Immediately after the rifle firing task (about 10 min after the road march), subjects walked about 10 m and performed a vertical jump. Soldiers removed their helmets, LCE and weapon. They stood with their feet on the ground and side of their body near a tall pole. They reached up and marked a board on the pole with a piece of chalk. In one motion subjects bent at the knees and hips, jumped upward and marked the board as high as possible. The difference between the standing mark and the high mark was the vertical jump distance. The highest of 3 trials was recorded.

After the vertical jump (about 15 min after the road march) subjects walked 5 m and performed a grenade throw for distance. Subjects threw simulated "pineapple" type grenades from the kneeling position with their knees perpendicular to the direction of the throw. Grenades weighed about 0.5 kg each. Although no particular throwing technique was prescribed, subjects were told to throw as far as possible. Three throws were allowed and the distance of the longest throw was measured and recorded.

Baseline measurements on all three performance tests were obtained 1-3 days prior to both the pre- and post-training road marches. On these baseline days subjects were transported to the small arms range (where all tests were conducted) by truck.

HEART RATE MONITORING

During both criterion road marches 20 soldiers from each of the 4 groups were monitored for heart rates. They wore Uniq^{tm} Model 8799 heart watches that consisted of (a) an electrode strap and transmitter that subjects wore on their chest and (b) a receiver that resembled a watch and that subjects wore on their wrist. The receiver contained a computer chip that stored heart rates once per minute. The entire unit weighed only 0.14 kg and no soldier complained that the device hampered their movements. Technicians placed the units on the soldier 30 to 60 min prior to the start of the march and removed them within 30 min of the finish. Soldiers were instructed not to manipulate the heart watches in any way. A marker was placed in the stored data within 1 minute of the start and finish of the road march.

After the road march, minute-by-minute heart rates were downloaded to a computer using Uniq^{tm} software. This produced (a) a graph of heart rate over time as shown in Figure 2 and (b) the digital heart rate values. Visual observations on the graphs indicated that heart rates increased at the onset of the road march. Sudden drops in heart rates of 20 b$\cdot$min^{-1} or more indicated periods of reduced activity and suggested subjects may be resting.

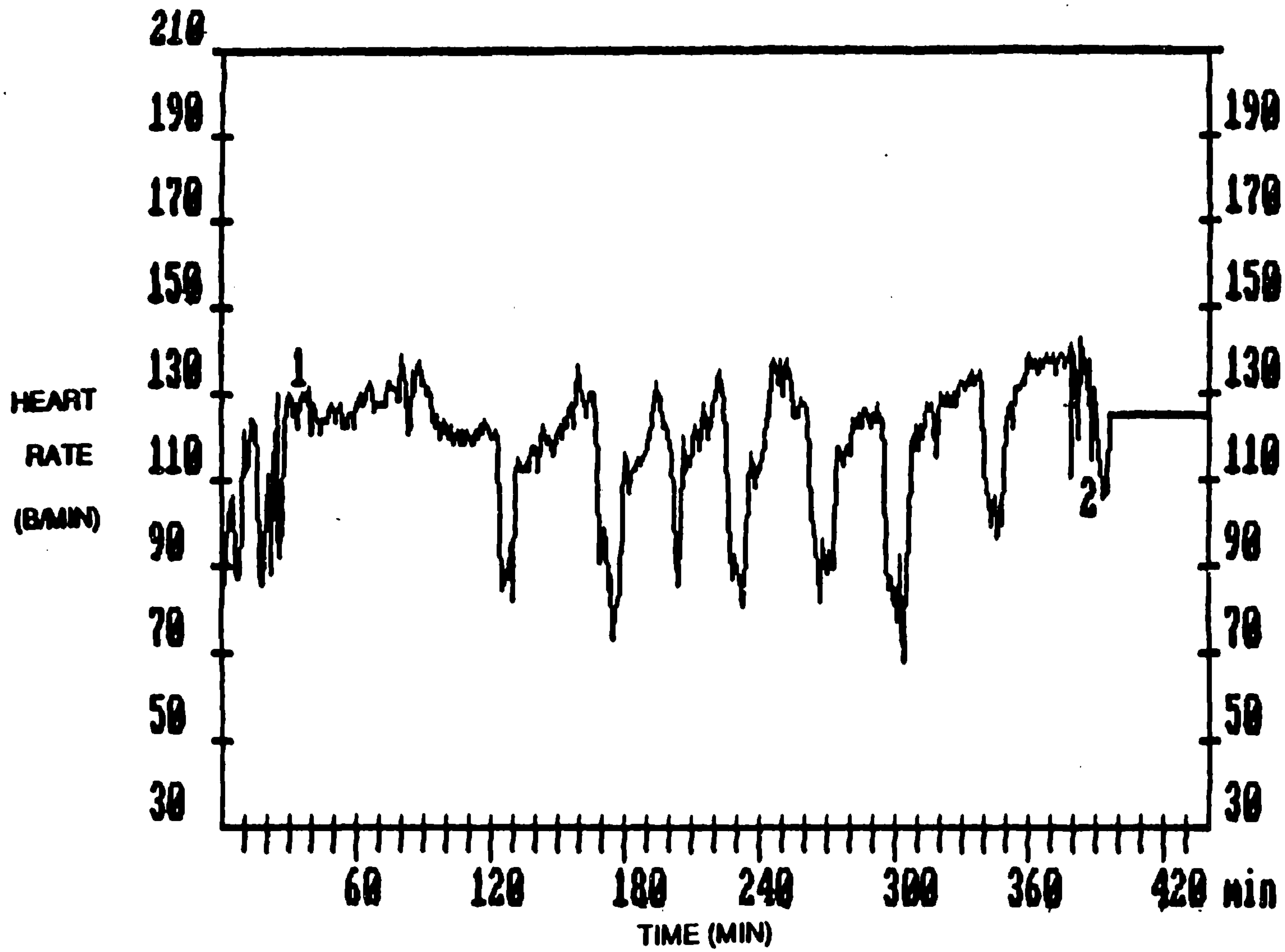


FIGURE 2. HEART RATE GRAPH
(NUMBERS WITHIN GRAPH REFER TO
START AND END OF ROAD MARCH)

The heart rate data were trimmed to include only heart rates obtained during the road march. An "average heart rate" was calculated by averaging all heart rates during the march. An "activity heart rate" (heart rates during actual road marching) and "resting heart rate" (heart rates while not marching) was obtained using a 20 beat·min^{-1} criterion. Data was initially reduced using a computer program that incorporated the Triplet comparison method of Mello et al. (37). This program compared each heart rate to the value of the previous 2 minutes'. If all 3 values were within 20 beats·min^{-1} of each other the value being compared was averaged with the other heart rates to that point (running average). If the value was less than 20 beats·min^{-1} of either heart rate being compared the running average was printed out along with the number of minutes. A new triplet comparison was begun using the next 3 heart rates.

At the conclusion of this process a series of heart rates and times were obtained. Each heart in the series was sequentially compared to the next heart rate in the series. If the value was within 20 beats·min^{-1} that heart rate was considered an activity heart rate and it was placed into the activity heart rate running average. If the heart rate was 20 beats·min^{-1} below the running average it was considered a resting heart rate and placed into the running average of the resting heart rates. Times associated with the activity and rest heart rates were summed to obtain an "activity time" and a "rest time".

TRAINING PROGRAM

The physical training program was designed to emphasize the major components of physical fitness (43) and improve road marching ability based on available information (14, 28, 36, 48). The program was 9 weeks in length. In the first week subjects performed an Army Physical Fitness Test (APFT, 9) and were familiarized with the resistance training techniques, interval training and warm-up practices. In the following 8 weeks soldiers performed the exercises shown in Table 1 and described below. Differences among the groups (Table 1) were due to scheduling conflicts or training distractors (e.g. inability to use the weight lifting facility, holidays, events that conflicted with training time). At the end of the 9 week training program the APFT was repeated.

TABLE 1.
PHYSICAL TRAINING PROGRAM BY GROUPS
(NUMBER OF TRAINING SESSIONS)

	RUNNING	RESISTANCE TRAINING* "A"	RESISTANCE TRAINING* "B"	INTERVALS	CIRCUIT TRAINING	PU/SU TRAINING	ROAD MARCH
GP0	12	7	5	4	4	11	8
GP1	12	6	6	4	4	12	4
GP2	12	5	7	4	3	11	2
GP4	12	6	6	4	3	12	0

* See Appendix C for the different exercises in "A" verses "B"

Running was performed in ability groups and progressed from about 5 to about 10 km over the 9 weeks. The exercises in the resistance training program are shown in Appendix C. In resistance training "A" soldiers used Nautilus devices, Universal machines or free weights. One to 3 sets of 8-12 repetitions of each exercise were performed. In resistance training "B", sand bags weighing 5, 9 and 18 kg were used to provide resistance. Exercises were performed 2-3 times with 20-45 sec for each exercise. Interval training consisted of short sprints progressing from 6 repeats of 100m to 8 repeats of 200m. For circuit training, soldiers sprinted or ran to a series of stations. When the soldiers arrived at a particular station they performed a specific calisthenistic-type exercise. For push-up and sit-up improvement soldiers performed 6 distinct push-up type exercises and 5 different sit-up type exercises. These differed in terms of placement of hands and feet and the range of motion completed.

Road march training was conducted on level dirt and paved roads. Road marching was progressive with respect to the load and distance as shown in Table 2.

STATISTICAL ANALYSIS

The data was analyzed using repeated measures analysis of variance. When significant F-values were found the Tukey test was used for post hoc analysis. Pearson product moment correlation coefficients were used for analysis of continuous variables and Spearman Rank order correlations for ordinal variables. The 0.05 level was taken to indicate statistical significance.

TABLE 2.
ROAD MARCH LOADS (KG) AND DISTANCES (KM)
FOR THE FOUR TRAINING GROUPS

	GROUP 0		GROUP 1		GROUP 2		GROUP 4	
WEEK	LOAD	DIST	LOAD	DIST	LOAD	DIST	LOAD	DIST
1	0	0	0	0	0	0	18	8
2	0	0	0	0	0	0	0	0
3	0	0	0	0	23	11	23	11
4	0	0	25	12	0	0	25	12
5	0	0	0	0	27	13	28	13
6	0	0	0	0	0	0	30	14
7	0	0	0	0	32	15	32	15
8	0	0	34	16	0	0	34	16
9	0	0	0	0	34	16	34	16

RESULTS

Not all subjects completed the criterion road marches. Table 3 shows the total numbers of subjects starting and completing the marches and reasons for dropping out. There were 16 subjects that did not return for the second road march (other than ETS and PCS) and the reasons for this are unknown. Despite the request for subjects who would be available for the entire training program, there were still 4 soldiers that left the unit prior to completion of the study (PCS and ETS). Temperatures and humidity on the 4 days of the road march are shown in Table 4.

TABLE 3.
NUMBERS OF SOLDIERS PERFORMING THE CRITERION ROAD MARCHES AND REASONS FOR NOT COMPLETING THE ROAD MARCHES

	PRE-TRAINING				POST-TRAINING			
	GP0	GP1	GP2	GP4	GP0	GP1	GP2	GP4
1. TOTAL STARTING ROAD MARCH	34	31	40	32	30	26	38	27
2. TOTAL COMPLETING ROAD MARCH	29	29	39	32	28	21	35	25
3. REASONS FOR DROPPING OUT								
a. INJURY	2	1	1	0	1	1	1	1
b. INCORRECT PACK WEIGHT	1	1	0	0	0	0	0	1
c. PCS OR ETS*	-	-	-	-	0	2	2	0
d. WRONG TURN ON COURSE	0	0	0	0	1	0	0	0
e. INVOLUNTARILY REMOVED	1	0	0	0	0	0	0	0
f. UNKNOWN	1	0	0	0	0	2	0	0
4. DID NOT RETURN FOR SECOND ROAD MARCH	-	-	-	-	4	5	2	5

*Left Unit Before Completion of Study (ETS=Estimated Time of Separation; PCS=Permanent Change of Station)

TABLE 4.
TEMPERATURE (°C) AND HUMIDITY (%) DURING THE ROAD MARCHES

	PRE-TRAINING				POST-TRAINING			
TIME	7APR89		12APR89		28JUN89		29JUN89	
OF DAY	TEMP	HUMID	TEMP	HUMID	TEMP	HUMID	TEMP	HUMID
0655	-6	71	1	69	14	72	17	70
0755	-3	71	3	59	16	67	18	65
0855	1	61	5	59	16	65	20	55
0955	3	54	7	51	19	54	21	51
1055	4	57	7	51	19	54	23	48
1155	5	55	8	47	21	53	24	43
1255	6	53	9	48	21	51	23	38
1355	7	51	9	44	22	51	25	38
1455	7	45	10	44	23	49	26	35
1555	7	45	10	44	23	48	25	35
1655	7	47	9	48	24	46	24	37
MEAN	3.5	55.3	7.1	51.2	19.8	55.4	22.4	46.6
SD	4.2	8.7	2.8	7.6	3.2	8.1	2.8	11.7

Table 5 shows the cumulative road march times for the soldiers that completed both the pre- and post-training road marches. Times on the post-training march were slower than times on the pre-training march ($F(1,98)=14.9$, $p<0.001$). There were no differences among the groups on the pre-training march ($F(3,98)=1.4$, $p=0.26$). On the post-training march there were differences among the groups ($F(3,98)=3.57$, $p=0.02$). Post hoc analysis revealed that GP2 and GP4 had faster post-training times than GP0 and GP1 ($p=0.04$).

Table 6 shows the average number of self-reported rests and amount of time spent resting during the road march. While the number of rests stops were about the same, the self-reported rest time was 17 min longer on the post-training march. The correlation between the change in total march time (post minus pre) and the change in total self-reported rest time was 0.72 ($N=96$, $p<0.001$).

TABLE 5.
CUMULATIVE ROAD MARCH TIMES (MIN) AT 5 KM INTERVALS

GROUP		PRE-TRAINING 5KM	10KM	15KM	20KM	POST-TRAINING 5KM	10KM	15KM	20KM
GP0	M	65	134	230	318	73	151	271	359
(N=26)	SD	14	29	57	72	22	37	64	82
GP1	M	60	129	212	310	67	138	251	353
(N=19)	SD	17	20	37	56	23	37	64	81
GP2	M	60	125	214	304	61	133	229	319
(N=33)	SD	13	27	52	75	12	29	49	63
GP4	M	57	121	203	285	57	125	219	307
(N=24)	SD	17	14	32	48	15	29	60	86

TABLE 6.
SELF-REPORTED REST STOPS AND REST TIME (N=56)

		REST STOPS (NO)	REST TIME (MIN)
PRE-TRAINING	M	5.6	43.7
	SD	4.6	36.6
POST-TRAINING	M	5.9	60.7
	SD	4.6	40.2
t-VALUE (PRE vs POST)		0.37	2.71*

*Statistically Significant, p=0.01

The average (+_SD) score on the Self Motivation Inventory (SMI) was 150+_21 (N=86). The correlation between the post-training march time and the SMI score was -0.38 (N=86, p=0.02).

Average values obtained on the Pain, Soreness and Discomfort Questionnaire are shown in Table 7. Soldiers reported the highest levels of soreness, pain and discomfort in the feet. The upper torso in back of the body (neck, shoulders, upper and lower back) was also perceived as having higher soreness, pain and discomfort than other parts of the body.

TABLE 7.
RESPONSES ON THE SORENESS, PAIN AND DISCOMFORT QUESTIONNAIRE

	MEAN	SD	MIN	MAX
FRONT OF BODY				
NECK (1)*	1.1	0.5	1	5
SHOULDERS (2)	2.2	1.6	1	6
UPPER ARM (3)	1.2	0.8	1	6
LOWER ARM (4)	1.1	0.6	1	5
HAND (5)	1.0	0.0	1	1
UPPER CHEST (6)	1.1	0.3	1	2
MID TORSO (7)	1.0	0.2	1	2
ABDOMEN (8)	1.7	1.3	1	6
UPPER LEG (9)	1.9	1.3	1	6
LOWER LEG (10)	1.4	1.1	1	6
FOOT (11)	4.7	1.6	1	6
BACK OF BODY				
NECK (1)	2.3	1.6	1	6
SHOULDERS (2)	3.4	1.8	1	6
UPPER ARM (3)	1.1	0.5	1	5
LOWER ARM (4)	1.1	0.5	1	5
HAND (5)	1.0	0.0	1	1
UPPER BACK (6)	2.1	1.6	1	6
LOWER BACK (7)	2.5	1.8	1	6
BUTTOCK (8)	1.8	1.5	1	6
UPPER LEG (9)	1.6	1.3	1	6
LOWER LEG (10)	2.2	1.6	1	6
FOOT (11)	3.8	2.0	1	6

*Numbers in parenthesis correspond to numbers on questionnaire (Appendix B)

Results of the APFT for subjects who completed the pre- and post-training road marches and pre- and post-APFT tests are shown in Table 8. There was an improvement in the number of push-ups ($F(1,82)=42.1$, $p<0.001$) and sit-ups ($F(1,82)=7.17$, $p=0.01$) on the post-training test. However, 2 mile run times were slower on the post-test ($F(1,80)=4.60$, $p=0.03$). There were no significant differences among the 4 groups on the push-ups ($F(3,82)=0.55$, $p=0.65$) or sit-ups ($F(3,82)=2.47$, $p=0.07$). On the 2 mile run there were differences among the groups ($F(3,80)=3.33$, $p=0.02$). Post hoc analysis indicated that GP0 was slower than the other 3 groups ($p=.02$).

TABLE 8.
APFT RESULTS

	N		PUSH-UPS (NO) PRE	PUSH-UPS (NO) POST	SIT-UPS (NO) PRE	SIT-UPS (NO) POST	2 MILE RUN (MIN) PRE	2 MILE RUN (MIN) POST
GP0	21	M	52	59	62	67	13.8	14.0
		SD	9	8	8	8	1.1	1.3
GP1	13*	M	54	59	66	66	13.2	13.4
		SD	9	11	9	8	0.7	0.5
GP2	31*	M	56	63	70	73	13.1	13.1
		SD	13	13	12	15	1.0	0.9
GP4	21	M	56	62	69	70	13.1	13.3
		SD	10	12	9	8	0.9	0.8

* These groups had 1 less subject on the 2 mile run. Both subjects were on profile for running when the test was taken.

GP2 and GP4 kept logbooks on individual attendance during the training program. Soldiers in GP2 were present for training an average (+_SD) 71+_15% of the time. Soldiers in GP4 were present for training 73+_15% of the time. Reasons for absences included illnesses, time in the field, schools, passes and other duties. GP0 and GP1 did not maintain logbooks.

Figure 3 shows performance on the performance tests. For the rifle shooting task, the number of hits declined 43% (F(1,34)=61.5, p<0.001) and the distance from the centriod increased 59% (F(1,30)=31.06, p<0.001) after the marches. Grenade throw distance decreased 9% (F(1,61)=87.0, p<0.001) and vertical jump height decreased 3% (F(1,61)=6.89, p=0.01) after the marches. Post hoc analysis showed that there were post-march decrements for rifle shooting and grenade throw distance on both criterion road marches (p<0.001); however, for the vertical jump performance decrements were seen on the post-training march (p=0.01) but not on the pre-training march (p=0.10). There were no differences on rifle shooting scores or the grenade throw as a result of the training program; however, vertical jump scores were higher after the training program compared to before the program (F(1,61)=76.23, p<.001).

There were only 25 subjects that had complete heart rate data on both the pre- and post-training road march. Data was lost for a variety of reasons including (a) subjects inadvertently hitting a button on the receiver, (b) electrode straps falling off during the march, (c) electrical interference from unknown sources, and (d) subjects dropping out of the march or training program (Table 3). Numbers of subjects with complete heart rate data in each group were G0=9, G1=3, G2=10, G4=3. Because of the small sample sizes comparisons among groups were not made.

Total criterion road march times for the 25 subjects monitored for heart rate was 339+_64 min and 352+_80 on the pre- and post-training tests, respectively. Road march times, speeds and average heart rates over 5 km intervals are shown in Table 9. There were no significant differences between the pre- and post-training road march times (F(1,24)=0.52, p=0.48), road march speeds (F(1,24)=1.07, p=0.31) or heart rates (F(1,24)=0.48, p=0.50). Among the distance intervals there were significant differences for road march times (F(3,72)=68.0, p<0.001), speeds (F(3,72)=76.9, p<0.001) and heart rates (F(3,72)=4.05, p=0.01). Post-hoc analysis of march times and speeds indicated that subjects were faster in the first half of the road march compared to the last half (p<0.01). Post-hoc analysis of heart rates by the Tukey test did not reveal any differences; however, when the Duncan Multiple Range Test was applied to the data pre- and post-training heart rates at 10-15 km differed significantly from those obtained pre-training at 0-5 km and post-training at 15-20 km (p<0.05).

FIGURE 3. PERFORMANCE TESTS: MARKSMANSHIP, VERTICAL JUMP, AND GRENADE THROW

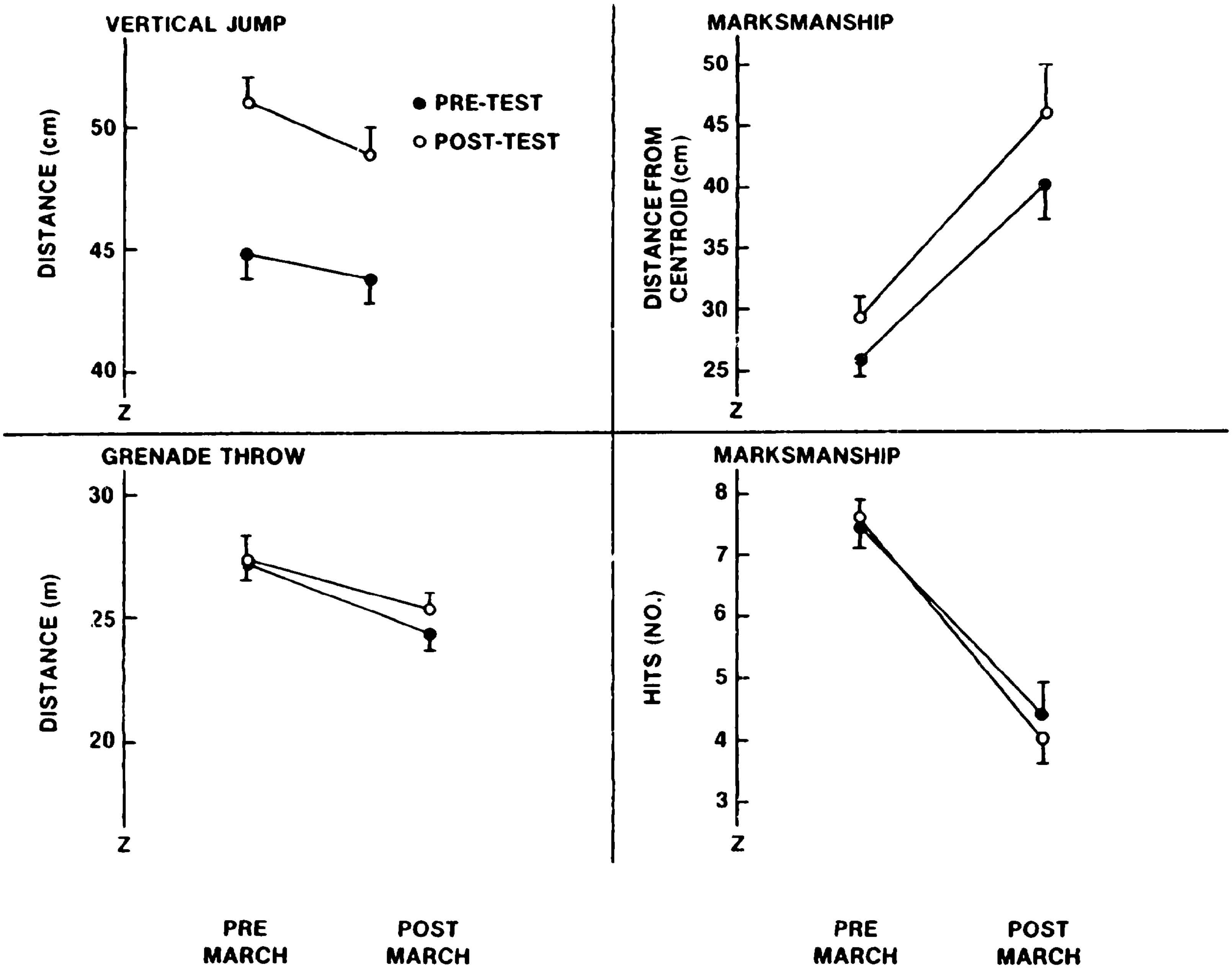


TABLE 9.
ROAD MARCH TIMES, SPEEDS AND HEART RATES FOR SUBJECTS WITH COMPLETE HEART RATE DATA (N=25)

			DISTANCE INTERVALS (KM)			
			0-5	5-10	10-15	15-20
ROAD	PRE	M	66	73	104	96
MARCH		SD	11	13	26	23
TIME	POST	M	72	75	108	97
(MIN)		SD	22	17	32	24
ROAD	PRE	M	4.7	4.3	3.1	3.3
MARCH		SD	0.8	0.7	0.8	0.8
SPEED	POST	M	4.5	4.2	3.0	3.3
($KM \cdot H^{-1}$)		SD	1.1	1.0	0.9	1.0
AVERAGE	PRE	M	137	131	129	131
HEART		SD	10	9	11	11
RATE	POST	M	135	133	131	137
($B \cdot MIN^{-1}$)		SD	15	14	15	17

Table 10 shows the measurements obtained by analysis of the minute-by-minute heart rate data. Calculated rest time was longer on the post- compared to the pre-training test. Correlation between the change in road march time (post minus pre) and the change in rest time was 0.93 (N=25, $p<.001$). Correlations between self-reported and calculated rest stops and rest time are shown in Table 11. The calculated and self-reported values show moderately strong relationships.

TABLE 10.
MEASUREMENTS CALCULATED FROM HEART RATE DATA (N=25)

		PRE	POST	t-VAL	P
ACTIVITY TIME (MIN)	M	282	270	1.53	0.14
	SD	32	38		
REST TIME (MIN)	M	54	81	2.04	0.05
	SD	42	58		
REST STOPS (#)	M	6.5	6.2	0.28	0.78
	SD	4.8	4.7		
ACTIVITY HEART RATE ($B \cdot MIN^{-1}$)	M	137	141	1.51	0.14
	SD	8	12		
RESTING HEART RATE ($B \cdot MIN^{-1}$)	M	102	104	0.68	0.50
	SD	8	8		

TABLE 11.
CORRELATION COEFFICIENTS BETWEEN SELF-REPORTED AND CALCULATED REST STOPS AND REST TIME*

	REST STOPS	REST TIME
PRE-TRAINING	0.81	0.85
POST-TRAINING	0.84	0.78

* All values are statistically significant, $p<0.01$

The numbers of subjects seeking medical attention during or after the pre- or post-training road march is shown in Table 12. There was one subject who was seen on both road marches so that 30 of the original 137 subjects (22%) were treated. There were no differences in the number of injuries among the 4 groups (chi square=2.86, p=0.41).

TABLE 12.
NUMBERS OF SOLDIERS SEEKING MEDICAL ATTENTION DURING THE PRE (RM1) OR POST-TRAINING (RM2) ROAD MARCH OR REPORTING TO THE BATTALION AID STATION 1-10 DAYS LATER WITH A ROAD MARCH RELATED INJURY

	GP0	GP1	GP2	GP4	TOTAL
RM1 SEEKING ATTN	3	4	3	7	17
RM2 SEEKING ATTN	2	5	3	4	14
NOT SEEKING ATTN	26	31	26	23	106
TOTAL	31	40	32	34	137

DISCUSSION

ROAD MARCH

Comparisons of the pre- and post-training road march times are confounded by longer rest times on the post-training test and temperature differences. Both self-reported (Table 6) and calculated (Table 10) rest times were significantly longer on the post-training test. There were also high correlations between the change in criterion road march times (post minus pre) and the change in both self-reported and calculated rest times. Thus, soldiers took longer voluntary rests on the post-training road march accounting for a large part of the increase in road march time.

Differences in environmental temperature may also help explain the longer post-training road march times. Post-training road march days were 16 °C warmer on the average than pre-training road march days. On the post-training march maximal and average temperatures were the highest of the year to date. Subjects were seen to sweat heavily. Although water was provided and subjects strongly encouraged to drink, soldiers may still have been partially dehydrated: subjects allowed unlimited access to water after exercise induced fluid loss do not fully rehydrate (15, 42). On a 29 km road march in which soldiers carried 24 kg and the dry bulb temperature was 28°C, soldiers voluntarily dehydrated to 3% of their body weight despite unlimited access to water and encouragement to drink frequently (46). In the present study pre- to post-training performance declines ranged from 5% (GP2) to 17% (GP1). Fluid losses equivalent to as little as 2-3% body weight can cause a 10-22% decrements in exercise time (4, 5, 42).

Differing aerobic fitness levels among the 4 groups do not seem to explain the differences in road march times. The 2 mile run has been shown to be highly correlated with VO_2max and thus serves as an index of aerobic fitness (24). VO_2max appears to be related to road march performance (23, 36) although the relationship between VO_2max and load carriage can account for no more than 28% of the variance between the 2 measures (36). GP0 had slower 2 mile run times than the other 3 groups. However, if aerobic fitness could account for large differences among the groups, pre-training road march times would have been significantly slower for GP0 compared to the other groups and this was not the case. Further, GP0 and GP1 had similar pre- and post-training road march times even though they had dissimilar aerobic fitness levels.

Despite the confounding problems mentioned above GP2 and GP4 completed the post-training road march an average of 43 min (12%) faster than GP0 and GP1. More importantly there was no difference between GP2 and GP4 suggesting that road marching twice a month with progressively increasing loads is as beneficial as marching 4 times per month. This is in consonance with training recommendations from the field (52) and suggestions from participants in the training program. Soldiers in GP4 complained of the frequency of the marches. The marches interfered with other training requirements and were fatiguing, especially when coupled in the same week with a 6 mile run.

The results of this study suggest that when planning training schedules units should regard 2 times per month as the minimum frequency for road march training. Road marching once a month (GP1) resulted in post-training road march times equivalent to no road march training at all (GP0). These results also support the specificity of training principle (35): despite the fact that all groups performed a physical training program designed to improve the major components of physical fitness (38) only the groups training at least twice a month were faster on the post-training march.

The criterion road march task was extremely strenuous. Soldiers had great difficulty completing the march and many rested often. They were visibly exhausted at the march's conclusion and a senior NCO commented that it was the most strenuous road march he had ever performed. The large number of injuries further illustrates this fact with 22% of the participants seeking medical attention during or after the march and 6% injured to the extent they could not complete the march. Interestingly, of the 8 subjects removed from the march because of injury, 4 had back strains.

The motivation of soldiers during the march was a problem as noted in previous investigations that have use similar maximal effort road march tasks (14, 36). Soldiers were seen to rest often despite instructions to complete the march as rapidly as possible. Soldiers also tended to march together despite direction not to do so. An attempt was made to measure motivation by use of the Self Motivation Inventory on the post-training march. This measure is a reliable and valid measure of adherence to a training or exercise program (11). A high score on this test may be more indicative of the importance of training in preparation for the road march rather than motivation on the road march per se. About 14% of the variance in the road march times was accounted for by the Self Motivation Inventory score. The average score of 150+_21 compares favorably with other samples: 140+_19 for college undergraduates (12), 142-155 for field artillery crewmen (26), 158+_15 for female members of a crew team (11) and 158+_17 for Army War College student-officers (Knapik and Rottner, Unpublished Data, 1987).

In order to provide better motivation in future road march studies, the march could be conducted in a controlled area such as a 1 mile loop. Soldiers should be observed continuously and the leadership should be present to provide encouragement and discipline. Rest stops should be planned so this factor is controlled (ten minute rest stops every hour are suggested in FM 21-18, Foot Marches).

PERFORMANCE TESTS

Shooting accuracy degraded severely as a result of the road march. An increase in body tremors due to fatigue or an elevated post exercise heart rate may account for this. Whole body sway while aiming a rifle is substantially increased even after a short period of exercise (39) and this may effect accuracy. Muscle tremors increase after brief or prolonged muscular contractions (17, 31) and these tremors appear to be localized to the muscles involved in the contraction (31). In the present study the shoulder muscles supported much of the rucksack load and subjects reported some pain and soreness and discomfort in this area (Table 7). While firing the weapon, the shoulder supports the butt of the rifle. If tremors were present here this could have effected marksmanship ability.

Another possible explanation for the degradation in marksmanship ability may be elevated heart rates. Slight movements of the rifle may occur when the heart beats. After exercise, heart rates are higher than baseline levels (9, 19) and the more intense the exercise, the greater the elevation (21). Reductions in heart rate through the use of beta-blockers can substantially improve shooting accuracy (29, 44).

Post road march decrements in the grenade throw may be attributed to a nerve entrapment syndrome, local fatigue and/or pain in the muscle groups used for this task. Compression of the brachial plexus by the shoulder straps of the rucksack can result in weakness, pain, paraesthesia and numbness in the upper extremities and this may limit throwing ability (3, 51). Local fatigue of the back and shoulder has been cited as a limiting factor in load carriage (18). Legg and Mahanty (30) found that subjects carrying framed rucksacks reported pain in mainly the neck and shoulder regions. In the present study the soreness, pain and discomfort questionnaires yielded some of the highest scores in the neck and shoulder region. A few subjects voluntarily complained that shoulder pain limited their grenade throwing ability and two other subjects, when questioned, provided similar assessments.

It is difficult to explain the post-training increases in vertical jumping ability. It has been shown that vertical jumping ability can be improved with weight training (2, 25). However, these improvements have been only 4-6% and the 12% improvement seen here may be too large to be accounted for by a training effect alone. Pre-training scores were low relative to other samples tested (2, 25).

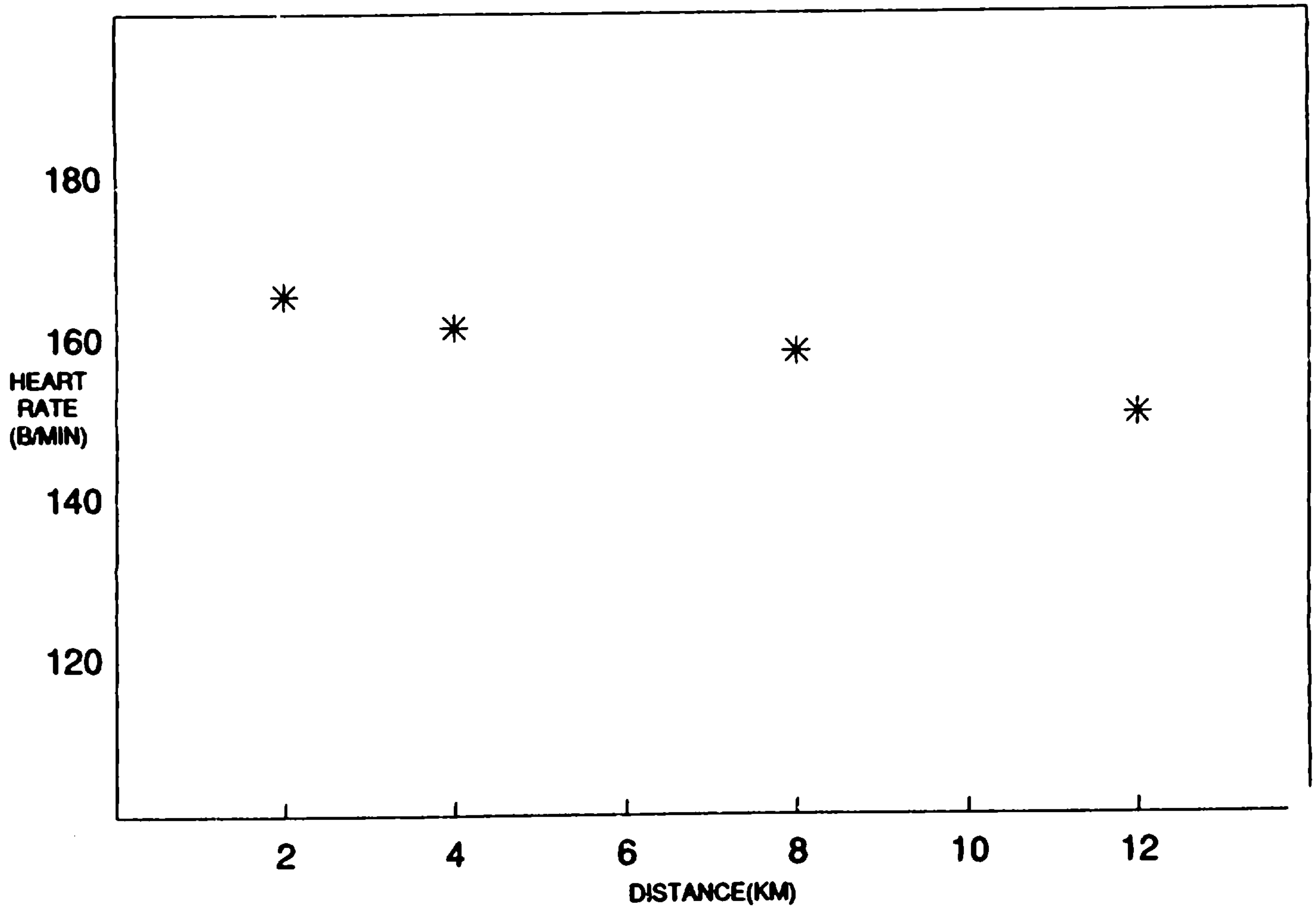
HEART RATE MONITORING

Unfortunately, subjects who were successfully monitored for heart rate cannot be considered representative of the training group as a whole in terms of criterion road march times. Monitored soldiers were considerably slower than those of the larger group on the pre-training march and close to the group average on the post-training march. They had no significant post-training decrement in road march times. However, monitored soldiers were similar to the training groups as a whole in that they demonstrated longer post-training rest times on the road march.

When subjects perform a loaded road march on a treadmill at a constant speed, exercise intensity increases over time if the load or speed is high enough (16, 41). However, in the present study there was little change in exercise intensity (heart rate) in spite of large changes in march speed (Table 9) and environmental temperature. It would appear that subjects' voluntary adjustments in march speed and/or rest periods resulted in the maintenance of a similar exercise intensity throughout the march.

It can be argued that the methods to reduce the heart rate data used in this study are not valid because they are based only on observation and have no sound physiological basis. However, there are several indicators that these methods provide at least an approximation of activity and rest times and activity heart rates. First, moderately high correlations were found between the self-reported and calculated rest time and number of rest intervals (Table 11). Second, extrapolations from the data of Mello et al. (36) suggests the activity heart rate, as determined from our data, is approximently that expected for a 20 km distance. Mello et al. (36) had soldiers perform road marches of 2, 4, 8, and 12 km while carrying a 46 kg total load. Although subjects were permitted to rest very few did so (Mello and Reynolds, personal communication). Figure 4 shows the average heart rate data at each distance. The linear regression equation to predict heart rate from these data

FIGURE 4. AVERAGE HEART RATES AT VARIOUS DISTANCES DURING ROAD MARCHING*



*FROM: MELLO et al.(36).

is $Y=-1.41X+167.6$. Heart rate at 20 km, predicted from this equation, is 139 $b \cdot min^{-1}$. This is very close to the values obtained for the activity heart rates in this study. It should be noted that the 20 km distance falls outside the range of observations in Mello's data and thus caution should be exercised in interpretation (38). Further, heart rate comparisons across studies are complicated by differences in temperature, fitness levels and other factors. With these qualification in mind, it can be seen that the extrapolated heart rate is very close to the activity heart rate in the present study (Table 10). This suggests the decrease in exercise intensity as the distance increases is similar in the 2 studies.

CONCLUSIONS

The 9 week training program described here incorporated (a) progressive increases in road march load and distance and (b) progressive increases in running distance and resistance training weight. Some interval and circuit training as well as specific training for push-ups and sit-ups was included. Under these conditions loaded road march training conducted at least twice a month resulted in faster 20 km road march times than a loaded road march training conducted once a month or not at all. Further, road march training conducted 4 times per month was no more beneficial than the twice a month program. The criterion 20 km road march also resulted in performance decrements in marksmanship and a grenade throw for distance.

REFERENCES

1. Army Development and Employment Agency. Training Development Strategy for Lighting the Load. Ft. Lewis, WA, 1986.

2. Bangerter BL. Contributive components in the vertical jump. Res Quart 39:432-436, 1967.

3. Bessen RJ, Belcher VW, Franklin RJ. Rucksack paralysis with and without rucksack frames. Milit Med 152:372-375, 1987.

4. Claremont AD, Costell DL, Fink W, Van Handel P. Heat tolerance following diuretic induced dehydration. Med Sci Sports 8:239-243, 1976.

5. Craig FN, Cummings EG. Dehydration and muscular work. J Appl Physiol 21:670-674, 1966.

6. Clarke HH, Shay CT, Matthews DK. Strength decrements from carrying various Army packs on military marches. Res Quart 26:253-265, 1955.

7. Corlett EN, Bishop RP. A technique for assessing postural discomfort. Ergonomics 19:175-182, 1976.

8. Dalen A, Nilsson J, Thorstensson A. Factors influencing a prolonged road march. FOA Report C50601-H6, 1976.

9. Davis CTM, diPrampero PE, Cerretelli P. Kinetics of cardiac output and respiratory gas exchange during exercise and recovery. J Appl Physiol 32:618-625, 1972.

10. Department of the Army. Physical Fitness Training (Field Manual 21-20), Washington, D.C., 1984.

11. Dishman RK, Ickes W, Morgan W. Self-motivation and adherence to habitual physical activity. J Appl Soc Psychol 10:115-132, 1980.

12. Dishman RK, Ickes W. Self-motivation and adherence to therapeutic exercise. J Beh Med 4:421-438, 1981.

13. Dubik, JM, Fullerton TD. Soldier loading in Grenada. Milit Rev PP38-47, 1987.

14. Dziados J, Damokosh A, Mello R, Vogel J, Farmer K. The Physiological determinates of load carriage. Natick, MA: USARIEM Technical Report No. T19-87, 1987.

15. Engell DB, Maller O, Sawka M, Francesconi R, Drolet L, Young A. Thirst and fluid intake following graded hypohydration levels in humans. Physiol Beh 40:229-236, 1987.

16. Epstein Y, Rosenblum J, Burstein R, Sawaka MN. External load can alter the energy cost of prolonged load carriage. Eur J Appl Physiol 57:243-247, 1988.

17. Furness P, Jessop J, Lippold OCJ. Long-lasting increase in the tremor of human hand muscles following brief strong effort. J Physiol 265:821-831, 1977.

18. Gupta KK. Problem of load carriage by infantry soldier. Bull Nat Inst Sci Ind 10:44-50, 1955.

19. Hagberg JM, Hichson RC, Ehsani AA, Holloszy. Faster adjustment to and recovery from submaximal exercise in the trained state. J Appl Physiol: Respirat Environ Exercise Physiol 48:218-224, 1980.

20. Holmes R. Acts of War. The Behavior of Men in Battle. New York: MacMillian, Inc., 1985.

21. Karpovich PV, Sinning WE. Physiology of Muscular Activity. Philadelphia: WB Sanders, 1971.

22. Knapik J, Daniels W, Murphy M, Fritzgerald P, Drews F, Vogel J. Physiological factors in infantry operations. Eur J Appl Physiol, 1990 (In Press).

23. Knapik J. Loads carried by soldiers: historical, physiological, biomechanical and medical aspects. Natick, MA: USARIEM Technical Report No. T19-89.

24. Knapik J. The Army physical fitness test (APFT): a review of the literature. Milit Med 154:326-329, 1989.

25. Knapik JJ, Drews F. Influence of a specific light infantry physical training program on physical fitness. Carlisle PA: APFRI Technical Report No T3-87, 1987.

26. Knapik JJ, Patton J, Ginsberg A, Redmond D, Rose M, Tharion W, Vogel J, Drews F. Soldier performance during continuous field artillery operations. Carlisle, PA: APFRI Technical Report No. T1-87, 1987.

27. Koplan JP Powell KE, Sikes RK, Shirley RW, Campell CC. An epidemiological study of the benefits and risks of running. JAMA 298:3118-3121, 1982.

28. Kreamer WJ, Vogel JA, Patton JE, Dziados JE, Reynolds KL. The effects of various physical training programs on short duration high intensity load bearing performance and the APFT. Natick, MA: USARIEM Technical Report No 30/87, 1987.

29. Kruse P, Ladefoged J, Nielsen U, Paulev PE, Sorensen JP. Beta-blockade used in precision sports: effect on pistol shooting performance. J Appl Physiol 61:417-420, 1986.

30. Legg S, Mahanty A. Comparison of five modes of carrying a load close to the trunk. Ergonomics 28:1653-1660, 1985.

31. Lippold O. The tremor in fatigue. Ciba Foundation Symposium No 82. London: Pitman Medical, 1981.

32. Lothian NV. The load carried by soldiers. J Roy Army Med Corps 38:9-24, 1922.

33. Marti B, Vader JP, Minder CE, Abelin T. On the epidemiology of running injuries. Am J Sports Med 16:285-294, 1988.

34. McArdle WD, Katch FI, Katch VL. Exercise Physiology. Philadelphia: Lea and Febiger, 1986.

35. Mcafferty WB, Horvath SM. Specificity of exercise and specificity of training: a subcellular review. Res Quart 48:358-371, 1977.

36. Mello R, Damokosk A, Reynolds K, Witt C, Vogel J. The physiological determinates of load bearing at different march distances. Natick, MA: USARIEM Technical Report No. T15-88, 1988.

37. Mello R, Jones B, Vogel J, Patton J. Assessment of physical activity intensity during infantry combat-simulated operations. Natick MA: USARIEM Technical Report No. T4-87, 1987.

38. Neter J, Wasserman W. Applied Linear Statistical Models. Homewood, IL: Richard D Irwin Inc, 1974.

39. Niinimaa V, McAvoy T. Influence of exercise on body sway in the standing rifle shooting position. Can J Sports Med 8:30-33, 1983.

40. Nordan LO. Today's infantryman. Nat Def Jan:35-40, 1986.

41. Patton J, Kaszuba J, Mello RP, Reynolds KL. Energy cost of prolonged load carriage performance. USARIEM Technical Report (In press), 1990.

42. Saltin B, Costill D. Fluid and electrolyte balance during prolonged exercise. In Horton ES, Terjung RL (Eds) Exercise Nutrition and Energy Metabolism. New York: Macmillan, 1988.

43. Sharky B. Physiology of Fitness. Champaign, IL: Human Kinetic Publishers, 1984.

44. Siitonen L, Sonck T, Janne J. Effect of beta-blockade on performance: use of beta-blockade in bowling and in shooting competitions. J Int Med Res 5:359-366, 1977.

45. Stewart TW, Knowlton DL. Soldier load planning graphic training aid (GTA). Army Development and Employment Agency: Ft Lewis WA, 1987.

46. Strydom NB, Wyndham CH, VanGraan LD, Holdsworth LD, Morrison JF. The influence of water restriction on the performance of men during a prolonged march. S Afr Med J 40:539-544, 1966.

47. Szlyk PC, Hubbard R, Matthews WT. Mechanisms of voluntary dehydration among troops in the field. Milit Med 152:405-407, 1987.

48. Rudzki SJ. Weight load marching as a method of conditioning Australian Army recruits. Milit Med 154:201-205, 1989.

49. Wenger HA, Bell GJ. The interaction of intensity, frequency and duration of exercise training in altering cardiorespiratory fitness. Sports Med 3:346-356, 1986.

50. Wilmore JH, Parr RB, Girandola RN, Ward P, Vodak PA, Barstow TJ, Pipes TV, Romero GT, Leslie P. Physiological alterations consequent to circuit weight training. Med Sci Sports Exerc 10:79-84, 1978.

51. Wilson WJ. Brachial plexus palsy in basic trainees. Milit Med 152:519-522, 1987.

52. Vogel R, Bushner CA. Toughening up the light infantry-a fitness program to prepare today's light fighter. Army Trainer 6:53-55, 1986.

APPENDIX A. INJURY RECORD DATA SHEET

LIGHTENING THE LOAD STUDY, 1989

INJURY RECORD DATA SHEET

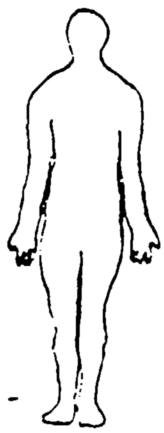
POST-TRAINING

NAME: ____________________ MEDIC'S NAME: ____________

SSN: ________

APPROX. KM OF INJURY: ______ TIME _____:_____ HRS

SITE OF INJURY (CIRCLE)



SIDE (CIRCLE): RIGHT LEFT BACK

SPECIFIC SITE: ______________

TYPE OF INJURY (CHECK ALL WHICH MAY APPLY)

_____: TRAUMATIC (SPRAIN, CONTUSION)
_____: BLISTERS
_____: MUSCLE CRAMPS
_____: HEAT INJURY
_____: COLD INJURY
_____: DEHYDRATION
_____: NONSPECIFIC PAIN
_____: EXCESSIVE FATIGUE
_____: OTHER (EXPLAIN) ______________

SEVERITY OF INJURY

_____: SOLDIER CONTINUED MARCH WITHOUT TREATMENT
_____: SOLDIER CONTINUED MARCH AFTER SOME TREATMENT
_____: SOLDIER REMOVED FROM MARCH

DIAGNOSIS: ______________

TREATMENT: ______________

APPENDIX B .

SORENESS, PAIN AND DISCOMFORT QUESTIONNAIRE

INSTRUCTIONS: RATE THE DEGREE OF SORENESS, PAIN OR DISCOMFORT THAT YOU ARE CURRENTLY FEELING FOR BODY PARTS 1-11. DO SO FOR THE FRONT AND THE BACK OF THE BODY.

NAME: ____________________

SSN: ____________________

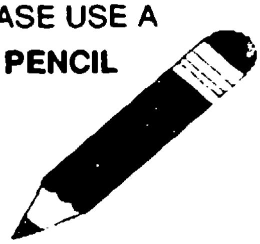
SOLDIER NUMBER: ____________________

FILL IN YOUR NUMBER

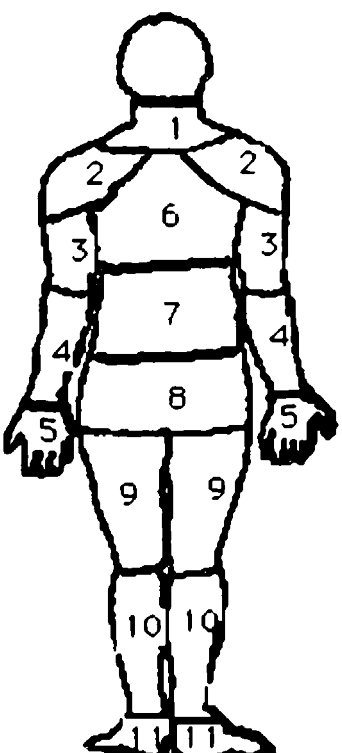
0 1 2 3 4 5 6 7 8 9

PLEASE USE A

#2 PENCIL



Proper Mark



FRONT OF BODY

	1	2	3	4	5	6	7	8	9	10	11
NONE											
MILD											
MODERATE											
SEVERE											

BACK OF BODY

	1	2	3	4	5	6	7	8	9	10	11
NONE											
MILD											
MODERATE											
SEVERE											

APPENDIX C.
RESISTANCE TRAINING EXERCISES

RESISTANCE TRAINING "A"

- Duo Squat (Nautilus)
- Hip Flexor
- Leg or Knee Extension
- Leg or Knee Curls
- Heel Raises
- Double Chest or Bench Press
- Rowing
- Double Shoulder
- Behind Neck
- Neck and Shoulder
- Multi-tricep
- Multi-bicep

RESISTANCE TRAINING "B" (SANDBAG CIRCUIT)

- Squats
- Front Lunge
- Heel Raises
- Dead Lift
- Push-ups
- Sit-ups
- Bent-over Row
- Alternate Overhead Press
- Tricep Extension
- Alternate Bicep Curl

DISTRIBUTION LIST

	NO. OF COPIES
Defense Technical Information Center ATTN:DTIC-DDA Alexendria, VA 22304-6145	2
Commander U.S. Army Medical Research and Development Center SGRD-RMS Ft. Detrick Fredrick, MD 21701-5012	2
Commandant Academy of Health Sciences, U.S. Army ATTN:AHS-CDM Ft. Sam Houston, TX 78234	1
Dir. of Biol. & Med. Sciences Division Office of Naval Research 800 N. Quincy Street Arlington, VA 20014	1
CO, Naval Medical R&D Command National Naval Medical Center Bethesda, MD 20014	1
HQ AFMSC/SGPA Brooks AFB, TX 78235	1
Under Secretary of Defense Research and Engineering ATTN: OUSDRE(RAT) E&LS Washington, DC 20310	1

Dean 2
School of Medicine
Uniformed Services University of Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20014

Assistant Secretary of Defense (Health Affairs) 1
ATTN: ASD(HA) PA&QA
Washington, DC 20310

Assistant Secretary of Defense (Acquisition&Logistics) 1
ATTN: OASD(A&L)SD
Washington, DC 20310

Commander 1
U.S. Army Troop Support Command
ATTN: AMSTR-E
4300 Goodfellow Blvd
St Louis, MO 63120-1798

Commander 1
U.S. Army Operational Test Evaluation Agency
ATTN: CSTE-ZX
5600 Columbia Pike
Falls Church, VA 22041

Commander 1
U.S. Army Training and Doctrine Command
ATTN: ATCD-S
Ft. Monroe, VA 23651

Commander 1
U.S. Army TRADOC Combined Arms Test Activity
ATTN: ATCT-PO
Ft Hood, TX 76544

Commander | 1
U.S. Army Material Command
ATTN: AMCDE-S
Alexandria, VA 22333

Commander | 1
U.S. Army Combined Arms Center
ATTN: ATZL-TAI-C
Ft. Leavenworth, KS 66027-5130

Commander | 1
U.S. Army Natick Research, Development and Engineering Center
Natick, MA 01760-5000

Commandant | 1
U.S. Army Troop Support Agency
Ft Lee, VA 23801

Commander | 2
USA FORSCOM
Pentagon
Washington, DC 20310

Director | 1
HQDA-DASG/PSF
Pentagon
Washington, DC

Director of Physical Education | 2
U.S. Military Academy
West Point, NY 10996

Commander | 1
91st Division (TNG)
Bldg 602
Ft Baker, Sausalito, CA 94965

Commander 2
U.S. Army Infantry School (USAIS)
Light Infantry Task Force
ATTN: ATSH-I-V-LITE
Ft Benning, GA 31905

Commander 2
Individual Soldier and Battle Environment Directorate
Individual Soldier and Equipment Team
ATTN: AMXHE-IS
Aberdeen Proving Ground, MD 21005-5001

Director 2
Army Physical Fitness Research Institute
Army War College
Carlisle, PA 17013

Commander 2
6th Infantry Division (Light)
Ft. Richardson, AK

Commander 2
7th Infantry Division (Light)
Ft. Ord, CA

Commander 2
10th Mountain Division (Light Infantry)
Ft. Drum, NY

Commander 2
25th Infantry Division (Light)
Schofield Barracks, HA

END

FILMED

DATE: 6-90

DTIC