ARMY RESEARCH LABORATORY

The Effects of Encapsulation on Dismounted Warrior Performance

by Lamar Garrett, Nathan Jarboe, Debra J. Patton, and Linda L. Mullins

ARL-TR-3789 **May 2006**

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14. ABSTRACT

This study examined difference effects of encapsulation, treating the assessment from a systems development perspective. The study, in part, sought to develop a systematic and diagnostic method for evaluating the interactions between various key components of the ensemble and *mobility, survivability, and information management technology* (e.g., personal digital assistant). Our purpose is to assess the utility of using standardized facilities and tasks for taking a more integrative, systems approach to Soldier-equipment compatibility. Three configurations (baseline-no encapsulation; current nuclear, biological, and chemical; future land warrior) were tested; dependent measures are discussed in terms of time to complete common Soldier tasks, shooter accuracy, and cognitive workload performance. The thesis was that it is possible, in a field-test environment in which subjects engage in tasks relevant for their operational missions, to conduct such an assessment and, in the end, provide needed insights that can shorten useful development and fielding times for these systems.

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[1]RSK, which is a trademark, stands for Robert S. Kennedy.

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1. Background

Encapsulation is defined as covering or enclosing the human body in such a manner that all skin is protected from exposure to the environment. The U.S. Army has a limited amount of research information and data regarding the performance effects of encapsulation on the dismounted Soldier. Previous research on chemical protective clothing (CPC) focuses on examining the effects of wearing the full CPC ensemble (Headley, Hudgens, & Cunningham, 1997) and Soldier performance of military operational tasks conducted while wearing chemical individual protective equipment (Davis, Wick, Salvi, & Kash, 1990). This type of information is critical to achieving effective mission performance as well as the survivability capabilities of future dismounted Soldiers of the Future Force. Although research has been conducted on individual items of combat equipment and various components of dismounted Soldier systems, very little performance-based research has been performed with the use of a systems approach to validate Soldier-equipment compatibility. For example, the integration of the protective mask, chemical protective clothing (including gloves), boots, and individual combat equipment (i.e., helmet) is required when Soldiers are operating in a suspected contaminated environment (Davis, Wick, Salvi, & Kash, 1990). The protective mask, chemical protective clothing, and the combat helmet were each developed independently of other Soldier systems and therefore require additional evaluation to examine compatibility issues, comfort and Soldier acceptance (Barker & Caretti, 2002).

Subsequently, individual Soldier combat equipment has been developed with a variety of suboptimal solutions. Insufficient integration of such protective equipment has contributed to unnecessary weight and bulk, as well as restriction of movement, visibility, hearing, and haptic perception—all elements detrimental to successful mission completion. The authors stress that the principal concerns expressed by Soldiers wearing various individual combat equipment configurations in the field involve design integration deficiency. This could have a direct impact on mission performance and comfort level (Taylor & Orlansky, 1991). This experiment analyzes encapsulation from a systems development perspective which involves design integration; examining the interactions between various components of the configuration; and mobility, survivability, and information management technology.

The purpose was to assess the utility of using standardized facilities and tasks for taking a more integrative systems approach to Soldier-equipment compatibility of encapsulation systems. The authors wanted to identify problems with a single nuclear-biological-chemical (NBC) system and to compare two or more NBC systems. Three configurations (baseline-no encapsulation; current [NBC]; and future warrior NBC) were evaluated. Dependent measures were time to complete common Soldier tasks, shooting performance, and cognitive workload performance. The research data and methodology analysis will be used to design future warrior performance research and ultimately to help guide the design of future dismounted warrior systems. Here, we examine encapsulation in a field testing environment.

With a system of systems approach, the following were hypothesized for this research experiment:

1. Encapsulation degrades individual performance.
2. As information processing increases, cognitive performance decreases.
3. As the encapsulation configuration's weight is increased, mobility and agility decrease and heat stress increases, leading to degraded mission performance.

2. Objective

The objective of this research was three-fold: (1) to examine the potential effects of encapsulation on mission performance of a dismounted warrior, (2) to determine or select methodologies for further research of encapsulation effects on current and future warrior-era Soldier systems, and (3) to determine the sensitivity of existing methods for measuring dismounted warrior encapsulation effects on mission performance.

3. Participants

3.1 Research Participants

A total of 12 U.S. Army infantry Soldiers participated in this research experiment. The 12 research participants ranged in age from 20 to 35 years (mean = 23.8 years) with 2 to 10 years in service (mean = 3.1 years). All 12 research participants were males with an infantry military occupational specialty (MOS) of 11B. One research participant was unable to participate during the final two days of this experiment, partly because of injury.

Research participants were assembled, assigned a participant number, and given an orientation about the purpose of the investigation and their participation. They were briefed about the objective and procedures for each experimental equipment load configuration that they were required to wear throughout the investigation. They also were told how the test results would be used and the benefits the military could expect from this investigation.

The volunteer agreement affidavit (see appendix A) was explained and its contents were verbally presented as required by 32 Code of Federal Regulations (CFR) 219 and Army Regulation (AR) 70-25. The investigators adhered to the policies for protection of human participants as prescribed in AR 70-25. Afterward, time was taken to address questions from the Soldiers. The Soldiers were then given the volunteer agreement affidavits to read and sign if they decided to volunteer.

In addition, eye examinations were given to each Soldier to measure far visual acuity and color vision. A Titmus[2] vision tester (Model QV-7M) was used to measure acuity (right eye, left eye, and both eyes). Ocular dominance was measured with the unconscious sighting method of Miles (1929, 1930).

The Soldiers completed a health and demographics questionnaire to document information related to medical history and their level of experience wearing protective equipment. After arriving at Aberdeen Proving Ground, Maryland, the investigators asked the Soldiers if any of them had a medical profile or history that jeopardized their safety if they participated in the investigation. Soldiers were also asked to complete the medical status form shown in appendix B. The vision screening, health, and demographics data taken for each Soldier are shown in appendix C.

3.2 Anthropometrics

Trained personnel obtained anthropometrics of each research participant's head, face, neck, and hands. These measurements were made in accordance to those described in the anthropometric measurement handbook (Clauser, Tebbetts, Bradtmiller, McConville, & Gordon, 1988). The measurements were converted to percentile values and compared to those in the 1988 Army Anthropometric Survey (Gordon, Churchill, Clauser, Bradtmiller, McConville, Tebbetts, & Walker, 1989). The anthropometric data taken for each Soldier are shown in appendix D.

4. Mobility, Portability, and Shooting Performance Investigation

4.1 Secondary Objective

The objectives of this experiment were to

1. Determine the compatibility of encapsulation configurations in relation to Soldiers' clothing and equipment.
2. Determine the impact of encapsulation on individual performance during mobility and portability maneuvers.
3. Investigate the ability of Soldiers to process information during movement.
4. Determine if encapsulation adversely affects individual shooting performance.
5. Assess methods for measuring effects of encapsulation on dismounted warrior mission performance.

[2]Titmus is a registered trademark of Titmus Optical.

6. Assess the stress perceptions of Soldiers and evaluate aspects of short-term memory during encapsulation.

4.2 Instruments and Apparatus

4.2.1 Equipment Compatibility Assessment Questionnaires and Interviews

To assess compatibility, questionnaires were given to each participant to complete after each daily trial and at the conclusion of the investigation. The questionnaires allowed the participants to rate the compatibility of the three equipment configurations pertaining to the mobility and portability course, cross-country course, shooting performance research facility, and an overall completion questionnaire. These are shown in appendix F. Questionnaires were designed to solicit the participants' opinions about their experiences in using the equipment configurations. The questionnaires contain 4-, 5-, and 6-point rating scales. Examples of the Equipment Compatibility Questionnaire are (1) "Overall, the fit of the equipment condition item was" and (2) "Depth perception while wearing the mask." The research participants also completed an exit interview at the end of the investigation. During this interview, the participants commented about the positive and negative aspects of each equipment configuration.

4.2.2 Cross-Country Course

The length of the cross-country course is 4 kilometers (km) (see figure 1). The course consisted of two segments along a path through the woods forming a loop and divided by a mid-point. Each segment of the course was approximately 2 km long. The terrain consisted of a path that is unobstructed in places but elsewhere crosses marshes, thick foliage, and fallen trees. The terrain is generally flat.

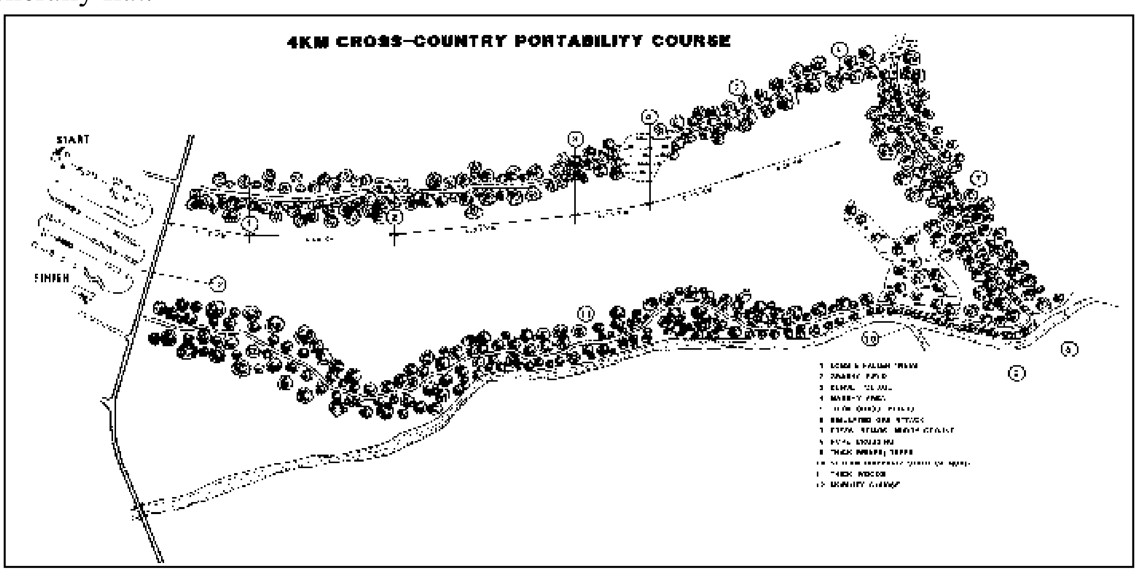

Figure 1. Wirsing cross-country course.

The course is designed to give research participants a chance to evaluate the comfort and utility of test loads, clothing, and equipment while they march at a moderate pace over natural terrain. Additionally, the cross-country course can disclose problems involving loads, which would not appear during a march over open terrain.

To assess the effects of encapsulation on situational awareness during movement along the cross-country course, a target detection task was used. It consisted of wooden silhouette targets, which could be placed at 24 general locations along the course. At each location, a target could be placed 30 meters to the left, 15 meters to the left, 15 meters to the right, or 30 meters to the right. The targets were counterbalanced from left to right at 15- and 30-meter intervals from the center of the course path and were spaced 80 meters apart over the length of the course. The target location was changed for each mission to minimize learning effects. The targets were presented visually using a target density of eight targets during the first three days and 16 targets during the last three days of the investigation. The performance measure for situational awareness is the number of targets detected.

To assess the effects of encapsulation on hearing and verbal comprehension during movement along the cross-country course, radio call signs were presented aurally to the participants throughout the duration of their movement along the 4-km cross-country course. These call signs came from the 66-item version of the Call Sign Acquisition Test (CAT). The CAT was developed by the U.S. Army Research Laboratory (ARL) to evaluate speech recognition with military relevant vocals (Rao & Letowski, 2003).

These call signs were two-part alphanumeric words. The first portion of the word was the military designation of a letter from among 11 possibilities. The second part was a number from a list of six (e.g., bravo-six, victor-three). Table 1 shows the 11 alpha and six numeric possibilities. All 66 combinations of alpha and numeric were used. The order of the 66 call signs was randomized and the time between call signs was randomized following a uniform distribution with a range of 20 to 40 seconds. After all 66 call signs were used, the list was repeated (in a different random order), for a total of 132 possible stimuli and responses. The total running time of the player was about 1 hour and 15 minutes. The research participants were instructed to listen for the call signs during their cross-country movement and, if they heard one, to repeat aloud what they thought they heard without interrupting their current activity. The digital audio recorders, described in the next paragraph, recorded these repetitions. The performance measure is the number of correct answers. Each call sign consists of one alpha item followed by one numeric item (refer to table 1).

Table 1. Eleven alpha and six numeric possibilities for call sign composition.

Alpha		Numeric
Alpha	Kilo	One
Bravo	Papa	Two
Charlie	Quebec	Three
Delta	Tango	Four
Echo	Victor	Five
Hotel		Eight

We used the following equipment to present call signs to and record responses from participants. The research participants were each outfitted with an MP3 digital audio player with built-in loudspeakers and an MP3 digital audio recorder with a microphone. The digital audio player was attached to the back of the participant's equipment, approximately 6 inches below the base of his neck. A powered microphone was attached to the front of the participant in the lapel area. For participants who were encapsulated, the microphone was located on the side opposite the mask's canister. For the baseline configuration (non-mask-wearers), the microphone was located on either side. The microphone was plugged into the recorder, which was stowed where convenient for the particular configuration; some sites used were the upper arm pocket, the first-aid pouch on the load-bearing equipment, and the mask carrier. The location of the recorder was not important as long as it was not in the way of the participant. The cable from the microphone to the recorder was taped to the equipment and run under the configuration so that it did not interfere with the participant tasks. Figure 2 shows a typical equipment placement for both the front (microphone) and back (player). The performance measure was the total number of correct responses.

Figure 2. MP3 digital audio player with built-in loudspeaker.

The research participants were instructed to listen for the call signs during their cross-country movement and, if they heard one, to repeat aloud what they thought they heard without interrupting their current activity. The digital voice recorders recorded these repetitions. After the completion of the experiment, the recordings were analyzed to determine what the response (if any) of the participant was to each speech stimulus.

4.2.3 500-meter Obstacle Course

The obstacle course comprises two running lanes, consisting of 20 individual obstacle events spread over a serpentine course approximately 500 meters long. Thirteen of the obstacles are equipped with electronic pressure pads so the research participants' beginning and ending times are recorded (see figure 3). A data acquisition system receives signals from the pads and computes total course and individual obstacle times. The course design requires Soldiers to alternate between load carriage methods to negotiate the various obstacles (i.e., switch from shoulder slung carry to hand carry, etc.). The course design employs most, if not all, of the research participants' muscle groups while managing the load being carried from varying body postures. The course exposed the research participants to the kinds of maneuvers they can expect to perform while executing an assault mission in combat, such as running, jumping, climbing, crawling, balancing, and negotiating buildings, stairs, and windows.

Figure 3. 500-meter mobility-portability course.

Individual performance measures enable experimenters to monitor participant consistency and to collect data to discriminate differences between various systems, load configurations, or both. If the item(s) the research participants are wearing or carrying are incompatible with their clothing, their equipment, or themselves, the problems will be most noticeable when negotiating the course. Another characteristic intrinsic with the variety of obstacles is its suitability to estimate the ruggedness of individual clothing, equipment, and man-portable weapon systems. The performance measure was time to complete course.

4.2.4 Grenade Throw

The grenade throw pit is a circular area 15 meters in diameter with a pole as a marker in the center of the pit. A log is placed 35 meters away from the center of the pit (see figure 4). Research participants are required to kneel behind the log and throw an inert grenade as close as they can to the center of the pit. The distance from the grenade to the marker is measured and recorded for each trial.

Figure 4. Grenade throw.

4.2.5 Individual Movement Technique (IMT) Course

The IMT course is laid out in an open field adjacent to the mobility-portability course. The course is 100 meters long with a log placed every 16 feet. When research participants ran the course, they were required to run to every other log and drop to a prone firing position behind it. Research participants alternated moving between positions, while their team member provided covering fire during movement (see figure 5). The time to complete the course was measured for each research participant.

Figure 5. Individual movement technique course.

4.2.6 Sandbag Carrying Course

The sandbag carry course is laid out with two 30.48-cm (12-in.) high platforms set 13.7 meters (45 feet) apart. On one of the platforms are 18 sandbags (six across stacked three high). Each sandbag weighs approximately 18.2 kg. The research participants were required to move the sandbags from one platform to another and stack them (see figure 6). The performance measure is time to complete this task. Research participants were instructed on the correct method of lifting and carrying the sandbags.

Figure 6. Sandbag carry.

4.2.7 Rifle Disassembly and Reassembly (M16A2) Exercise

Research participants performed a rifle disassembly and reassembly trial, consisting of assembly and disassembly of a small arms rifle to measure the participant's dexterity in a field environment (see figure 7). The experimenters used a stopwatch to record the participants' time to complete the disassembly and reassembly trials.

Figure 7. Rifle disassembly and reassembly (M16A2).

4.2.8 Road March

All research participants conducted a 1-mile tactical road march along a specified route, from the mobility-portability course to the shooting performance research facility. The course was designed to give research participants a chance to evaluate the comfort and utility of test loads, clothing, and equipment, while marching at a moderate pace over open terrain. The time to complete the march was the performance measure (see figure 8).

Figure 8. Road march.

4.2.9 Shooting Performance Facility (M-Range)

M-range is an outdoor small arms research facility that is subdivided into four firing lanes (A, B, C, and D lanes). Each lane is designed to present targets to a single shooter, located at a fixed firing position, at ranges of 50, 75, 100, 150, 200, 250, 300, 400, 500, and 550 meters, (for this particular study, no targets were engaged beyond 200 meters). The range is designed with four identical firing lanes with a firing station for each lane. The range also has a center firing position which is used for firing over more than one lane. For this study, all lanes were used; the shooter operated from a center firing position with the wide field of view (FOV) afforded by the position (see figure 9).

Figure 9. ARL’s shooting performance research facility (M-range).

The targets used at M-Range are olive drab (O.D.) “E” type silhouette targets. Targets contain foam inserts sandwiched between two thin sheets of aluminum. The aluminum sheets are wired to electronic sensors. These targets are attached to target-holding mechanisms, which are in turn wired to a command and control center containing a computer-linked target controller. The target controller and software are capable of presenting an array of targets on each lane programmed in any sequence and for any time interval, as well as recording the results.

Hits are registered when a copper-jacketed projectile pierces the front aluminum sheet, passes through the foam, and touches the rear aluminum sheet, completing the circuit between the two sheets. When the circuit is completed, the system electronically registers and records a hit and simultaneously lowers the target. The equipment is capable of electronically recording shooter identification, target range, target exposure time, time to fire each round, number of rounds fired, which round hit the target, and total number of targets hit. All targets were presented for

5 seconds with a 3-second interval between target exposures. The performance measure was time to first shot, number of hits, and the number of shots per target.

Soldiers fired M4 carbines from a central location on the firing range, centered among the four firing lanes. The center firing position was used so that targets could be presented across the entire range. Using the whole range offered targets at a wider FOV than any one of the four lanes alone could provide. This four-lane method helped assure that if there were any differences among configurations with respect to FOV, these differences would become apparent with targets presented at increasingly wider FOVs.

4.2.10 Distance of Target

Figure 10 refers to the overhead view of ARL's shooting performance research facility (SPRF), which was divided into three sections by range. The targets were presented at various ranges in section 1, from 50 to 90 meters, in section 2 from 90 to 140 meters, and in section three from 140 to 200 meters. Within a firing lane at any specified distance (e.g., 100 meters), the left target is at 95 meters, the center target is at 100 meters, and the right target is at 105 meters. When participants are firing from the center firing position while engaging targets in all four firing lanes, the actual distance varies (refer to figure 10).

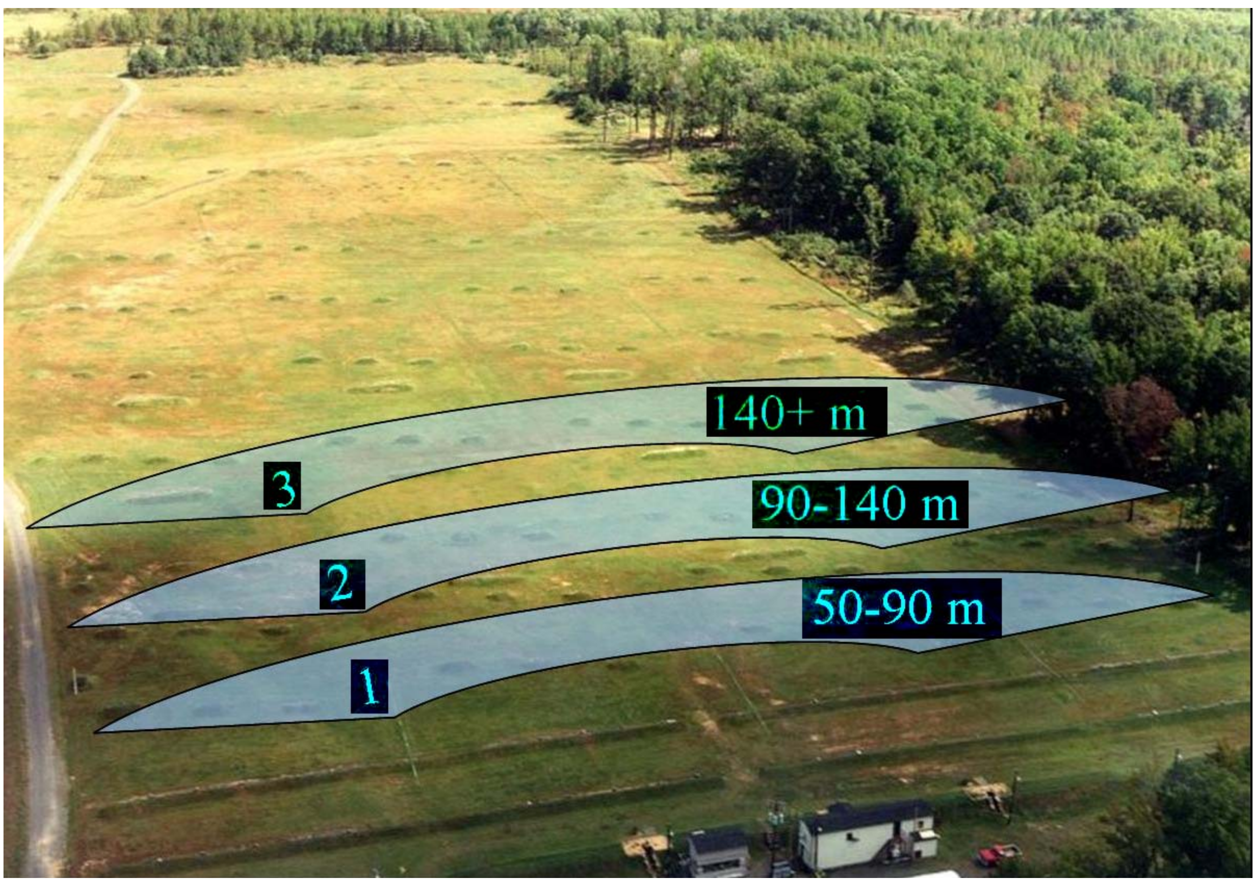

Figure 10. Overhead view of ARL's SPRF that has been divided into three sections by range.

4.2.11 Angle of Target Away from Centerline

Figure 11 refers to the target presentations divided into four 25-degree regions. Target presentations were divided into specific portions and evaluated by range.

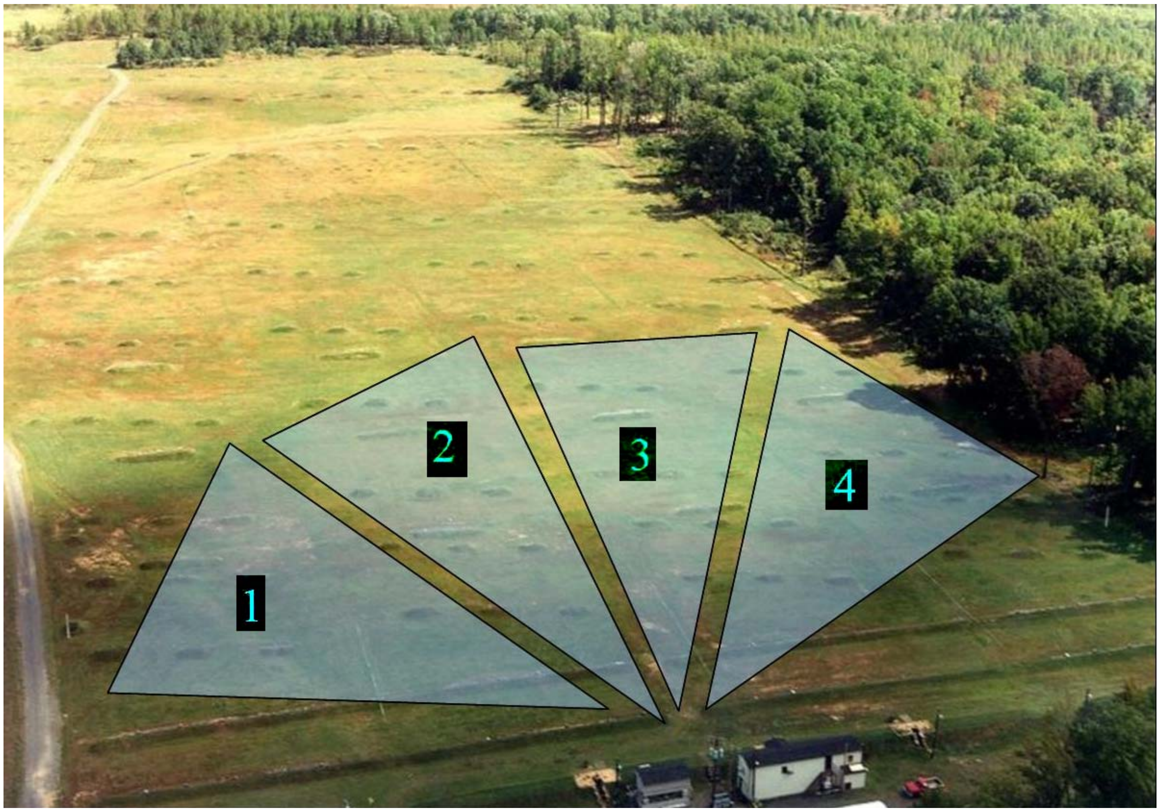

Figure 11. Shooting range evaluated as four separate angle sections.

4.2.12 Range and Angle Effects Merged

Figure 12 refers to the firing range being divided into 12 sections by range and by angle (arrow indicate firing position). The term “range” indicates actual line-of-sight distance to the target, and “angle” designates the angle, measured in degrees, that targets were presented away from the firing range centerline.

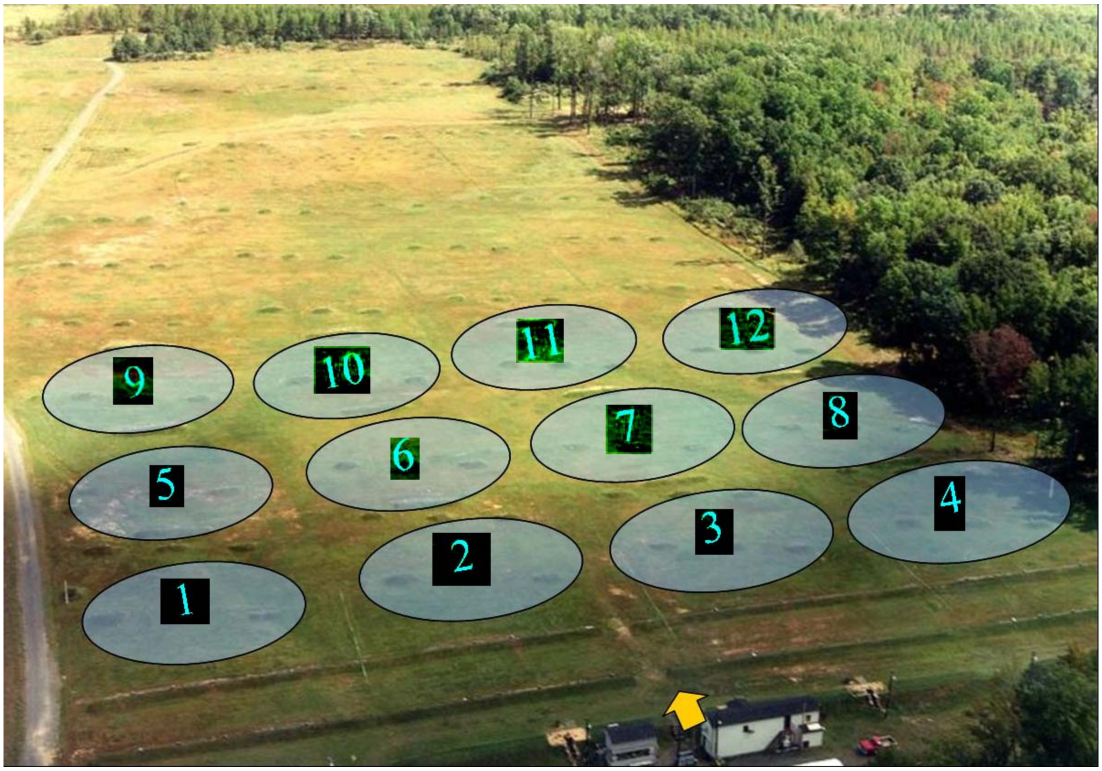

Figure 12. Firing range analyzed in 12 sections by range and by angle. (Arrow indicates firing position.)

4.2.13 Psychological Stress Measures

Stress was assessed using the Multiple Affect Adjective Check List-Revised (MAACL-R) (Lubin & Zuckerman, 1999), the Subjective Stress Scale (SUBJ) (Kerle & Bialek, 1958), and the Specific Ratings of Events Scale (SRE) (Fatkin, King, & Hudgens, 1990). This group of questionnaires was administered to the research participants. This battery, which has been used in previous ARL research investigations, has been proven sensitive to the degree of stress experienced in a variety of situations and includes standardized measures that have demonstrated construct validity within the stress research literature (Fatkin, King, & Hudgens, 1990; Hudgens, Malkin, & Fatkin, 1992; Blewett, Redmond, Fatkin, Popp, & Rice, 1995; Fatkin & Hudgens, 1994; Fatkin, Knapik, Patton, Mullins, Treadwell, & Swann, 2002; Fatkin, Hudgens, Chatterton, Patton, & Mullins, 1996).

4.2.13.1 Multiple Affect Adjective Check List-Revised (MAACL-R)

The MAACL-R (Lubin & Zuckerman, 1999) was administered to assess individual stress perceptions. It consists of five primary sub-scales (Anxiety [sense of uncertainty], Depression [sense of failure], Hostility [sense of frustration], Positive Affect [sense of well-being], and Sensation Seeking [vigor]) derived from a one-page list of 132 adjectives. A sixth sub-scale, Dysphoria (negative affect), is an overall distress score and is calculated from the Anxiety, Depression, and Hostility scores.

The form was easily administered, completed within 1 to 2 minutes, and provided critical information regarding the dynamics of the stress experienced by the respondents. Each sub-scale score indicated the level or intensity of the stress response, as well as the primary stress components contributing to that response. This provides information about the specific stress components at work and assists in a more appropriate assignment of effective countermeasures needed to potentially enhance performance.

4.2.13.2 Subjective Stress Scale (SUBJ)

The SUBJ (Kerle & Bialek, 1958) detects significant affective changes in stressful conditions. The Soldiers were instructed to select one word from a list of 15 adjectives that best described how they "feel right now" and later "how they felt" during a specific time point during the study. This form was administered in conjunction with the MAACL-R and the SRE. It took less than 1 minute to administer.

4.2.13.3 Specific Rating of Events (SRE)

The SRE scale (Fatkin, King, & Hudgens, 1990) allows participants to rate (on a scale of 0 to 100) how much stress they have experienced during a specific period of time during the study. This form was administered in conjunction with the MAACL-R and the Subjective Stress Scale. It took less than 1 minute to administer.

4.2.13.4 Situational Self-Efficacy (SSE) Scale

The SSE (Bandura, 1977) was administered to evaluate the predictive power of efficacy expectations about behavior or task performance. Participants were asked to rate (from 1 to 10) their level of confidence in their ability to do well. There is extensive evidence that self-efficacy is associated with higher levels of motivation and performance for both civilian and military populations (Fatkin, 1998; Fatkin & Hudgens, 1994).

4.2.14 Cognitive Performance Assessment for Stress and Endurance (CPASE)

Cognitive performance was assessed with the 6-minute CPASE which examines aspects of short-term memory, logical reasoning, mathematical calculation and perception, and spatial processing functioning.

This assessment was administered as a test booklet, containing five timed tests: Verbal Memory (1 minute experiment, 1 minute recall), Logical Reasoning (1 minute), Addition (30 seconds), Addition with a Constant (30 seconds), and Spatial Manipulation (2 minutes). Each participant had two practice sessions to become familiar with the test battery and to decrease influences of the learning effect (Baddeley, 1968).

4.2.14.1 Verbal Memory

Short-term memory is tested with lists taken from a word usage text (Thorndike & Lorge, 1944). Each list consists of 12 one- or two-syllable words with the most common usage rating (100 or more per million). Research participants have 1 minute to study the list and 1 minute for recall.

4.2.14.2 Logical Reasoning

This reasoning test evaluated the research participants' understanding of grammatical transformations on sentences of various levels of syntactic complexity (Baddeley, 1968). Each item consists of a true/false statement such as 'A follows B----AB' (false) or 'B precedes A----BA' (true). The tests were balanced for the following conditions: positive versus negative, active versus passive, proceeds versus follows, order of statement letter presentation, and order of letters in letter pair (equivalent to balancing for true/false). Letter pairs are selected to minimize acoustic and verbal confusion. Research participants have 1 minute to complete as many of the 32 items as possible.

4.2.14.3 Addition and Addition with a Constant

This task, adapted from Williams and Lubin (1967), is used to test working memory. Each item consists of a pair of three-digit numbers that were selected from a random number table. The task is participant paced. Research participants have 30 seconds to complete as many of the 15 problems as possible. Addition with a constant is set up in the same manner as addition except that research participants are required to add a constant of seven to the sum.

4.2.14.4 Spatial Manipulation

Spatial skills are tested with a mental Manipulation task adapted from Shepherd's work (1978). A six-by-six grid is enclosed within a hexagon measuring 2.8 centimeters. Areas of the grid are filled to create random patterns. To the right of each test pattern are three similar patterns. One of the three patterns is identical to the test pattern except that it has been rotated. The task is to select the rotated pattern. Each test consists of 18 items balanced for the number of grids filled (7, 9, or 11), pattern density (adjacent blocks filled versus one break between pattern blocks), and Manipulation of the correct answer (90, 180, 270 degrees). Research participants have 2 minutes to complete as many items as possible.

4.3 Procedures

4.3.1 Familiarization

During the first day, the Soldiers were administered a series of pre-trial cognitive battery tests and were taken on a familiarization march through the cross-country and obstacle courses. During this time, a demonstration was conducted to illustrate the proper procedures on how to safely negotiate the obstacles. After the initial march, each research participant practiced negotiating the obstacle course twice in all three conditions.

4.3.2 Training

Before training on day 1, stress perception and cognitive performance measures were administered to familiarize the Soldier with the procedures to be followed in the collection of these data during the test period and to obtain baseline measures. All participants then were given two practice sessions for the CPASE. They were allowed to ask questions as often as needed during these practice periods. Each practice period was separated by 45 minutes. The Soldiers participated in training (mobility, portability, and live firing) during the second and third days of the investigation. Research participants were administered before, during, and after cognitive battery tests. The participants negotiated the cross-country course, obstacle course, threw hand grenades, performed IMT, carried sandbags, performed the road march, and conducted live fire exercises daily.

4.3.3 Testing

4.3.3.1 Mobility, Portability, and Shooting Performance Scenario

The participants received a briefing about the mobility, portability, and shooting performance scenario (see table 2). This scenario was repeated over the course of 6 days. The time for each Soldier to complete the courses and events (see figure 13) and any human factors and compatibility issues observed, were recorded.

Table 2. Research participant mobility, portability, and shooting performance scenarios.

a. Research participants arrived at test site in morning.
b. Research participants were administered a pre-trial cognitive and stress battery test.
c. Research participants negotiated the cross-country course in assigned equipment configuration.
d. When research participants arrived at midpoint of cross-country course, an experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
e. Research participants completed the second half of the cross-country course. Experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
f. Research participants were given a 10-minute rest period to adjust equipment load for obstacle course.
g. Research participants were administered a cognitive and stress battery test (during); in addition to the measures above, equipment compatibility questionnaires and interviews were used.
h. Research participants negotiated obstacle course, and when finished, were administered a cognitive and stress battery test (during).
i. Research participants conducted a grenade throw to measure distance and accuracy while kneeling.
j. Research participants completed grenade throw. Experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
k. Research participants conducted individual movement techniques from a pre-determined distance (40 meters). Experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
l. Research participants conducted sandbag carry to measure time to complete course. Experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
m. Research participants conducted road march from known distance mobility-portability course to shooting performance research facility.
n. Research participants completed road march. Experimenter(s) inspected all equipment. Shortcomings or failures observed by research participants or experimenter(s) were noted.
o. Research participants conducted small arms live fire exercise, (Two 18 target training scenario) pre- and post-firing audiogram.
p. Research participants were administered a cognitive and stress battery test (post).
q. Research participants conducted small arms field strip exercise (time to disassemble and reassemble an M16A2 rifle).
r. Research participants completed questionnaires, were transported back to the mobility-portability course, and participated in debriefing.

The schedule, by day for each research participant to complete the scenario is shown in figure 13. Performance measures along with any human factors and compatibility issues were recorded.

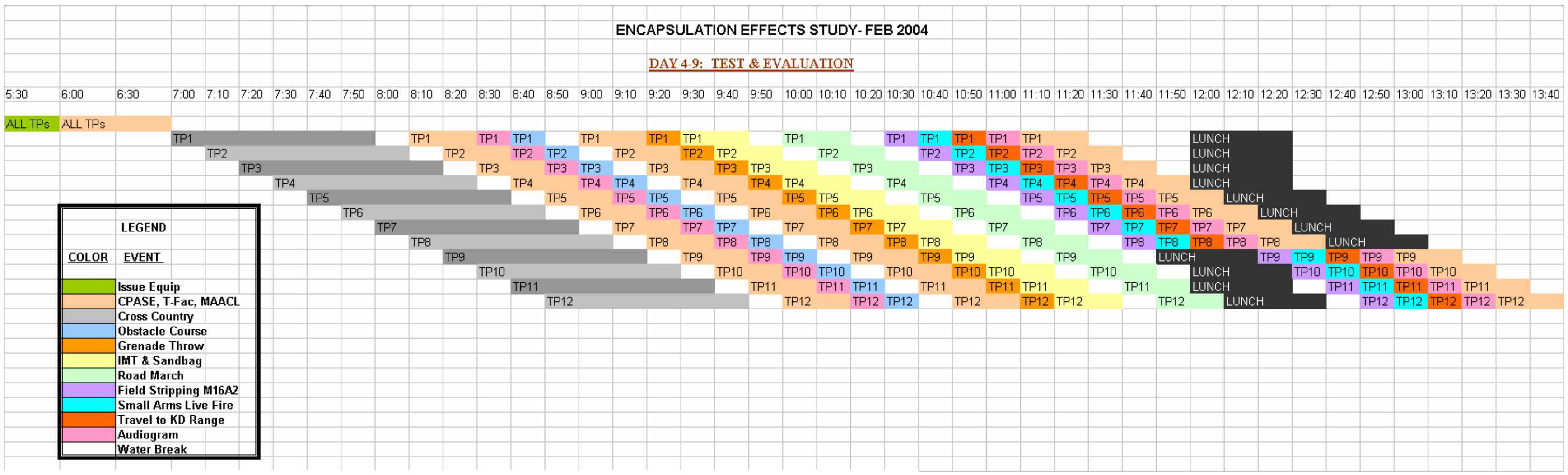

Figure 13. Research events schedule. (TP stands for test participant.)

Table 3. Experimental condition matrix.

Conditions	Configuration
A	Base Line
B	Current (NBC)
C	Future Warrior

Table 4. Presentation order.

Research Participants	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
1	A	B	C	A	B	C
2	B	C	A	B	C	A
3	C	A	B	C	A	B
4	B	A	C	B	A	C
5	C	B	A	C	B	A
6	A	C	B	A	C	B
7	A	B	C	A	B	C
8	B	C	A	B	C	A
9	C	A	B	C	A	B
10	B	A	C	B	A	C
11	C	B	A	C	B	A
12	A	C	B	A	C	B

4.4.1 Independent Variables

The independent variables for the mobility, portability, and shooting tasks were the equipment configurations (conditions A, B, and C). All research participants wore the standard battle dress uniform (BDU). In addition, three configurations (baseline-no encapsulation; current NBC; future warrior) were evaluated (see figure 14). Refer to appendix E for the "total fighting load," including a weighted mock-up of his individual weapon (M4 carbine inert dummy rifle). The independent variables for the stress and cognitive performance were the equipment configurations (conditions A, B, and C), replications (time 1 and time 2), and session (before and after the cross-country course, after the obstacle course, and after live fire).

Figure 14. Equipment configurations (from left to right: the baseline, the current [NBC] and future warrior equipment configurations).

4.4.2 Dependent Variables

The dependent variables for the stress assessment are the six MAACL-R scales, the SUBJ scale, and the SRE scale.

The dependent variables (as described in table 5) are time to complete the obstacle course, time to complete the cross-country course, targets detection rate and percentage, CAT, IMT course times, sandbag task times, accuracy and distance measures for the grenade throw, disassembly and reassembly of weapon (M16A2), shooting accuracy, time to first shot, number of shots per target, subjective questionnaire responses, debriefing comments, and human factors observations.

Table 5. Dependent variables.

Activity	**Data Collected**
Obstacle course	Time to complete course, participant comments and experimenter observations
Cross-country course Target detection CAT	Number of targets identified and reported, time to complete, and CAT, participant comments and experimenter observations
Grenade Throw	Distance from target, participant comments and experimenter observations
IMT	Time to complete, participant comments and experimenter observations
Sandbag carry course	Time to complete, participant comments and experimenter observations
One-mile road march to M-range	Time to complete, participant comments and experimenter observations
Disassembly and reassembly of weapon (M16A2)	Time to complete, participant comments and experimenter observations
Small arms live fire	Shooting accuracy (hit or miss), time until first shot, number of shots per target, questionnaire data, participant comments and experimenter observations

5. Results and Discussion

5.1 Equipment Compatibility Assessment Questionnaires and Interviews

Means and standard deviations were computed from the questionnaire data for each of the three rated categories by each equipment configuration. These data are shown in appendix F. Soldiers' suggestions and exit interview comments are summarized in appendices G and H. Based on the results of the mixed linear model analysis, research participants had a difficult time seeing the obstacles in each of the configurations. Observations and participants comments about the current configuration B (NBC chemical protective suit) were similar to those made during previous field studies (Caretti & Barker, 2002). First, the chemical suit made the participant feel enclosed and hot, and the protective mask provided limited visibility. During this investigation, the participants commented that the total weight and total weight distribution associated with Future Warrior configuration C hindered their ability to maneuver comfortably and safely in and around obstacles. The research participants reported problems with heat stress and fatigue. It was noted that at least one research participant experienced a problem with claustrophobia during this study.

5.2 Mobility and Portability Performance

The total time data for the obstacle course, cross-country course, target detection, grenade throw, IMT, sandbag carry, road march, M16A2 disassembly and reassembly were subjected to a mixed model ANOVA. Additionally, the percent of correct identification for the CAT and the target detection test, which were conducted while the Soldier completed the cross-country course, were subjected to a mixed model ANOVA. *Post hoc* tests were conducted with the use of the least significant difference (LSD) method. The results for these analyses, F-tests, and the means for the different dependent variables for each equipment configuration are shown in figures 15 through 24.

The analyses indicate that there were statistically significant differences between encapsulation load configurations for the cross-country course, obstacle course time, sandbag carry time, and the IMT time. The analyses also indicated that research participants wearing Future Warrior equipment configuration negotiated the cross-country course trial ($F = 21.49$, $p < .001$) and obstacle courses trial ($F = 50.57$, $p < .001$) significantly more slowly than they did in the current encapsulation configuration. The experimenters believe that the reason for the difference between encapsulation configurations was attributed to heat stress, fatigue, and the total weight and total weight distribution between configurations.

5.2.1 Obstacle Course

The average time to complete the obstacle course for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 15. The results of the mixed linear model analysis revealed significantly shorter times to complete the course with the baseline configuration than either the current or Future Warrior systems; additionally, analysis indicated significant differences between the current and future systems, so that the current system resulted in shorter times than the Future Warrior system.

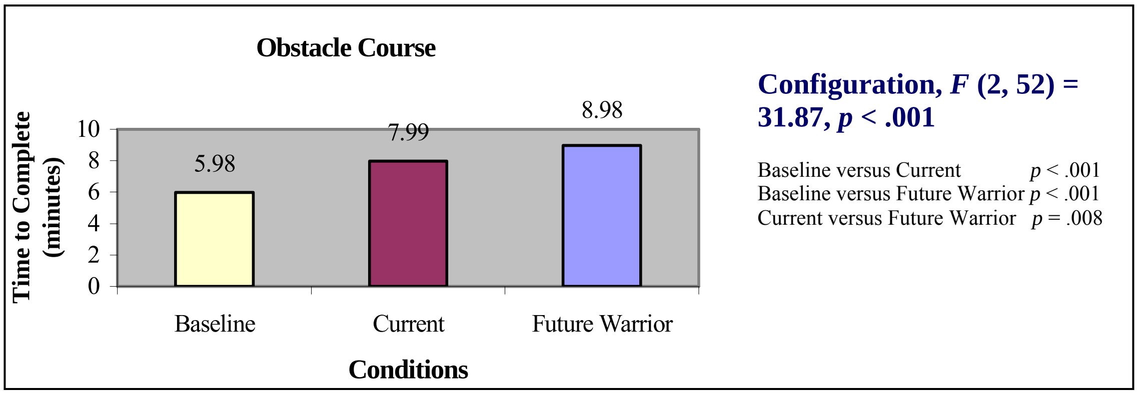

Figure 15. Time to complete obstacle course.

5.2.2 Cross-Country Course

The average time to complete the cross-country course for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 16. As expected, participants required significantly shorter times to complete the cross-country course with the baseline configuration than with either the current or Future Warrior system. Additionally, a significant difference was found in completion times between the current configuration and the Future Warrior system.

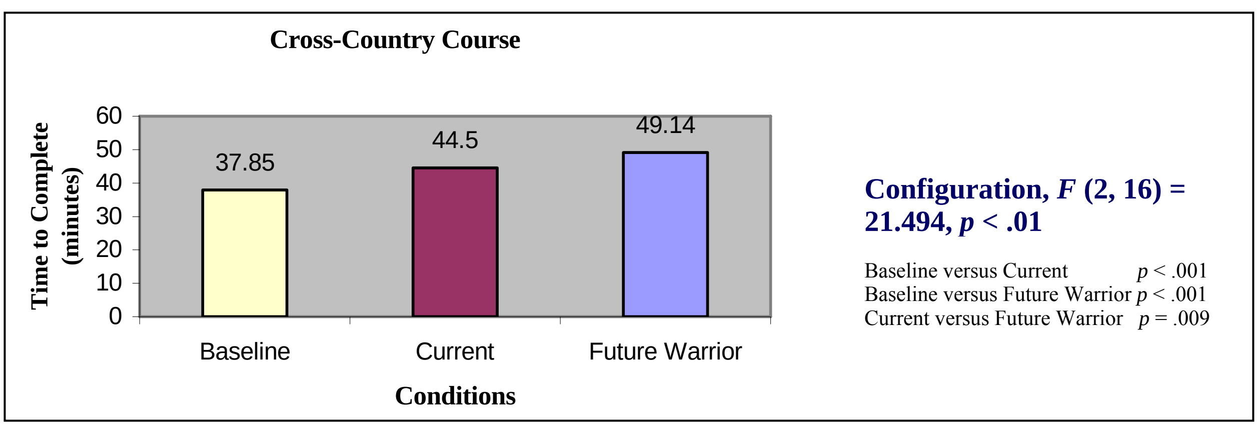

Figure 16. Time to complete cross-country course.

5.2.3 Target Detection

Mixed linear model analysis was applied to the target detection data. There was no main effect for density. There were no main or interaction effects for the equipment configurations. Results showed a significant Density x Distance interaction F (1, 67) = 4.47, p < .038 and main effect of distance F (1, 67) = 48.16, p < .001. Figure 17 provides the mean target detection percentage between the low and high density groups. To explain this interaction, mixed model analyses were applied to the data of each target density group separately. For the low density group, there was a difference between distance F (1,70) = 24.30, p < .00 in the percentage of target detected. For the high density group, there was a difference between distance F (1,70) = 24.30, p < .00 in the percentage of target detected F (1, 64) = 8.25 p < .00.

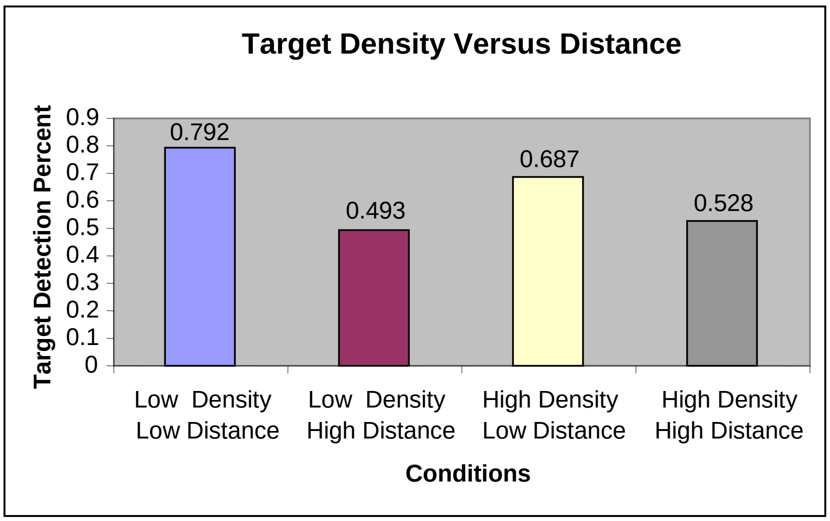

Figure 17. Target detection percentage.

5.2.4 Call Sign Acquisition Test (CAT)

Of 72 possible data sets (12 Soldiers x 6 experimental days), 61 usable sets were recorded. One participant was essentially unintelligible on the recordings because of volume (he spoke extremely quietly), speed of his response (he spoke very rapidly), and slurring or chopping of his speech sounds. All six of his data sets were unusable. One participant quit after four days because of injury; therefore, two days' data were not collected for him. Finally, three data sets were lost to equipment malfunction or possible experimenter error.

By examining the descriptive statistics, we determined that there was great variability in the data collected for all participants. However, when the data were aggregated, a pattern did emerge. Figure 18 shows the percent of detections and the percent of correct responses for all participants by equipment configuration. A "detection" is defined as the participant verbally responding to a stimulus, either with the correct call sign, a partially correct call sign (alpha correct but not numeric, or vice versa), or with a response such as "I don't know" or "something" that clearly indicates he heard the stimulus, although not well enough to even guess which one it was. A "correct identification" occurred when the participant responded with the correct call sign (both alpha and numeric).

The results clearly indicate that the baseline configuration (no encapsulation) yielded the greatest number of correct identifications, as expected. The speech identification scores were significantly higher than the respective scores obtained with the two encapsulated configurations. There were no significant differences in score between the current and Future Warrior systems.

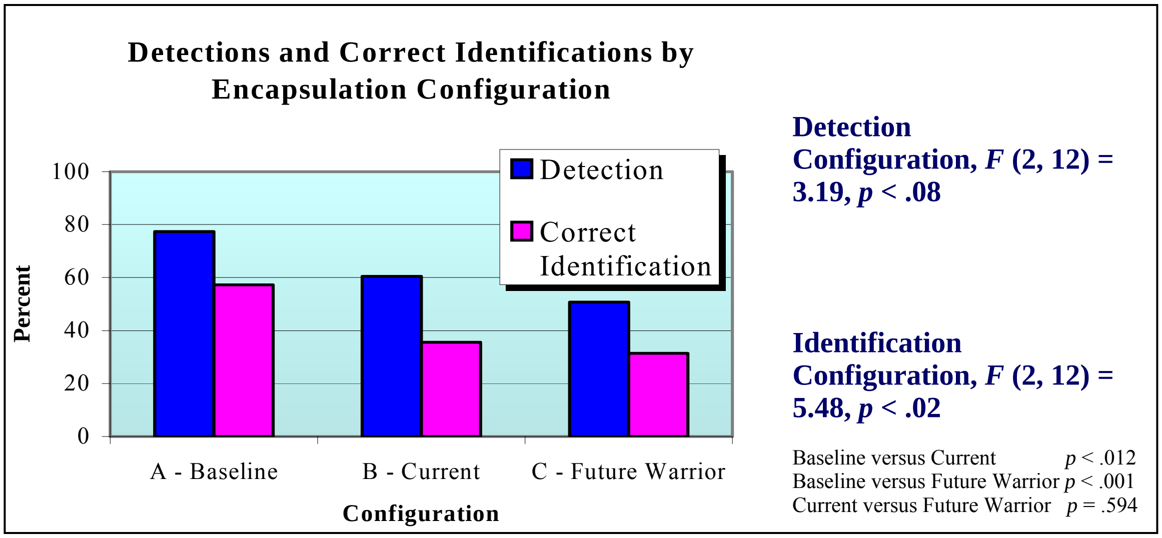

Figure 18. Percentage of detections and correct responses to items from CAT test.

The results of the ANOVA show that the type of configuration used by the Soldier has a significant effect on identification performance. To determine exactly where significant results were arising, pairwise t-tests were performed on the difference in mean proportion correct scores for each pair of configurations; i.e., baseline versus current, baseline versus future warrior, and current versus future warrior. The *t* statistics show that there is a significant difference between the performances in configuration A (baseline) versus configuration B (current) and in configuration A (baseline) versus configuration C (future warrior), but no significant difference between performances in the current versus the future warrior configurations. In other words, configurations that included encapsulation yielded approximately equal results and were significantly worse than the baseline configuration.

5.2.5 Grenade Throw

The average time to complete the grenade throw for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 19. There were no significant differences between the baseline, current, and Future Warrior systems.

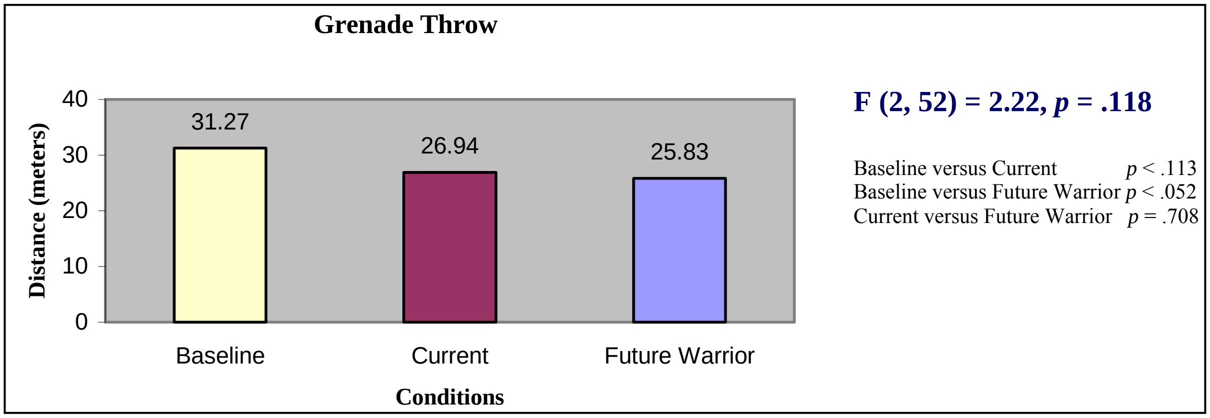

Figure 19. Distance measured in meters of grenade throw.

5.2.6 Individual Movement Techniques (IMT) Course

The average time to complete the IMT course for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 20. The results of the mixed linear model analysis revealed significantly shorter times to complete the IMT course in the baseline configuration, than with either the current or Future Warrior system; there was no significant difference between current and Future Warrior systems.

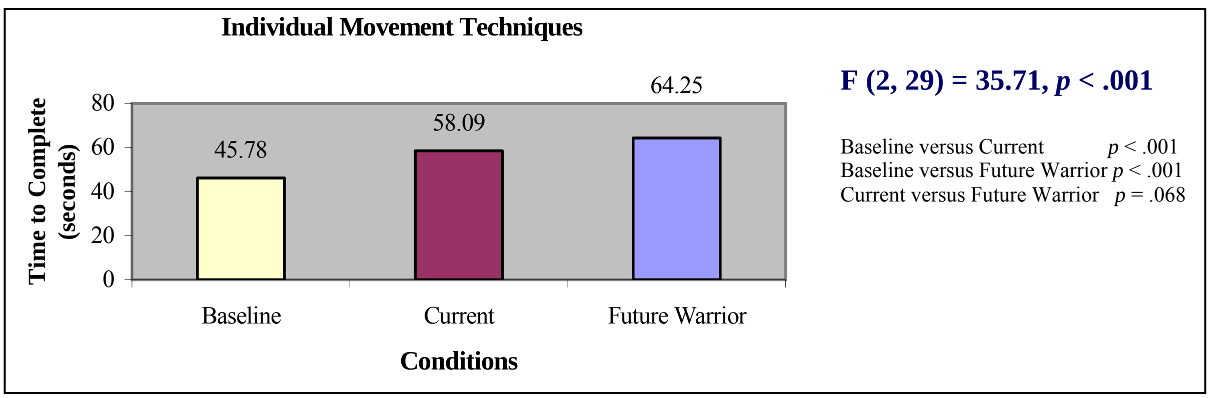

Figure 20. Time to complete IMT course.

5.2.7 Sandbag Carry Course

The average time to complete the sandbag carry course for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 21. The results of the mixed linear model analysis revealed significantly shorter times to complete the course with the baseline configuration than with either the current or Future Warrior systems; additionally, analysis indicated differences between current and Future Warrior systems.

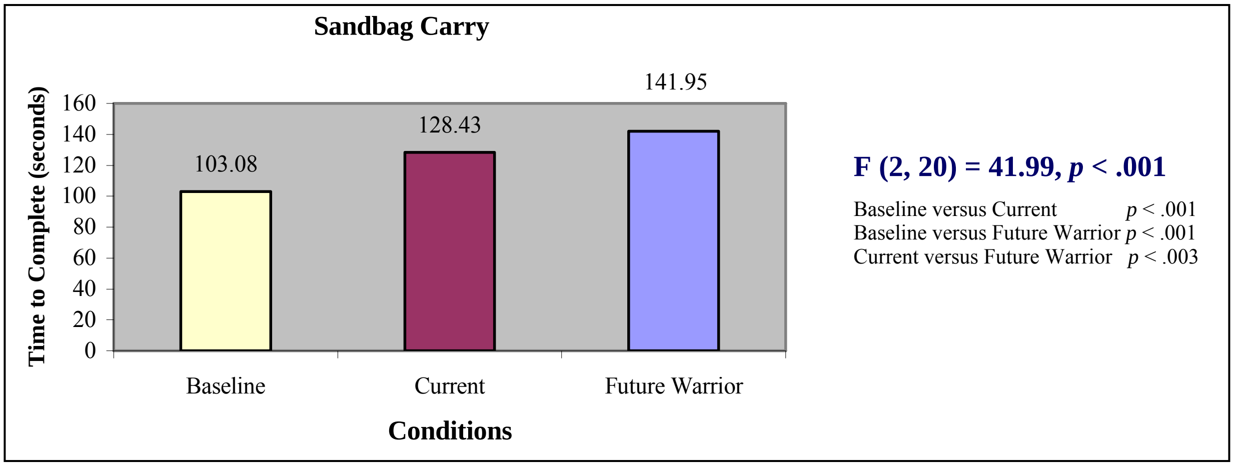

Figure 21. Time to complete sandbag carry.

5.2.8 Road March

The average time to complete the road march for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 22. There were significant differences in performance between the baseline and current and between the baseline and Future Warrior systems. However, no differences were found between current and Future Warrior systems.

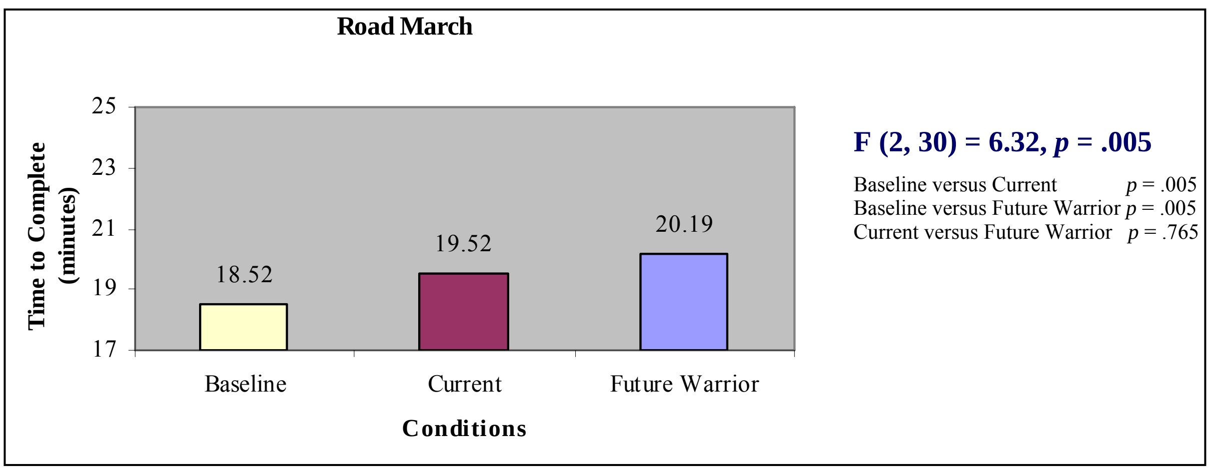

Figure 22. Time to complete road march.

5.2.9 Disassembly (M16A2 rifle)

The average time to complete the disassembly (M16A2 rifle) for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 24. The results of the mixed linear model analysis revealed significantly shorter times for rifle disassembly with the baseline configuration than with either the current or Future Warrior system; additionally, analysis indicated no significant differences between current and Future Warrior systems.

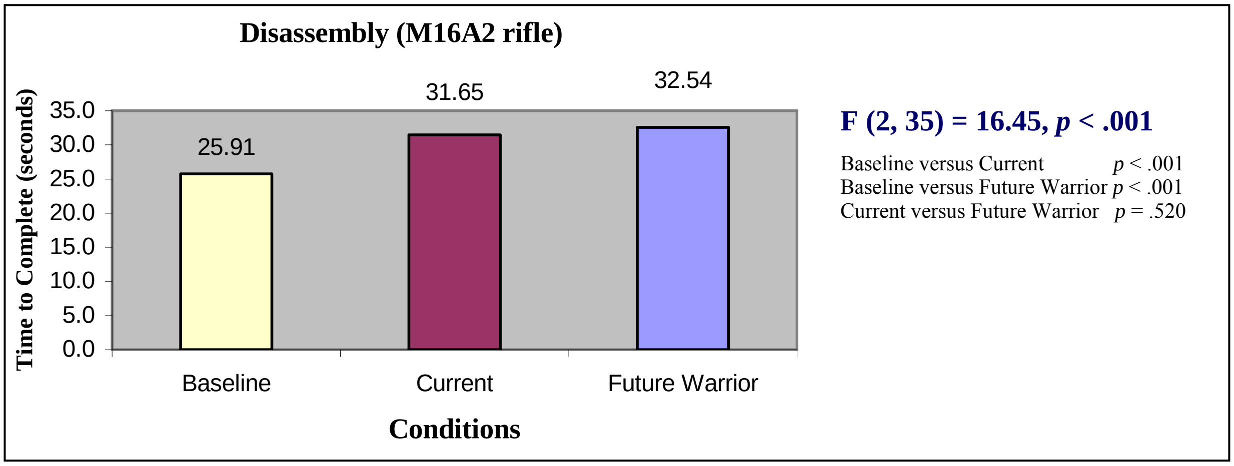

Figure 23. Time to complete disassembly (M16A2 rifle).

5.2.10 Reassembly (M16A2 rifle)

The average time to complete the reassembly (M16A2 rifle) for each of the three configurations as well as the results of the mixed linear model analysis and *post hoc* tests, if appropriate, is shown in figure 23. The results of the mixed linear model analysis of data revealed significantly shorter times for rifle assembly with the baseline configuration than with either the current or Future Warrior systems; additionally, analysis indicated no significant differences between current and Future Warrior systems.

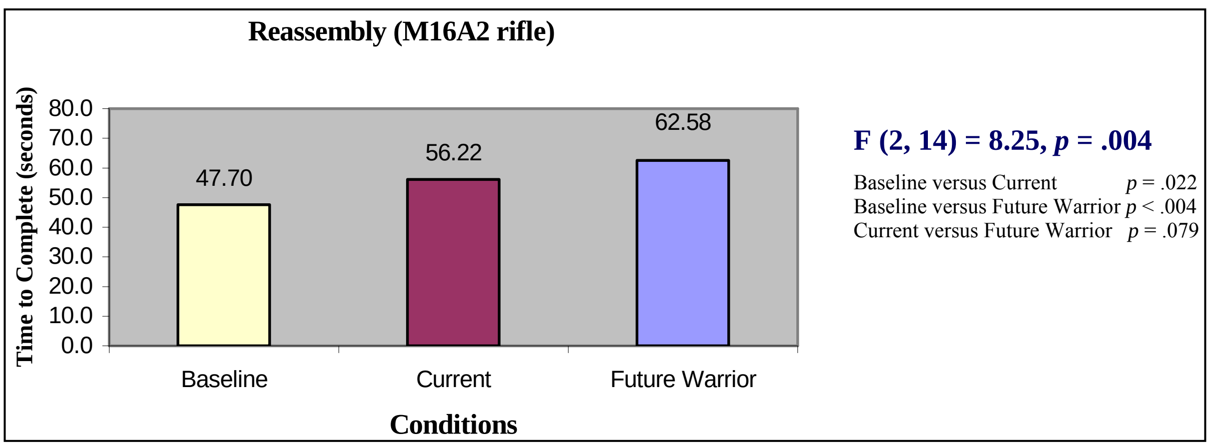

Figure 24. Time to complete reassembly (M16A2 rifle).

5.2.11 Discussion of Mobility and Portability Performance

Objective data were collected to measure and compare Soldiers' performance in the three equipment configuration conditions. Questionnaire data were collected to assess compatibility issues with the equipment configurations. The primary objectives were to investigate the effects of encapsulation on mission performance of the dismounted Soldiers and to select methodologies for further research of encapsulation effects.

The results of the analyses show that the following hypotheses were supported to varying degrees: (1) Using a system of systems approach demonstrated that encapsulation impacted individual performance; (2) as information processing increased, cognitive performance decreased; and (3) as the encapsulation configuration's weight increased, mobility and agility decreased and heat stress increased, leading to degraded mission performance. Only a limited number of durability problems were observed. Problems with claustrophobia were observed by experimenters throughout the course of the trials, which effectively degraded Soldiers' performance because of issues related to comfort and equipment compatibility.

Observations and participants comments made for the current configuration B (NBC chemical protective suit) were consistent with those made during previous field studies (Caretti & Barker, 2002). First, the chemical suit made the participant feel enclosed and hot, and the protective mask provided limited visibility. During this investigation, the participants commented that the excessive weight and bulk associated with Future Warrior configuration C hindered their ability to maneuver comfortably and safely in and around obstacles. However, the participants commented that although configuration A (Baseline) afforded greater mobility, it provided minimal protection against weapons of mass destruction.

Based on the interviews, it would appear that the encapsulation configurations presented major challenges to Soldiers, specifically in terms of weight distribution and heat stress, which had effects on mobility, situational understanding, and decision making. It is important to stress that the reported data are only applicable to the three configurations tested in this study and cannot be extrapolated to other configurations. The data clearly indicate that encapsulation significantly deteriorates verbal communication and presents clear distinctions between the configurations' effects on cognitive workload and common Soldier tasks. The determination of an effect does not necessarily imply a mission impact. However, it is very likely that sooner or later, it will impact the Soldier's mission and survivability.

Although the evaluation process presented here is time and personnel intensive, it is not necessary and perhaps not advisable to evaluate various components separately and then to attempt to integrate the data into a meaningful whole; it is not clear that statistical or operational procedures support such a modular approach. The instrumented facilities allowed consistent and balanced evaluations across the participant pool. The goal and benefit of research such as this is to provide information for models and simulations to determine encapsulation effects.

In practical terms, the results indicate that the research and development community should carefully plan how they can use a system integration approach for future encapsulation configuration design. Advancing the technology of war-fighting equipment without solving the associated human factors issues can present problems for Soldiers. Therefore, designers of future force systems should consider these as key points to future design requirements: the Soldier's ability to maneuver and actively engage targets, hearing protection, and enhanced communications systems under increased cognitive workload without conflicting with the performance of critical tasks during encapsulation. Designers should also plan on involving the user in all phases of the design process.

5.3 ARL's Shooting Performance Research Facility

5.3.1 Main Effects on Dependent Variables

Linear, univariate, repeated measures ANOVAs were conducted in conjunction with Tukey's honestly significant difference (HSD) *post hoc* analyses. Data from trials 1 and 2 were combined before analysis. Three dependent variables were analyzed for their interaction with the independent variable of encapsulation level:

> Hit percentage - the percentage of targets hit.
>
> Time to first shot – time (in seconds) that elapsed between each target presentation and when the participant fired his first shot at the target.
>
> Target engagement percentage – percentage of targets in which participants fired at least a single shot.

A novel method for shooting data analysis was developed during this study, which took into account the range and the angle where targets were presented. Significant statistical interactions were not found between encapsulation level and range, encapsulation level and angle, nor between encapsulation level when both range and angle effect were combined. Though significant findings did not occur as a result of this analytical method, separating range and angle into two independent variables may offer benefits for future studies.

The data summarized the main effects related to target hit percentage, time to first shot, target engagement percentage, and Tukey's HSD *post hoc* analysis of equipment configuration on target hit percentage. Tables 6 and 7 and figures 25 through 27 show data for results that were not statistically significant.

Table 6 refers to the mean hit percentage, time to first shot, and engagement percentage by configuration and target distance for each of the three configurations. All Soldiers hit a higher percentage of targets at shorter ranges, as common sense would dictate, but no significant interactions surfaced between encapsulation level and range during the statistical analysis.

Table 7 refers to the mean hit percentage by configuration and angle for each of the three configurations. Shooters in the baseline configuration shot better than those in masks at all angles. No interaction occurred between encapsulation level and angle.

Table 6. Mean hit percentage, time to first shot, and engagement percentage by configuration and target distance.

Configuration	Range (meters)	Mean Hit Percentage	Mean Time to First Shot (seconds)	Target Engagement Percentage
Baseline	50-90	.872	3.463	0.958
	90-140	.598	3.953	0.924
	140+	.557	4.086	0.930
Current	50-90	.788	3.714	0.935
	90-140	.492	4.163	0.883
	140+	.399	4.314	0.872
Future Warrior	50-90	.794	3.679	0.927
	90-140	.497	4.133	0.893
	140+	.427	4.414	0.862

Table 7. Mean hit percentage by configuration and angle. (Angle regions correspond to those depicted in figure 24.)

Configuration	Angle Region	Mean Hit Percentage	Mean Time to First Shot (seconds)	Target Engagement Percentage
Baseline	1	0.549	4.022	0.941
	2	0.868	3.720	1.000
	3	0.875	3.552	0.990
	4	0.417	4.041	0.819
Current	1	0.424	4.221	0.896
	2	0.764	3.888	0.969
	3	0.715	3.880	0.993
	4	0.340	4.261	0.729
Future Warrior	1	0.458	4.204	0.896
	2	0.726	3.987	0.986
	3	0.753	3.849	0.976
	4	0.354	4.254	0.719

The effects on mean target hit percentage for each of the three configurations are as follow: ANOVA results indicated a significant main effect of equipment configuration on target-hit percentage (F (2, 22) = 13.88, $p < 0.001$). Other significant main effects on hit percentage were found, such as type of weapon sight (F (1, 11) = 19.96, $p < 0.001$), target range (F (2, 22) = 87.57, $p < 0.001$), and angle from center of firing range (F (3, 33) = 143.11, $p < 0.001$) and were noted, but none demonstrated significant interaction with encapsulation level at the 0.05 significance level.

The effects on mean time to first shot for each of the three configurations are as follow: Analyses of main effects on time to first shot revealed a significant effect of configuration (F (2, 22) = 29.87, $p < 0.001$), weapon sight (F (1, 11) = 8.27, p < 0.015), range (F (2, 22) = 78.01, $p < 0.001$), and angles (F (3, 33) = 40.17, $p < 0.001$). An interaction surfaced between configuration and weapon sight, indicating that participants in the encapsulated condition engaged targets more quickly if they used the close combat optic sight versus the standard iron sights on the M4 carbine (F (2, 22) = 6.81, $p < 0.004$).

Figure 25 demonstrates graphically the hit percentage at three ranges for each of the three configurations. There was no statistical difference between equipment configurations.

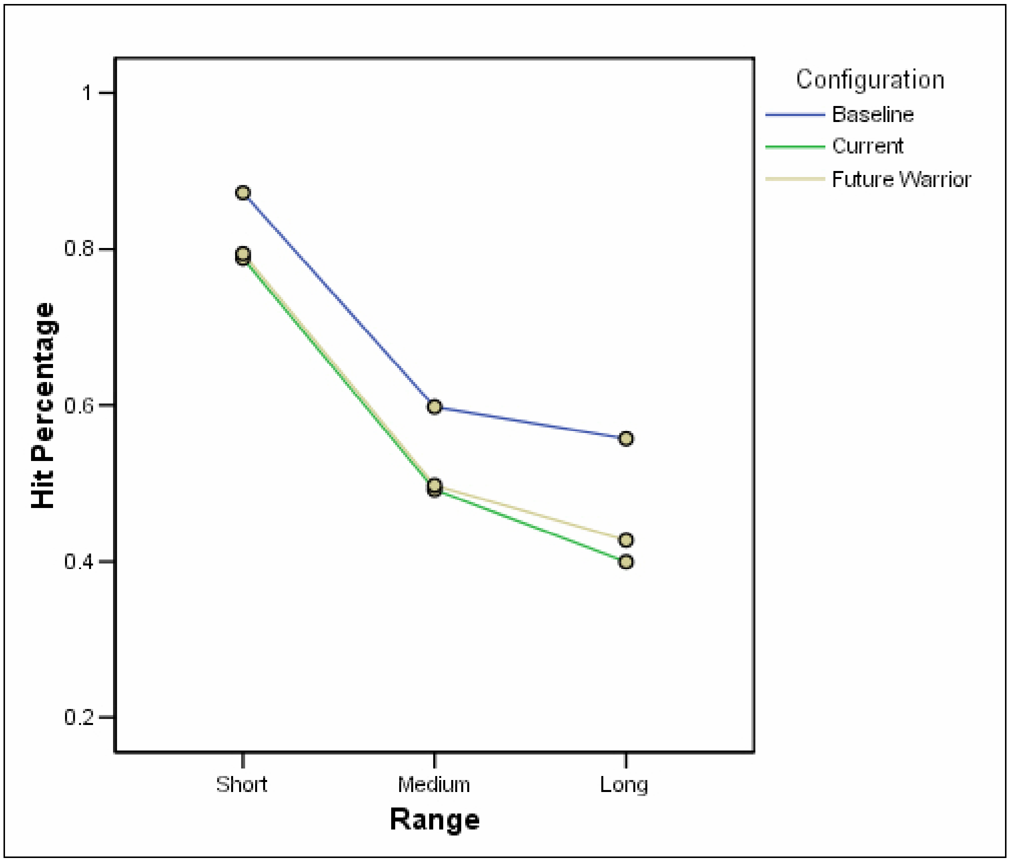

Figure 25. Hit percentage at three ranges and in three encapsulation conditions.

The effects on target engagement percentage for each of the three configurations are as follow: Main effects on target engagement percentage included significant effects of configuration (F (2, 22) = 5.70, p = 0.010), weapon sight (F (1, 11 = 4.87, p < 0.048), range (F (2, 22) = 7.28, p < 0.004), and angle (F (3, 33) = 78.12, p < 0.001).

Tukey's HSD *post hoc* analysis of equipment configuration on target hit percentage was performed for each of the three configurations. Soldiers recorded more target hits while in the baseline condition than they did with either mask configuration. Configurations B (current) and C (Future Warrior) shot the M4 carbine with almost equal accuracy; there were no significant differences between groups.

Figure 26 refers to the mean hit percentages of four separate range sections for each of the three configurations. There was no interaction between equipment configuration and angle.

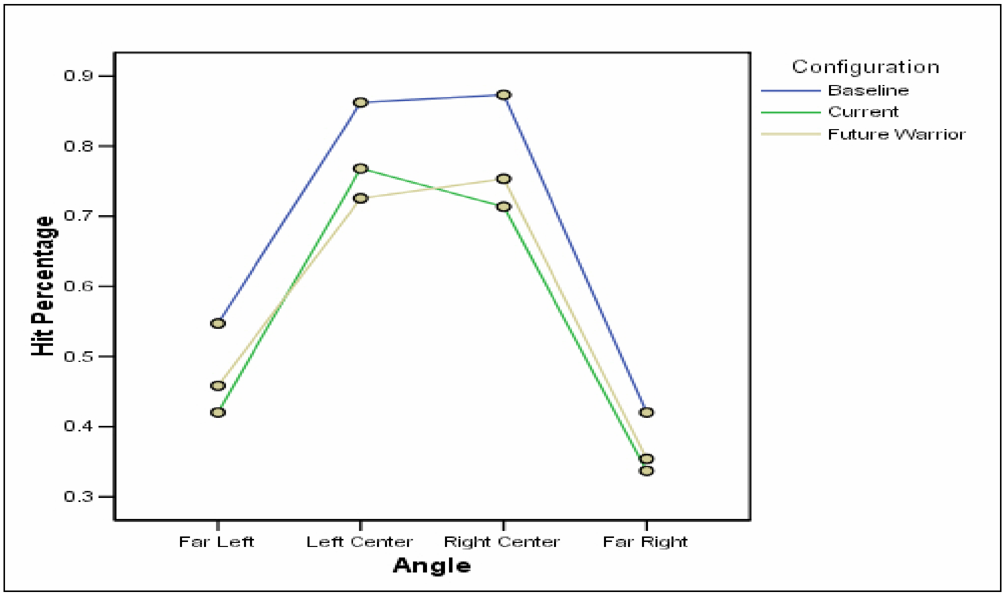

Figure 26. Mean hit percentages of four separate range sections in three encapsulation conditions.

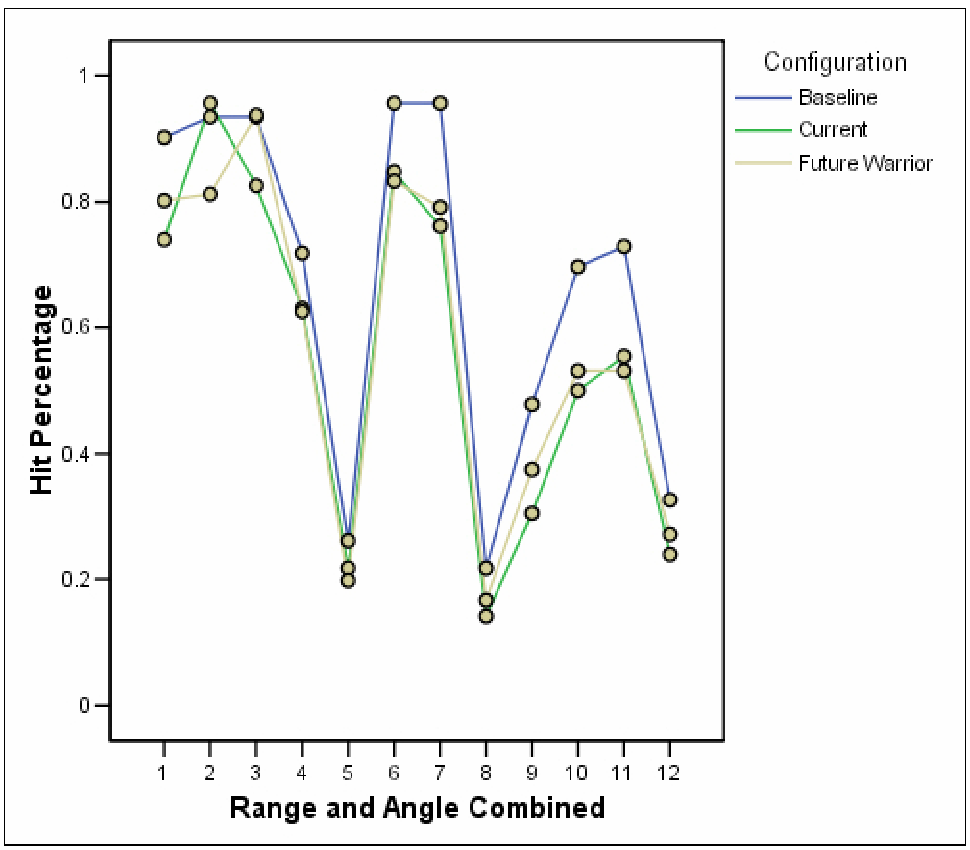

Figure 27. Hit percentage in 12 range and angle locations on the firing range in three different encapsulation conditions. (Areas labeled 1 through 12 correspond to those depicted in figure 12. No significant interaction was found between encapsulation conditions and the "range and angle combined" variable.)

Refer to table 8 for the mean hit percentages that correspond to figure 12. Differences in this table were not statistically significant at the $p \leq 0.05$ level.

Table 8. Mean hit percentages in different range and angle sectors, based on encapsulation conditions. (Range and angle regions correspond to those of figure 27.)

Range and Angle Region	Configuration	Mean Hit Percentage	Mean Time to First Shot	Target Engagement Percentage
1	Baseline	.90	3.566	0.979
	Current	.74	3.682	0.948
	Future Warrior	.80	3.548	0.937
2	Baseline	.93	3.329	1.000
	Current	.96	3.521	0.979
	Future Warrior	.81	3.665	0.979
3	Baseline	.93	3.245	1.000
	Current	.83	3.526	1.000
	Future Warrior	.94	3.513	1.000
4	Baseline	.72	3.118	0.854
	Current	.63	3.129	0.812
	Future Warrior	.63	2.955	0.792
5	Baseline	.26	3.976	0.927
	Current	.22	3.800	0.865
	Future Warrior	.20	3.991	0.917
6	Baseline	.96	3.779	1.000
	Current	.85	3.811	0.979
	Future Warrior	.83	3.975	1.000
7	Baseline	.96	3.346	0.979
	Current	.76	3.817	1.000
	Future Warrior	.79	3.673	0.979
8	Baseline	.22	3.421	0.792
	Current	.14	3.118	0.687
	Future Warrior	.17	3.044	0.677
9	Baseline	.48	3.760	0.917
	Current	.30	3.798	0.875
	Future Warrior	.37	3.699	0.833
10	Baseline	.70	4.053	1.000
	Current	.50	3.955	0.948
	Future Warrior	.53	4.164	0.979
11	Baseline	.73	3.951	0.990
	Current	.55	4.204	0.979
	Future Warrior	.53	4.077	0.948
12	Baseline	.33	3.354	0.812
	Current	.24	3.033	0.687
	Future Warrior	.27	3.163	0.687

5.3.2 Discussion of Shooting Performance

The objective of this study was to examine the potential effects of encapsulation on mission performance. Shooting is a critical activity of most missions and was shown to be affected by encapsulation. The hypothesis of the shooting trials for purposes of analysis was that encapsulation would affect shooting performance. The hypothesis was proven correct: shooting performance was hindered by encapsulation.

A novel method for shooting data analysis was developed during this study, which took into account both the range and the angle at which targets were presented. The main effect for angle accounted for more variability in shooting performance than did distance. There was no main effect for range and angle combined. In addition, statistically significant interactions were not found between encapsulation level and range, encapsulation level and angle, nor between encapsulation level when both range and angle effects were combined. Though significant interaction findings between encapsulation level and these variables did not occur as a result of this analysis method, separating range and angle into two independent variables may offer benefits for future studies.

The term “range” indicates actual line-of-sight distance (50 to 200 meters) to the target, and “angle” (9 to 52 degrees from the center firing position) designates the angle, measured in degrees, that targets were presented away from the firing range centerline. Data that were shown in table 8 summarized the main effects related to target hit percentage. Weapon sight, range, and angle all affected number of targets hit but showed no interaction with the variable of concern, configuration.

Encapsulated Soldiers fired on significantly fewer targets, hit significantly fewer targets, and required significantly more time to engage targets than those in the baseline condition. A significant Configuration x Weapon Sight interaction revealed that Soldiers firing with a protective mask required more time to engage targets with conventional iron sights than with a close combat optic (CCO). The exact cause of increased reaction times on the firing range because of encapsulation cannot be fully explained with results from this particular study, but further work focused on visual acuity issues, fatigue, and the corresponding heat stress associated with encapsulation could help determine the cause of this disparity.

5.4 Psychological Stress Assessment

5.4.1 Multiple Affect Adjective Checklist- Revised

The General Linear Model procedure (GLM), repeated measures option, was used to analyze the stress perceptions of the participants collected over several sessions. There were three within-subjects factors: Configuration (baseline, current, Future Warrior) x Time (first time, second time) x Session (before cross country, obstacle course, and live fire). The dependent variables were the six MAACL-R subscales. A criterion level of $p < 0.05$ for significance was employed throughout the analyses.

This analysis revealed a significant main effect for configuration (Wilks' $\lambda = .42$; $F(2,10) = 6.92$; $p = .013$). Main effects were not found for time (Wilks' $\lambda = .761$; $F(1,11) = 3.45$; $p = .09$) or session (Wilks' $\lambda = .67$; $F(3,9) = 1.50$; $p = .281$). When the analytical results were not significant, the data were pooled. Therefore, data were collapsed across time and session. This pooling of the data left us with one measure of each subscale for each configuration.

Once the data were collapsed for time and session, paired t-tests were conducted to determine exactly where the significant differences occurred within each subscale and in which configuration.

For the subscale Anxiety, participants reported significantly lower levels of uncertainty in the current configuration than during the baseline configuration ($t(11) = -2.872$, $p = .015$). Figure 28 refers to the mean MAACL-R depression score for each of the three configurations. Participants reported significantly higher levels of depression or a sense of failure during the current and Future Warrior configurations when compared to the baseline configuration ($t(11) = -2.96$, $p = .013$; ($t(11) = -3.037$, $p = .011$), respectively.

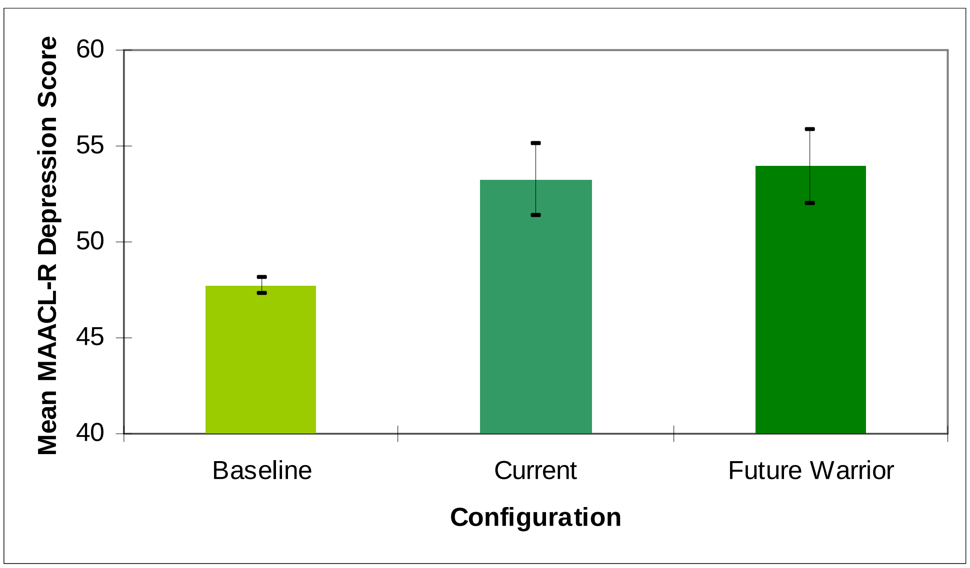

Figure 28. Mean (±standard error of the mean [SEM]) MAACL-R depression score for each configuration.

Figure 29 refers to the mean MAACL-R hostility score for each of the three configurations. For the subscale Hostility, participants reported higher levels of frustration during the current and Future Warrior encapsulation configurations than reported in the baseline configuration ($t(11) = -2.56$, $p = .025$; $t(11) = -4.15$, $p = .002$), respectively. Then, mean MAACL-R hostility scores for all configurations were compared with the non-stress condition. The non-stress condition typically reflects little to no stress. Soldiers wearing the current and Future Warrior encapsulation configurations reported significantly higher hostility levels (t (11) = -2.99; p = .01; t (11) = -4.08; p = .01) than they did on the non-stress day.

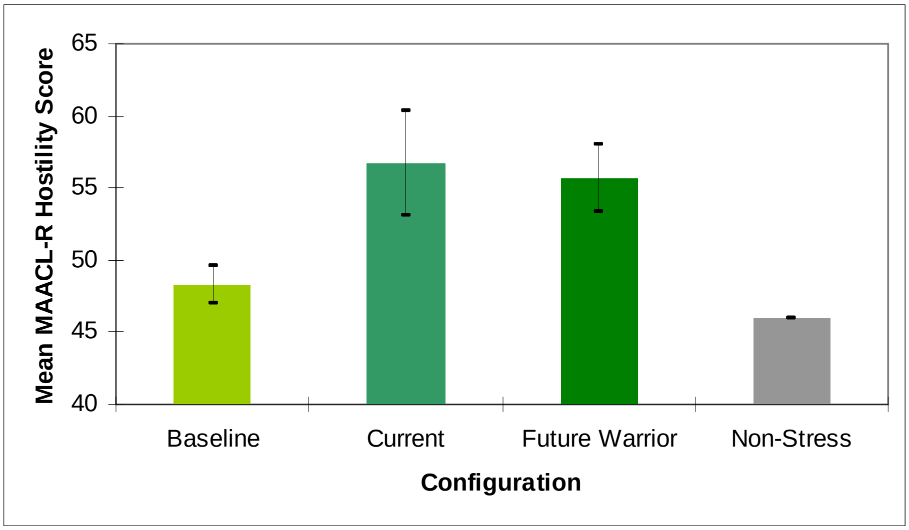

Figure 29. Mean (±SEM) MAACL-R hostility for all configurations compared with the non-stress condition.

Figure 30 refers to the mean MAACL-R dysphoria score for all configurations compared with the non-stress condition. Negative affect levels were significantly higher during both encapsulation configurations when compared to the baseline configuration (t (11) = -2.99, p = .012; t (11) = -4.59, p = .001). Baseline configuration levels of sensation seeking are significantly higher than both encapsulation configurations (t (11) = 3.139, p = .009; t (11) = 5.122, p = < .000).

Next, paired two-tailed t-tests were performed to compare the experimental data with those of the non-stress day. For the subscale Dysphoria, only Soldiers wearing the Future Warrior configuration reported significantly higher levels than they did on the non-stress day (t (11) = -2.59; p = .025).

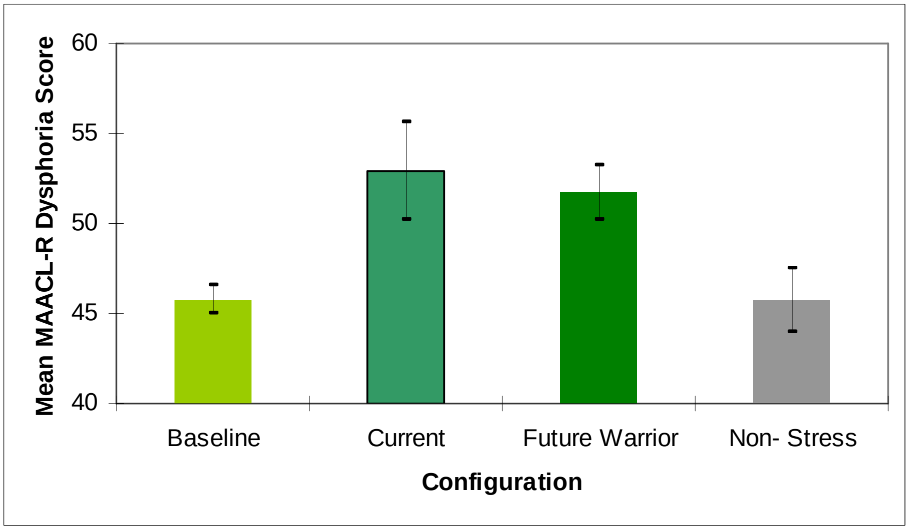

Figure 30. Mean (±SEM) MAACL-R dysphoria Score for all configurations compared with the non-stress condition.

Figure 31 refers to the mean MAACL-R positive affect score for all configurations compared with the non-stress condition. When the current and Future Warrior encapsulation configurations were worn, positive affect levels were significantly lower than levels reported on the non-stress day (t (11) = 2.64; p = .04; t (11) = 2.27; p = .023), respectively. Positive affect levels as reported by the participants were significantly higher during the baseline configuration than the current configuration (t (11) = 2.685, p = .021).

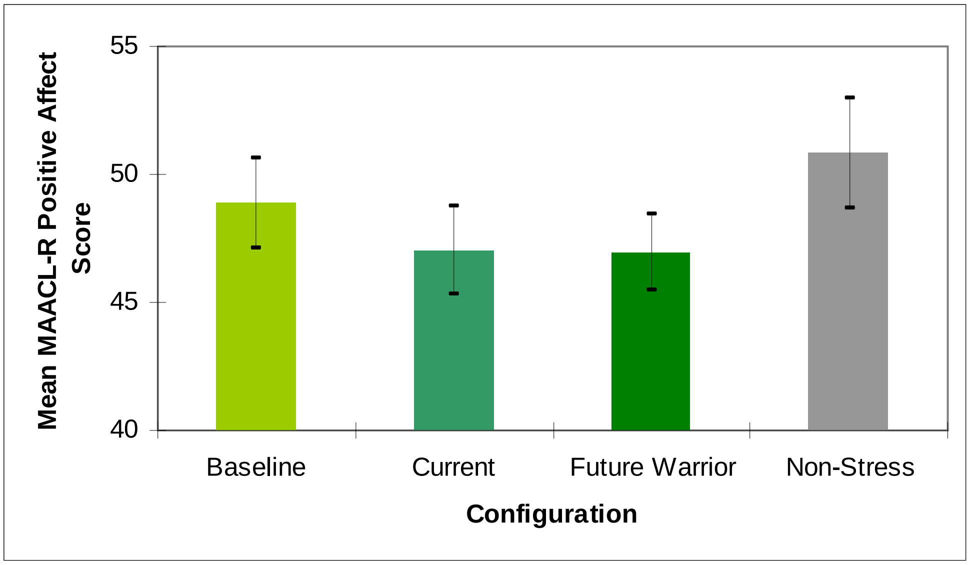

Figure 31. Mean (±SEM) MAACL-R positive affect score for all configurations compared with the non-stress condition.

5.4.2 Subjective Stress Scale (SUBJ) and the Specific Rating of Events (SRE)

Although the SUBJ and the SRE are stress perception measures, they are not part of the MAACL-R and therefore must be analyzed separately. As in the previous analysis, there were three within-subjects factors: Configuration (baseline, current, Future Warrior) x Time (first time, second time) x Session (before cross country, obstacle course, and live fire). A main Configuration x Session interaction was found (Wilks' λ = .17; F (6,6) = 5.03; p = .035). There were significant main effects for all factors included in the GLM, repeated measures analysis (see table 9).

Table 9. GLM, repeated measures results (SUBJ and SRE).

N = 12	
Session	Wilks' λ = .34; F (3,9) = 5.791; p = .017
Time	Wilks' λ = .68; F (1,11) = 5.304; p = .042
Configuration	Wilks' λ = .33; F (2,10) = 10.224; p = .004

Once the GLM, repeated measures analysis was completed, paired two-tailed t-tests were conducted to see where the interaction was significant. For the SUBJ (see figure 32), participants reported significantly higher levels of global stress during the cross-country course in the current configuration (t (11) = -3.362.; p = .006) and the Future Warrior configuration t (11) = -3.50.; p = .005) compared to the baseline configuration. Similarly, levels of stress were significantly higher for both encapsulation configurations during the obstacle course (t (11) = -3.842; p = .003; t (11) = -4.414.; p = .001) compared to the baseline configuration.

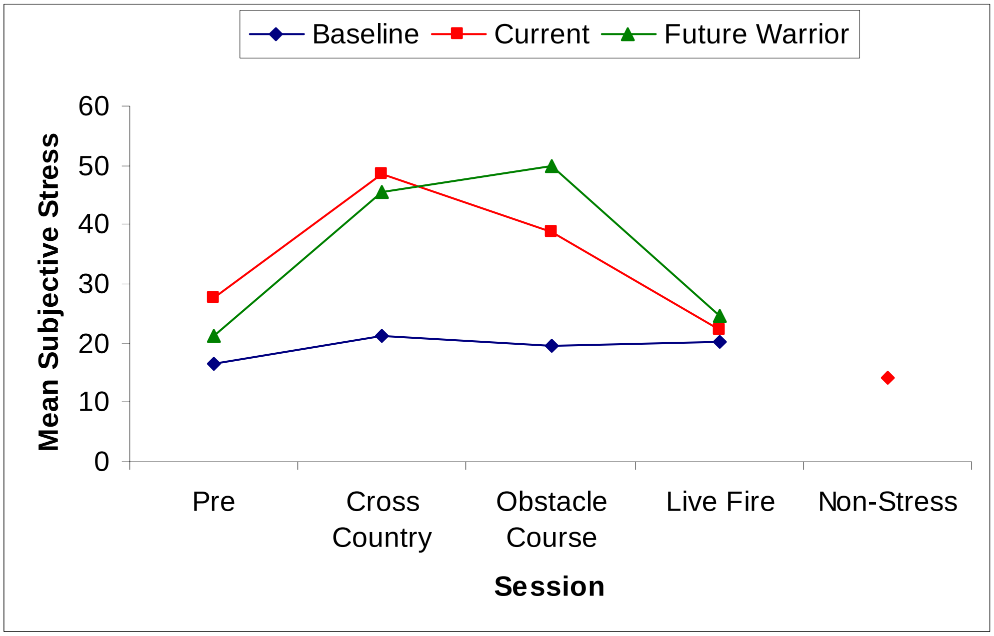

Figure 32. Mean SUBJ scores for all sessions compared with the non-stress day scores.

Next, paired two-tailed t-tests were performed to compare data from the experimental sessions with those of the non-stress day referred to as non-stress on the figures. For the SUBJ scale (see figure 33), levels were significantly higher during the pre-measure session than during the non-stress day (t (12) = -2.21; p = .05) for the current configuration only. For both encapsulation configurations, stress levels reported during the cross-country and the obstacle course sessions were significantly higher than those reported during the non-stress day (t (12) = -3.51; $p < .01$; t (12) = -3.68; $p < .01$; t (12) = -3.36; $p < .01$; t (12) = -4.34; $p < .01$). Stress levels reported during the live fire session were significantly higher than those reported during the non-stress day for the baseline and the Future Warrior configurations (t (12) = -2.83; p = .02; t (12) = -2.39; p = .04).

For the SRE (see figure 33), participants reported significantly higher levels of stress during the cross-country course in the current configuration (t (11) = -4.437.; p = .016) and the Future Warrior configuration t (11) = -2.993.; p = .034), compared to the baseline configuration. Similarly, levels of stress were significantly higher for both encapsulation configurations during the obstacle course (t (11) = -4.958; p = .003; t (11) = -4.121.; p = .010) compared to the baseline configuration. Overall stress levels for the Future Warrior configuration were significantly higher than the current configuration (t (11) = -2.241; p = .047) during the obstacle course.

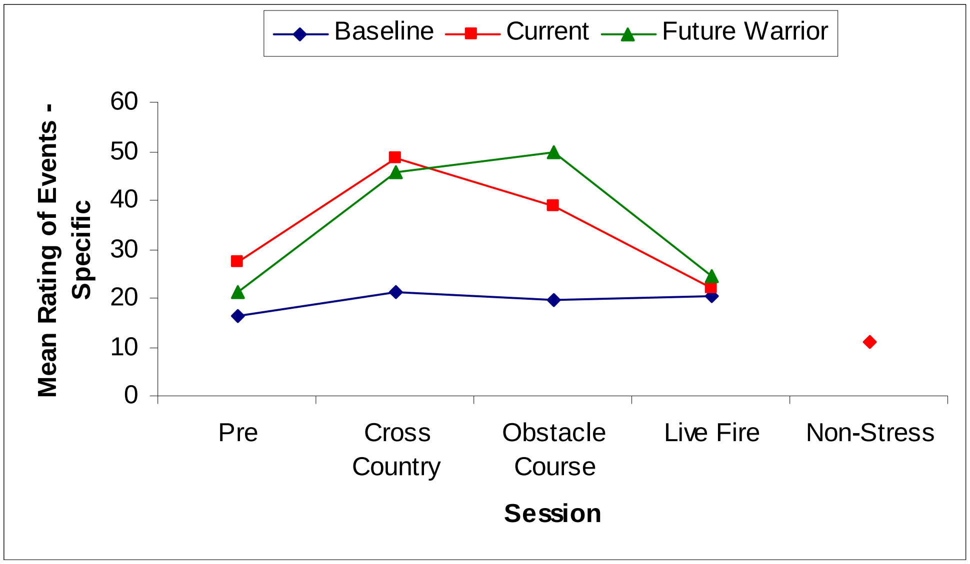

Figure 33. Mean SRE scores for all sessions compared with the non-stress Day scores.

Next, paired two-tailed t-tests were performed to compare the experimental data with those of the non-stress day (see figure 34). For the SRE, Soldiers in both encapsulation configurations reported significantly higher stress levels during the cross-country and the obstacle course sessions than they did on the non-stress day (t (12) = -3.47; $p < .01$; t (12) = -2.74; $p = .02$; t (12) = -3.12; $p < .01$; t (12) = -3.29; $p < .01$).

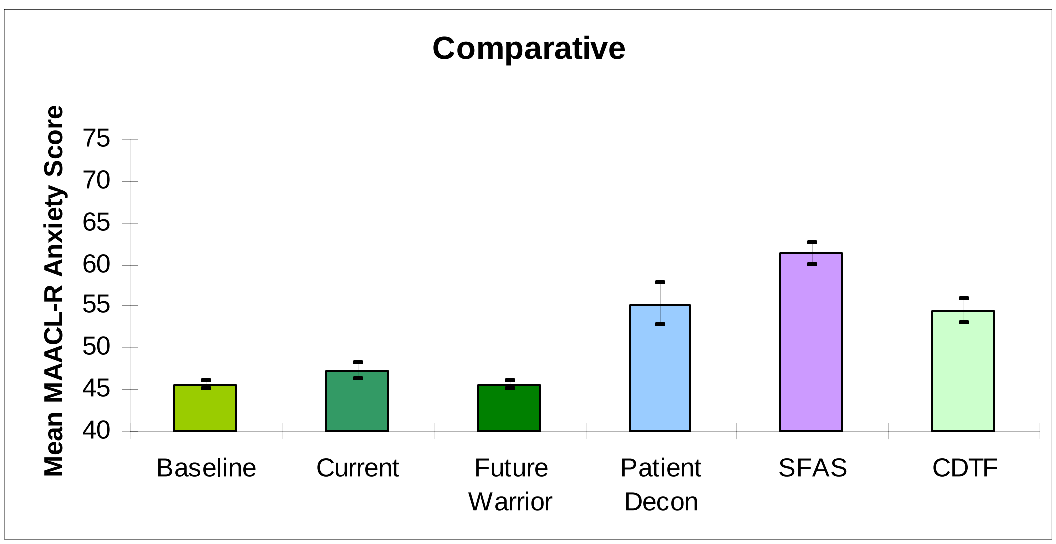

Figure 34. Mean (±SEM) MAACL-R anxiety score for the comparative groups.

5.4.3 Comparative Stress Profiles

In order to put these stress levels into perspective, we compared these results with other encapsulated research efforts. We chose other military relevant experiments that applied the same stress assessment battery. The groups include Soldiers performing patient litter decontamination (patient decontamination), where the participants wore mission-oriented protective posture (MOPP)4 and had to perform during day operations; Chemical Defense Training Facility (CDTF) students in 6 hours of MOPP4 training to decontaminate weapons and vehicles in a live agent environment; and Special Forces Assessment and Selection (SFAS) participants in training to be selected for a Special Forces assignment.

In order to analyze this data set, we performed an ANOVA; and *post hoc* comparisons were made for significant results through Bonferroni's Test or Tukey's HSD analyses. These analyses showed significant results on the MAACL-R, SUBJ, and the SRE. The ANOVA results are listed in tables 10 and 11.

The MAACL-R anxiety levels in the baseline, current, and Future Warrior configurations were significantly lower than those of the SFAS group (Bonferroni *post hoc* test, $p < .01$), as shown in figure 34.

Depression levels in the baseline configuration only are significantly lower than those of the patient decontamination group ($p < .01$), as shown in figure 35.

Table 10. ANOVA multiple comparison results (MAACL-R) measure.

1. MAACL-R		**Sum of Squares**	**df**	**Mean Square**	**F**	***p***
Anxiety						
	Between Groups	7300.010	5	1460.002	8.07	.000
	Within Groups	51219.422	283	180.987		.000
	Total	58519.432	288			
Depression						
	Between Groups	4002.706	5	800.541	4.60	.000
	Within Groups	49223.397	283	173.934		
	Total	53226.103	288			
Hostility						
	Between Groups	5715.203	5	1143.041	3.78	.003
	Within Groups	85697.453	283	302.818		
	Total	91412.656	288			
Dysphoria						
	Between Groups	6015.867	5	1203.173	5.00	.000
	Within Groups	68088.048	283	240.594		
	Total	74103.915	288			
Positive Affect						
	Between Groups	856.594	5	171.319	30.26	.011
	Within Groups	16022.761	283	56.618		
	Total	16879.355	288			
Sensation Seeking						
	Between Groups	232.415	5	46.483	1.10	.359
	Within Groups	11936.704	283	42.179		
	Total	12169.119	288			

Table 11. ANOVA multiple comparison results (SUBJ and SRE) measure.

		Sum of Squares	df	Mean Square	F	*p*
Subjective Stress Scale						
Cross Country						
	Between Groups	232.415	5	46.483	1.10	.359
	Within Groups	11936.704	283	42.179		
	Total	12169.119	288			
Obstacle Course						
	Between Groups	11534.908	5	2306.982	5.94	.000
	Within Groups	109835.40	283	388.111		
	Total	121370.31	288			
Live Fire						
	Between Groups	6138.204	5	1227.641	3.47	.005
	Within Groups	100172.72	283	353.967		
	Total	106310.92	288			
2. Specific Rating of Events (SRE)						
Cross Countr						
	Between Groups	9480.063	5	1896.013	3.52	.004
	Within Groups	152352.02	283	538.346		
	Total	161832.08	288			
Obstacle Course						
	Between Groups	9945.312	5	1989.062	3.70	.003
	Within Groups	152057.56	283	537.306		
	Total	162002.87	288			
Live Fire						
	Between Groups	19494.172	5	3898.834	7.75	.000
	Within Groups	142462.64	283	503.402		
	Total	161956.82	288			

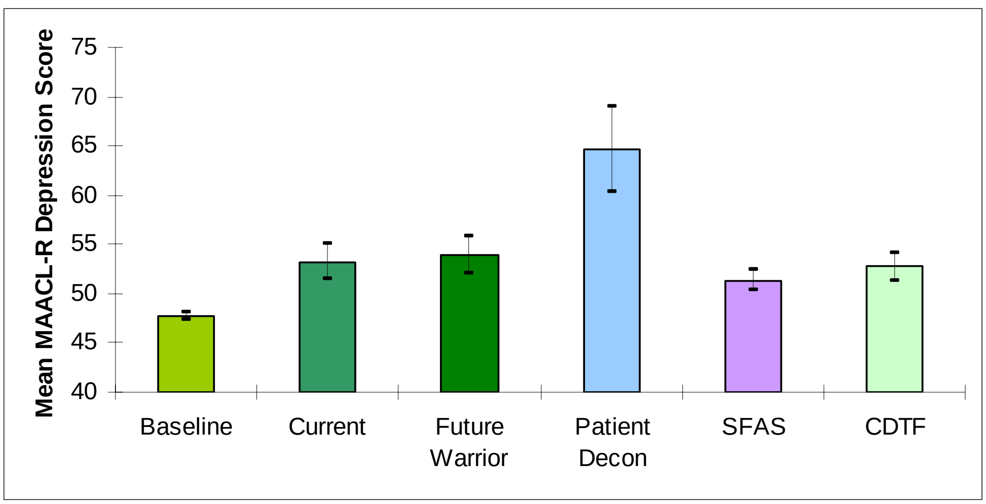

Figure 35. Mean (±SEM) MAACL-R depression score for the comparative groups.

Figure 36 refers to the hostility mean score for the comparative groups for each of the three configurations. Hostility levels in the baseline configuration were also significantly lower than the patient decontamination group ($p < .05$).

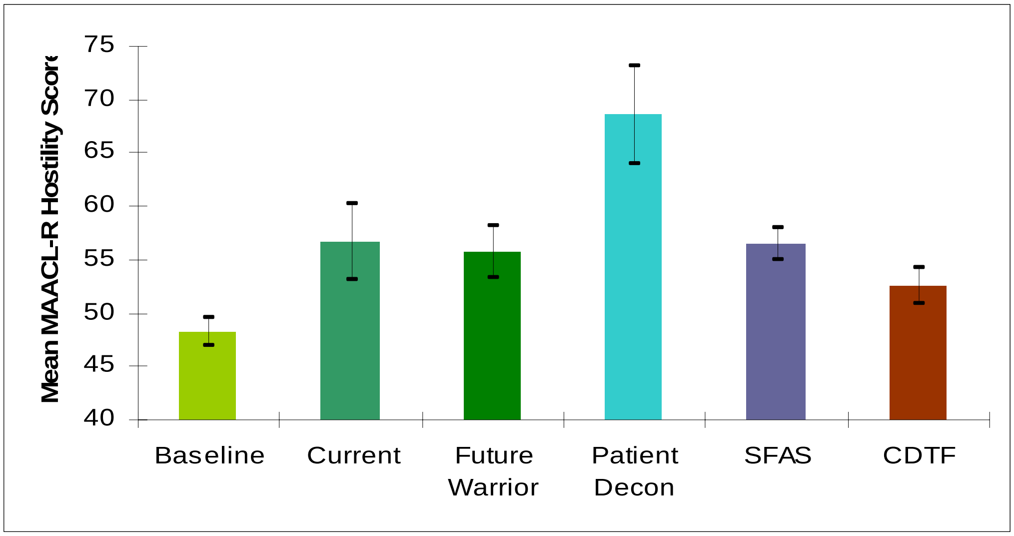

Figure 36. Mean (+SEM) MAACL-R hostility score for the comparative groups.

Figure 37 refers to the mean MAACL-R Dysphoria (negative affect) scores for the comparative groups for each of the three configurations. For the Dysphoria subscale, the baseline configuration is significantly lower than the patient decontamination and the SFAS (Bonferroni *post hoc* test, $p < .05$). For all encapsulation configurations, positive affect and sensation seeking levels were not significantly different from the levels reported in the comparative groups.

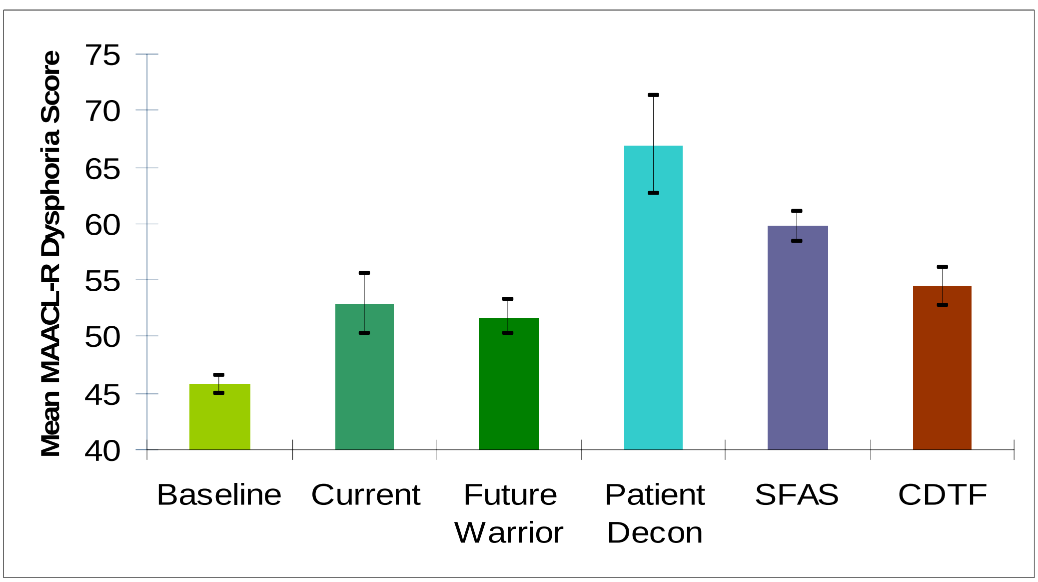

Figure 37. Mean (+SEM) MAACL-R dysphoria (negative affect) scores for the comparative groups.

Figure 38 refers to the Mean Subjective Stress Scale comparison data for each of the three configurations. During the obstacle course, participants wearing the baseline configuration reported lower stress levels than when wearing the Future Warrior configuration and the patient decontamination group ($p < .01$). Soldiers wearing the Future Warrior configuration reported stress levels significantly higher than levels reported from both the SFAS and the CDTF groups ($p < .01$). During the live fire exercise, the baseline configuration participants reported significantly lower stress levels compared to the patient decontamination group ($p < .05$).

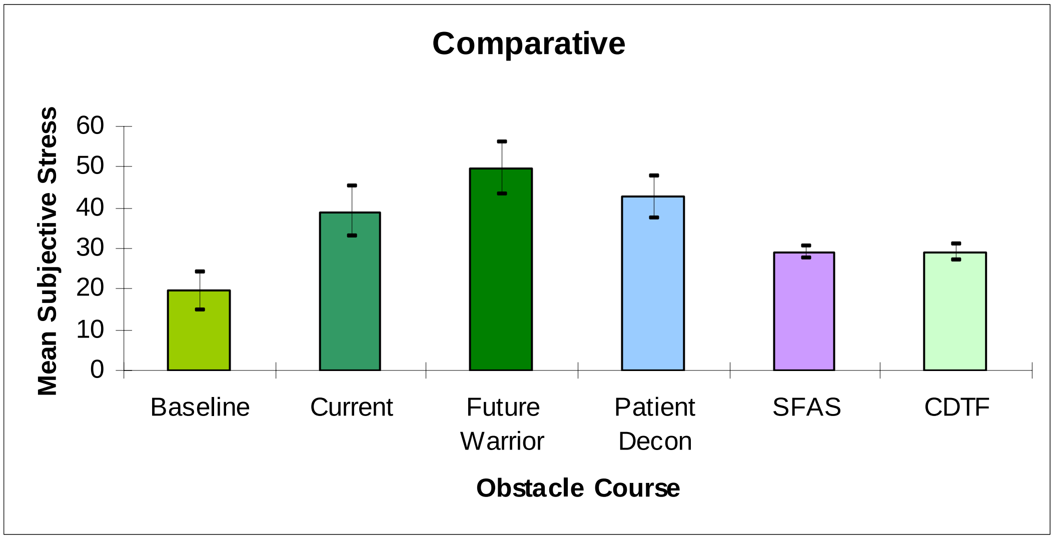

Figure 38. Mean (±SEM) SUBJ comparison data.

Baseline configuration SRE stress levels during the cross-country course and on the obstacle course were significantly lower than the patient decontamination groups ($p < .01$). During the live fire exercise, participants reported significantly lower stress levels in all configurations compared to the patient decontamination group ($p < .05$). In the current configuration, stress levels were also significantly lower than the SFAS ($p < .05$), and stress levels for the Future Warrior configuration were significantly lower than the CDTF ($p < .05$).

5.4.4 Correlations With Performance

Pearson correlations were conducted with performance times on the cross-country and obstacle courses. There were significant positive correlations between stress perception levels and performance on the obstacle course for the current configuration only. Soldiers who took longer to complete the course reported higher overall stress levels on the SRE scale ($r = .58$, $p = .046$) than those who completed the course in less time. Also, Soldiers who experienced high levels of frustration, as indicated by the MAACL-R Hostility scale, took more time to complete the obstacle course than those who reported lower frustration levels ($r = .84$, $p = .001$).

5.4.5 Discussion of Psychological Stress Assessment

For specific events during this research effort (i.e., during the cross-country and obstacle courses), participants demonstrated significant differences in stress levels related to wearing the different configurations (current and Future Warrior) compared to the baseline. The MAACL-R showed sensitivity as a measure of the Soldiers' stress perceptions between encapsulation configurations and indicated significant differences in the perception of negative affect and hostility between the experimental condition and the non-stress day.

Anxiety levels that are significantly lower than other encapsulation research efforts demonstrate that these Soldiers were confident in their ability to perform the duties required of them. Hostility levels were reported higher during encapsulation. These levels of hostility are comparable to the other comparative military scenarios, particularly when new equipment is being researched (Glumm, Branscome, Patton, Mullins, & Burton, 1999; Kaufman & Fatkin, 2001).

Positive affect levels during this research effort are low and comparable to levels reported from other military operations, such as military firefighters (Fatkin, King, & Hudgens, 1990) and Soldiers performing patient litter decontamination procedures at mobile medical facilities (Blewett, Redmond, Fatkin, Popp, & Rice, 1995). This measure represents the participants' overall sense of well-being.

During the obstacle course portion, the SRE ratings were significantly higher for Soldiers wearing the Future Warrior configuration than for those wearing the baseline or during the SFAS and the CDTF training. This was most likely because the mask fit properly. This mask tended to fog so much that one participant could not see the ground beneath his feet. Subsequently, he tripped over large obstacles, ran into tree branches, and at the midpoint, he had to doff his mask to wipe it clean. Other participants reported similar experiences. Both encapsulation configurations were more stressful than the baseline during the cross-country course. This was because of the configuration itself. There were weight issues, mask issues, and the terrain inconsistencies to confront during this scenario.

Experience factors should also be recognized when one is considering appropriate counter-measures for the negative effects of encapsulation. Previous investigations conducted within an Army program by Blewett, Redmond, Fatkin, Popp, and Rice (1995) assessed the psychological reactions of Soldiers in MOPP4 participating in training in a simulated chemical agent environment and in a toxic agent environment. Results indicated that amount of practice, mission rehearsal, and experience significantly affected reports of anxiety or uncertainty. Three separate anxiety measures indicated that while a junior enlisted group experienced a moderate level of stress, an experienced group did not report a level of anxiety that was significantly different from an independent control group.

During the live fire exercise, Soldiers reported significantly lower SRE and SUBJ ratings than the other military scenarios. This is believed to be associated with the nature of live fire scenarios. Soldiers have a desire to fire live ammunition. In this session, their responses on the subjective measures indicated that this was a positive experience for them. Previous research using psychological and physiological measures conducted on this live fire range (Torre, Wansack, Hudgens, King, Fatkin, Mazurczak, & Breitenbach, 1991) showed that testosterone levels are high and vigor and vigilance reign. Their stress levels across the board are lower during the live fire scenario.

In general, although the various sessions included in this research effort (such as negotiating the cross-country and obstacle courses) showed differences in stress response levels, these levels were correlated with degraded performance only when Soldiers negotiated the obstacle course. Based on previous research, donning encapsulation configurations is stressful in and of itself, especially for inexperienced individuals. The factors associated with the Soldiers' stress perceptions, particularly frustration levels, are also reported from first responders and other emergency care personnel functioning in chemical and biological warfare (CBW) environments (Fatkin, 1994; Fatkin, 1998; Fatkin, 2003; Headley & Hudgens, 1997). These professionals are required to wear encapsulated systems for varying durations of time and during uncertain conditions. Even with the proper training, experience, and sufficient practice, these individuals demonstrated delayed stress effects after a period of no apparent symptoms. At the time of the delayed responses, the emergency care responders may experience a decline in work performance as well as deterioration in family relationships and increased health problems (Fatkin, 2003). Some stress response symptoms related to critical incidents are headaches, nightmares, fatigue, or poor concentration. These problems are not new and have been reported for approximately a decade. In a study of emergency care workers within CBW environments, Fullerton and Ursano (1994) reported similar findings. Responses included claustrophobia, difficulties with masks, overheating, feelings of having failed, increased risk associated with dedication to the group, dehydration secondary to alcohol use, failure to recognize danger, and anxiety. It is time to take a systematic approach to decreasing casualties and enhancing performance within CBW-related environments. We need to heed the findings of previous research indicating powerful factors that can influence casualty rates and performance outcomes, such as leader alertness, flexibility, ongoing availability, and willingness to engage in immediate problem solving.

5.5 Cognitive Performance Assessment for Stress and Endurance (CPASE)

The CPASE consisted of four cognitive performance tasks: verbal memory, logical reasoning, addition, and spatial manipulation. Each performance task was evaluated as to the number of items completed correctly. Twelve repeated measure ANOVAs were conducted, one for each of the events (cross country, obstacle course, and weapons firing) with the four performance measures (verbal memory, logical reasoning, addition, and spatial manipulation). Each analysis was a 3 (equipment configuration; baseline, current, Future Warrior) x 2 (repetition; trial 1, trial 2) x 2 (session; pre, post) repeated measure ANOVA. A criterion level of $p < 0.05$ for significance was employed throughout the analyses. *Post hoc* comparisons were also made for significant results through Tukey's HSD Test.

5.5.1 Verbal Memory Recall

Figure 39 refers to the pre-post main effect for the word recall task. This short-term memory test required written recall of 12 single and double syllable words. Participants were given 1 minute to study the word list. The word list was then collected and the participants had 1 minute to recall and write as many of the 12 words as they could. Significant main effects were found between the pre- and post-measures for the cross-country ($F(1, 11) = 19.12$; $p = .001$) and the obstacle course ($F(1, 11) = 16.64$; $p = .002$) tasks. Participants performed slightly higher on the pre-test condition. The mean for the pre-measure was 7.35, the post cross-country course was 6.39, and the post obstacle course was 6.40.

There was a significant main effect for repetition for the obstacle course condition ($F(1, 11) = 4.72$; $p = .05$). Performance on the second trial increased slightly with a mean of 6.60 on trial 1 and 7.15 on trial 2. This was most likely because of practice effects. A significant interaction occurred between equipment configuration and repetition for the weapons firing condition ($F(2, 22) = 6.65$; $p = .006$). There was no difference between trials for the baseline and Future Warrior configurations. This interaction was attributable to an increase in performance on trial 2 during the current encapsulation configuration.

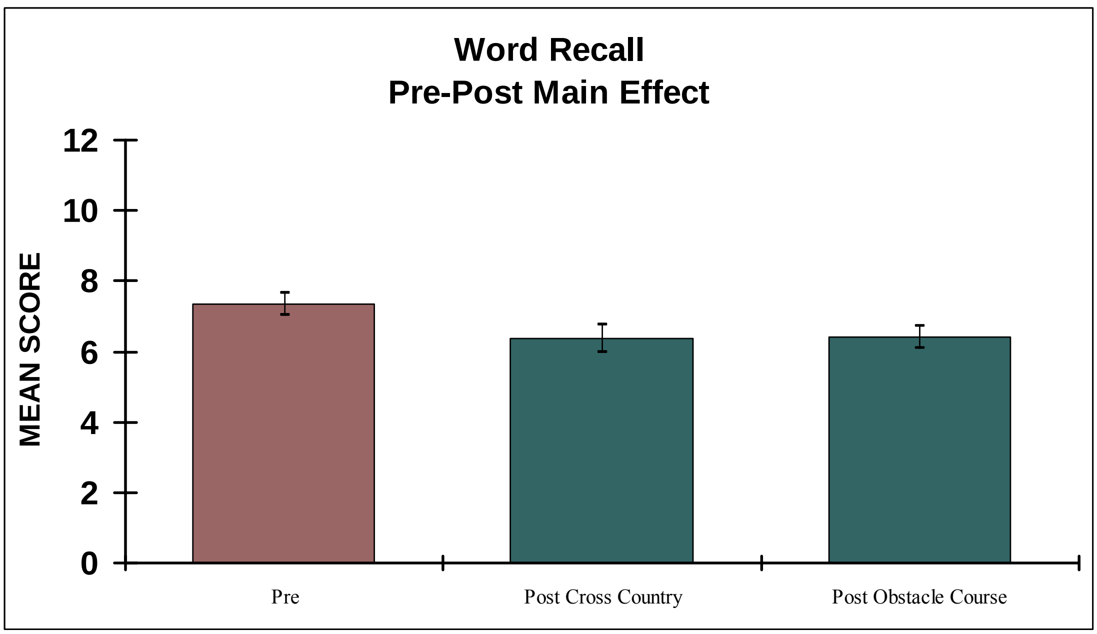

Figure 39. Pre-post main effect for the word recall task.

5.5.2 Logical Reasoning

Figure 40 refers to the pre-post main effect for the Logical Reasoning task. This reasoning task (Baddeley, 1968) involved 32 evaluations of two-letter pairs and a phrase describing the letter pair ordering. Each evaluation was judged as “true” or “false”. Participants had 1 minute to complete as many of the 32 items as possible. Significant main effects were found between the pre- and post-measures for the cross-country course (F (1, 11) = 6.13; $p = .03$), the obstacle course (F (1, 11) = 3.29; $p = .01$), and the weapon firing (F (1, 11) = 14.91; $p = .003$) tasks. Participants performed slightly higher on the pre-test condition. The mean for the pre-measure was 13.78, the post cross-country course measure was 12.53, the post obstacle course measure was 12.75, and the post weapon firing measure was 12.21.

Figure 41 refers to the cross-country course condition: main effect for equipment configuration for the Logical Reasoning task for each of the three configurations. For the cross-country course condition, there was a significant main effect for equipment configuration (F (2, 22) = 3.91; $p = .04$) and a significant interaction for session (pre, post) and equipment configuration (F (2, 22) = 3.60; $p = .05$). Performance when Soldiers wore the baseline configuration was higher than for either of the encapsulation configurations, with the following means: baseline means 13.94, current means 12.56, and Future Warrior means 12.96 (baseline versus current $p = .005$; baseline versus Future Warrior $p = .006$). For the Pre-post x Equipment Configuration interaction, there was a slight decline in performance from baseline for the encapsulation configurations (figure 42).

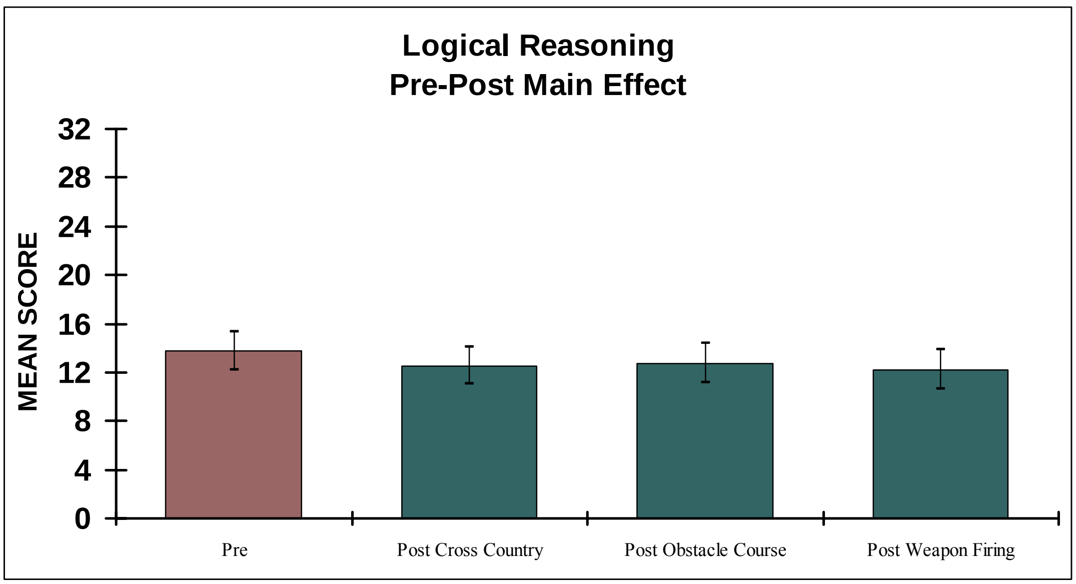

Figure 40. Pre-post main effect for the logical reasoning task.

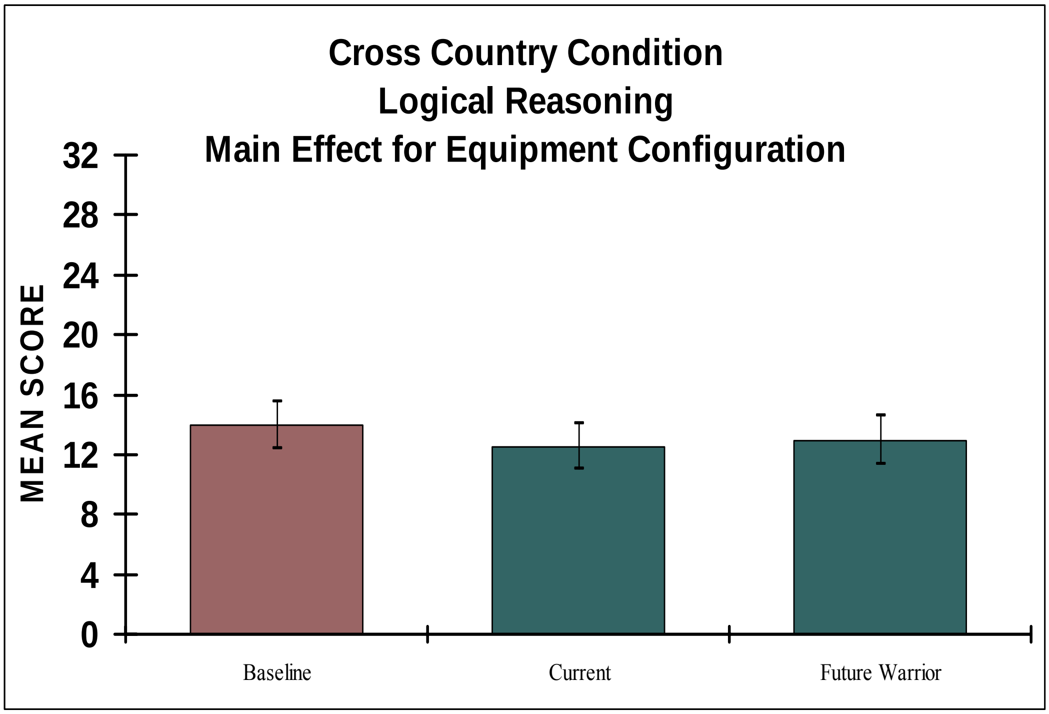

Figure 41. Cross-country condition: Main effect for equipment configuration for the logical reasoning task.

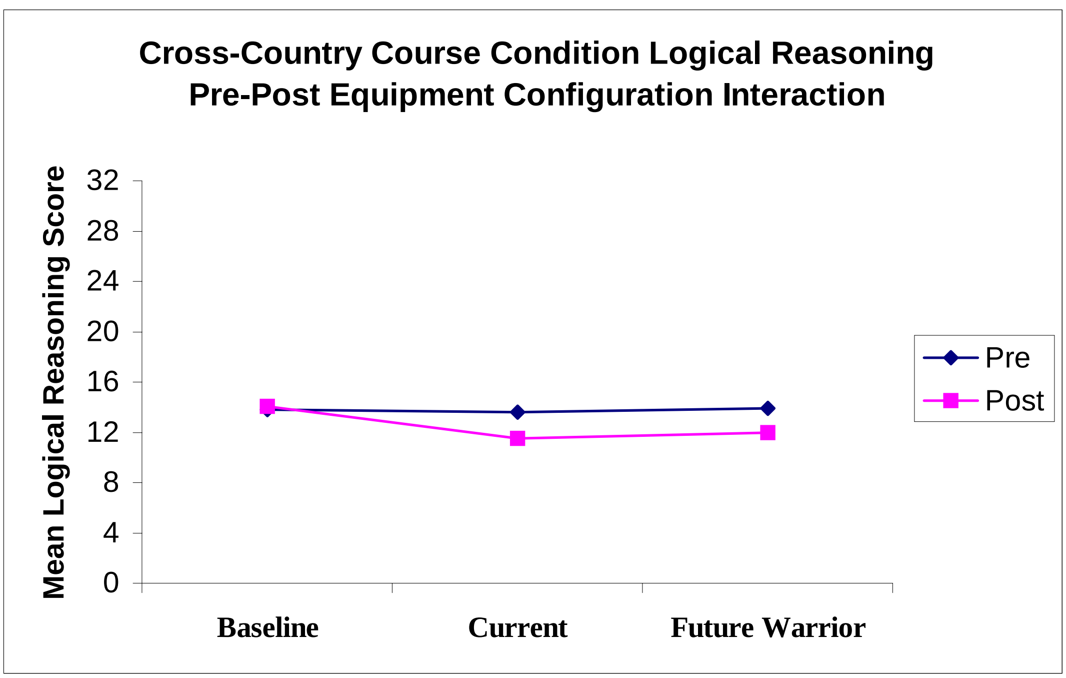

Figure 42. Cross-country condition: Pre-post x Equipment Configuration interaction for the logical reasoning task.

There was a significant Session (pre-post) x Repetition interaction for the cross-country condition (F (1, 11) = 4.02; $p = .03$). For the pre-condition, performance was the same for both repetitions with a mean of 13.78. Performance declined from repetition 1 (mean = 12.94) to repetition 2 (mean = 12.11) for the post measures.

5.5.3 Addition and Addition With a Constant

Figure 43 refers to the cross-country course condition: Main effect for equipment configuration for the Addition task for each of the three configurations. This computation task, adapted from Williams and Lubin (1967), is used to test working memory. Each item consists of a pair of three-digit numbers, which were selected from a random number table. The task is participant paced. Test participants have 30 seconds to complete as many of the 15 problems as possible. For the cross-country condition, there was a significant main effect for equipment configuration (F (2, 22) = 3.81; $p = .04$). This was because of a significant difference between the baseline configuration (mean = 7.96) and the Future Warrior configuration (mean = 6.98) (baseline versus Future Warrior, $p = .02$).

For the obstacle course condition, there were significant main effects for session (pre post) (F (1, 11) = 6.45; $p = .03$) and repetition (F (1, 11) = 33.51; $p = .001$). Performance was higher for the post measure (pre mean = 7.31; post mean = 7.85). Performance also increased for the second repetition (trial 1 mean = 6.92; trial 2 mean = 8.24). There was a significant Session (pre post) x Repetition interaction for the weapon firing condition (F (1, 11) = 25.66, $p = .001$). Performance was higher for post trial 1 and pre trial 2 (Means: pre trial 1 = 6.81; post trial 1 = 8.00; pre trial 2 = 7.81; post trial 2 = 6.78). These effects are most likely because of practice. This is consistent with other findings. Williams and Lubin (1967) found the addition task to be especially susceptible to practice.

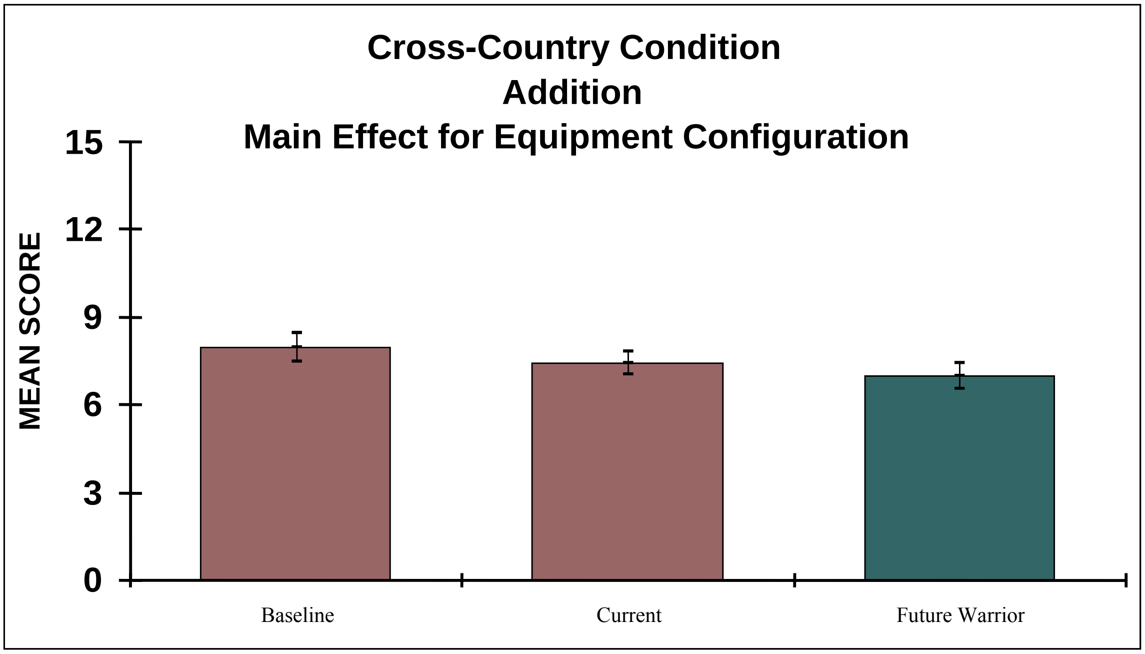

Figure 43. Cross-country course condition: Main effect for equipment configuration for the addition task.

5.5.4 Spatial Manipulation

Figure 44 refers to the cross-country condition: main effect for equipment configuration for the spatial manipulation task for each of the three configurations. Soldiers' performance on the spatial manipulation task involved pattern recognition and figure manipulation. Spatial skills were tested with the use of a mental manipulation task adapted from Shepherd's work (1978). A six-by-six grid is enclosed within a hexagon measuring 2.8 centimeters. Areas of the grid are filled to create random patterns. To the right of each test pattern are three similar patterns. One of the three patterns is identical to the test pattern except that it has been rotated. The task is to select this pattern. Each test consists of 18 items balanced for the number of grids filled (7, 9, or 11), pattern density (adjacent blocks filled versus one break between pattern blocks), and manipulation of the correct answer (90, 180, 270 degrees). Test participants have 2 minutes to complete as many items as possible. For the cross-country course condition, there was a significant main effect for equipment configuration ($F(2, 22) = 4.05$, $p = .03$). The Future Warrior configuration was significantly worse than the baseline and current equipment configurations (baseline versus Future Warrior, $p = .01$: current versus Future Warrior, $p = .04$).

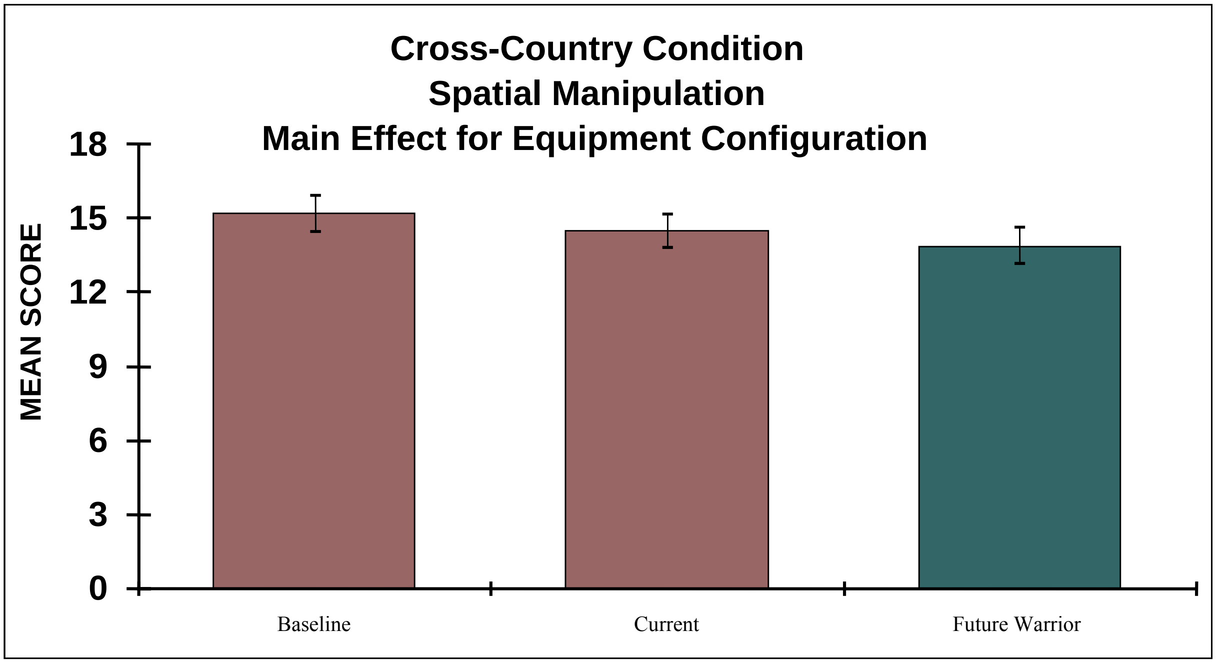

Figure 44. Cross-country condition: Main effect for equipment configuration for the spatial manipulation task.

There were main effects for repetition for the cross-country course (F (1, 11) = 11.33, *p* = .006) (mean trial 1 = 13.88; mean trial 2 = 15.11) and weapon firing (F (1, 11) = 12.18, *p* = .005) (mean trial 1 = 13.72; mean trial 2 = 15.39). There was a significant interaction between session (pre post) and repetition for the obstacle course condition (F (1, 11) = 17.53, *p* = .002). These effects are most likely attributable to practice.

5.5.5 Discussion of CPASE

There were no significant encapsulation effects for post obstacle course or post live fire testing. Significant post cross-country encapsulation effects were found for three of the four cognitive tests: logical reasoning, addition, and spatial manipulation. Logical reasoning had a significant decline in performance from baseline (M = 14.0), with lower scores for current (M = 11.5; 18% decline) and Future Warrior (M = 12.0; 14% decline) configurations (figure 42). The baseline (M = 8.5) measure for addition was significantly different from the Future Warrior configuration (M = 6.9; 19% decline) (figure 44). Spatial manipulation had a significant decline in performance for the Future Warrior (M = 13.6) from the baseline (M = 15.5) and current (M = 14.6) configurations (12% and 7% decline, respectively) (figure 45). Encapsulation effects may have been found only for the cross-country condition because it was physically demanding and other cognitive tasks (target detection and speech intelligibility) were associated with this condition.

Another explanation may be related to the additional time and exertion required to complete the cross-country condition compared to obstacle course or weapons firing conditions. An effect of walking cross country for a prolonged amount of time possibly resulted in increased body temperature. The thick textile material required for encapsulation ensembles tends to hinder body cooling because of the evaporation of body sweat. This hinders the body's ability to thermo-regulate, and the cumulative effects over time result in heat storage in the body, creating thermal stress. Faerevik and Reinertsen (2003) found that decrements in cognitive performance were correlated with increases in body temperature. Unfortunately, it was not feasible to monitor an individual's core temperature during this study, but further research in this area is warranted. The significant changes in cognitive performance found in this study may be attributable to increased temperature caused by the higher physical load associated with the cross-country condition. If increased core body temperature is related to cognitive performance declines, this offers a powerful predictor for field performance. This physiological measure could potentially be used by commanders as an indicator or warning to watch for declines in individual mission performance.

Cognitive performance decrements found in this study are consistent with other research. Previous research has indicated that exercise, such as the cross-country condition, while Soldiers wear chemical protective clothing (CPC) produces significant declines in cognitive performance (Williams, Englund, Sucec, & Overson, 1997). For logical reasoning, they found exercise participants wearing CPC had more lapses and worked at a slower pace. Performance declines were also found for addition and spatial tasks in their study. The cognitive performance decrements found in the current study were as high as 19%. This would have a significant impact on military operations that require these basic cognitive skills.

6. Conclusions

The objectives of this study were to investigate the effects of encapsulation on mission performance of dismounted Soldiers and to select methodologies that can be used effectively in future research of encapsulation effects on mission performance. The results of the research demonstrate that (1) mobility tasks took longer while Soldiers were encapsulated because of increased weight and heat stress as reported subjectively, (2) individual shooting performance was degraded because of visual restriction associated with the encapsulation system, and (3) encapsulation systems produced more psychological stress. From a methodology standpoint, the cross-country course distinguished differences between encapsulation systems both physically and psychologically.

As for the results themselves, it is evident that an encapsulation system can create at least two sources of poor performance. First, this occurs for the individual components of the configurations, where data are required to assess relative contribution and location of "high error" components. Second, and at least as important if somewhat more complex to assess, poor performance results from the entire encapsulated system (encapsulation, weapons, and other subsystems). There is no other way to determine positive or negative interactive effects among configurations, such as the joint effects of gloves (potential to restrict tactile feedback), clothing (binding at body joints can prohibit natural or comfortable posture), and vision protection (can prohibit quick and clear target sighting, identification of friend or foe, etc.). While the evaluation process presented here is time and personnel intensive, clear distinctions between the ensembles' effects on common participant tasks can be made. It is not necessary (and perhaps not advisable) to evaluate various components separately and then to attempt to integrate the data into a meaningful whole, and it is not clear that statistical or operational procedures support such a modular approach. Given that battlefield conditions requiring encapsulation are becoming increasingly necessary, it is important for Soldier safety, sustainment, and survivability that the overall system performance be assessed in the aggregate.

Only a limited number of durability problems with the equipment were observed. Problems with claustrophobia, which effectively degraded Soldiers' performance, surfaced during this study. Encapsulation proved a detriment to live fire shooting performance. It is likely that the lower hit percentages and lower target engagement percentages of Soldiers in encapsulated conditions occurred because of their failure to engage targets within the allotted time. Those in the encapsulated configurations periodically failed to fire at a target that was presented to them, which thereby lowered their target engagement percentage and ultimately reduced their number of targets hit. However, based on the interviews, it would appear that the encapsulation presented major challenges to Soldiers, specifically in terms of the equipment total weight, total weight distribution, heat stress, and fatigue.

Although advancements in technology may enhance Soldiers' performance, it is imperative that Soldiers can perform their mission under increased cognitive workload without conflicting with the performance of critical tasks during encapsulation. New and emerging technologies such as three-dimensional auditory sound localization devices (e.g., Tran, Letowski, & Abouchacra, 1995), personal hearing protection against dangerous noise levels (e.g., Price & Kalb, 2001) and mobile communications devices are each designed to provide improved performance for Soldiers by addressing the human factors issues that sometimes accompany advanced technology. In practical terms, the results of this study indicate that the research and development community should carefully plan how they can use a system integration approach for future encapsulation equipment design. Designers should plan to involve the user in all phases of the design process.

7. Recommendations

The following recommendations are intended to provide information that may be helpful in the refinement of future design of encapsulation systems. The users of this information are cautioned that the results of this study are based on a limited sample size and are constrained by other equipment limitations. Based on the results of this study, designers of tactical protective equipment must take into consideration the physical and psychological stress presented to Soldiers while they are encapsulated. Designers must recognize that developing individual combat equipment with a variety of independent solutions limits the capabilities of the Soldier to keep pace with advances in technology. The principal concerns expressed by Soldiers wearing encapsulation configurations involved design integration and effects on mission performance. If advancement in equipment technology is to enhance Soldier performance, the research and development community must focus on minimizing excessive equipment bulk, quantifying the distribution of equipment weight, and conducting performance-based research that emphasizes a system of systems approach.

There are several different approaches to enhance the methodology used here, including body core temperature pills to assess the impact of heat stress on performance and a portable metabolic system to measure oxygen consumption during a single set of conditions. Here we have considered a somewhat complex methodology designed to characterize the encapsulation ensemble capabilities. It is hoped that the recommended methodologies outlined here might be a "talking point" for some future collaboration between interested research parties.

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Appendix A. Volunteer Agreement Affidavit

The proponent for this research is:

U.S. Army Research Laboratory
Human Research and Engineering Laboratory
Aberdeen Proving Ground, MD

Authority:	Privacy Act of 1974, 10 USC 3013, 44 USC 3101, and USC 1071-1087
Principal purpose:	To document voluntary participation in the Research program. Social Security number (SSN) and home address will be used for identification and locating purposes.
Routine Uses:	The SSN and home address will be used for identification and locating purposes. Information derives from the project will be used for documentation, adjudication of claims, and mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies.
Disclosure:	The furnishing of SSN and home address is mandatory and necessary to provide identification and to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this data collection.

Part A – Volunteer agreement affidavit for research participants in approved Department of Army research projects
Note: Volunteers are authorized all necessary medical care for injury disease that is the proximate result of their participation in such studies under the provisions of AR 40-38 and AR 70-25.

Title of Research Project:	Performance Measure Sensitivity for Dismounted Warrior Encapsulation Effects; A Pilot Experiment	
Human Use Protocol Log Number:	ARL-20098-03011	
Principal Investigator(s):	MSG Lamar Garrett ARL (HRED)	Phone: (410) 278-3413 Lgarrett@arl.army.mil

Purpose of the Research

The purpose of this experiment is to conduct a pilot experiment to evaluate Performance Measures of Sensitivity for Dismounted Warrior Encapsulation Effects. Encapsulation is defined as enclosing the body in such a manner that all skin is protected from exposure to the elements of the battlefield. The evaluation is to assess the impact of encapsulation on your ability to perform various warfighter tasks. The results will be used to create assessments and recommendations in support of the future Warrior System program. The Army Research Laboratory (ARL) – Human Research and Engineering Directorate (HRED), is conducting this experiment.

PROCEDURES

Prior to your participation in this evaluation, the experimenters will ask if you have/had any injury, medical profile or have a medical problem that would preclude your participation in this experiment. If you have a medical problem or medical profile that could put you at risk in this experiment, you will not be allowed to participate. If you are eligible and choose to participate, you must sign the Volunteer Agreement.

You will be one of twelve personnel participating in this evaluation from 17 February- 5 March 2004. During this evaluation, participants perform the following tasks: 4-km cross country course, 500-meter obstacle course, grenade throw for accuracy, individual movement technique (IMT), sandbag carry, 1-mile road march, field strips an M16A2 rifle, and small-arms live firing with an M4 Carbine weapon, using the "Soldier performance test paradigm." Your working schedule will be Monday through Friday, 0600 to approximately 1500. The following information is a step-by-step process of the experiment.

During the first three days of the experiment, you will be assigned a research participant number, complete a health and demographics questionnaire and conduct training on doing tasks of the Soldier performance test paradigm. On the following days you will perform varying sets of the tasks in which you have been trained. Additionally, the experimenters will take anthropometric measurements. Anthropometric measurements will be compared to the 2nd through 98th percentile values for military personnel from the 1988 U.S. Army Anthropometric Survey (Gordon et al., 1989) and the 1977 U.S. Marines Corps Anthropometric Survey (White and Churchill, 1977). An individual with anthropometric measurements training will take the following measurements: Stature, Weight, Bizygomatic Breadth, Interpupillary Breadth, Head Length, Head Circumference, Head Breadth, Menton-Sellion Length, Neck Circumference, Bitragion Chin Arc, Bitragion Coronal Arc, Hand Length and Hand Breadth. Following the measures, you will be fitted with an M40 and M45 protective mask.

You will be wearing three different configurations of Soldier systems. During your march into the woods, you will be presented with visual targets to locate. Additionally, a hearing task will occur simultaneously that involves detection and identification of speech presented to the Soldier from a digital player/loudspeaker mounted on your back, weighting approximately 7 ounces. Throughout the course, Call sign Acquisition Test (CAT) will be played from the loudspeaker and you will respond by repeating the call sign. Responses will be recorded via a microphone onto a digital recorder. For the purpose of conducting this task, simulated targets will be emplaced at various locations at pre-determine distance and direction along the routes of the cross-country course. There will be a person at the mid-point way to insure that you are in proper condition and to provide water, if needed.

Prior to each day of evaluation trials, the principal investigator will question you, to assure that no apparent condition exists that may jeopardize your safety or health. Examples of such conditions would be a respiratory tract infection, excessive fatigue, recent excessive use of alcohol, or other ailments that may compromise safety.

Prior to each individual evaluation trial, a visual inspection will be performed to ensure that all experimental and war-fighter equipment is donned properly. Water will be available to you at all times. The second portion of the evaluation will be used to investigate the compatibility between the mask and select pieces of individual equipment. You will wear either the M40 or M45 with various pieces of protective equipment, body armor, helmets and load bearing equipment while carrying a dummy M4 carbine while negotiating the Soldier performance test paradigm.

During each trial you will wear the mask for a maximum of 60 minutes. You will perform no more than 1 course trial each day. You will be given a break of a minimum of ten minutes between each trial, with the exception of the mobility/portability course. Participants completed a familiarization walk through and 3 practices runs prior to the beginning of evaluation trials. At the end of the 500-meter obstacle course and small arms live-fire trial you will remove your equipment and complete a questionnaire. Also, during each trial you will wear a heart rate monitor attached to your LBV, which will be started prior to each trial and will be observed at the end of each trial.

The third portion of the evaluation will investigate the compatibility between the encapsulation configuration and small arms. The small arms compatibility section of this evaluation consists of two parts. The first part of the evaluation will consist of investigating shooter performance by firing live rounds at HRED's M-Range small arms live-firing range. The safety procedures at M-Range will be briefed to you. The weapons that will be fired during the live fire trials are the M16A2, and the M4 Carbine. After each live fire trial you will complete a questionnaire. After you have completed the live fire exercise you will be given a pre and post audiogram to determine if there is a change in hearing sensitivity.

The fourth portion of the evaluation is an assessment of encapsulation configurations comfort and cognitive performance measures, which affect the ability of the Soldier mental workload level (both Subjective and objective measures), stress, and shooting performance of the Soldier while shooting under various workload presentation modalities. Additionally, this study will examine the potential for friendly fire in a shoot-don't shoot scenario under various modes of workload presentation. Detect, identify, and localize sounds while in an operational environment. You will be asked to perform field- stripping trials. During each trial, the experimental will utilize a stopwatch to measure dexterity.

During the 3 to 6 hours of encapsulation, you will complete the Soldier performance test paradigm. You will walk through the "Soldier performance test paradigm" with the basic combat load, completing one trial in the helmet-on condition, which consists of wearing the M40 with the BDO suit, body armor vest, butyl rubber gloves, black vinyl overshoes (BVOs), PASGT helmet and the M4 carbine rifle.

You will complete two more trials wearing the M45 mask with the JSLIST suit, Interceptor, outer tactical vest, butyl rubber gloves, BVOs, MICH helmet-on condition and M4 Carbine rifle and either Future Warrior Soldier System configuration.

On days ten, eleven, and twelve are reserved, as make up days should the test fall behind schedule for any reason. If the test is completed on time, these three days will be used to assess the compatibility between ability of the Soldier mental workload level (both Subjective and objective measures), stress, and shooting performance of the Soldier while shooting under various workload presentation modalities. Additionally, this study will examine the potential for friendly fire in a shoot-don't shoot scenario under various modes of workload presentation. Detect, identify, and localize sounds while in an operational environment.

A photographer will be taking pictures during this pilot experiment. If you do not wish to have your photograph taken please inform the experimenters. If you agree to be photographed steps were implemented to protect the participants' identity from being published in any photograph or produced videotape.

Your identity will not be revealed in any documentation resulting from this work. All data collected during the experiment will be considered privileged and held in confidence. You can have access to any of the data collected from you upon request.

You may withdraw without penalty at anytime should you decide to do so. To summarize, below is a brief list of the tasks that you may perform during this evaluation:

1. Donning and doffing the mask (M40/M45), with individual chemical protection equipment (BDO/JSLIST).

2. Navigating a mobility-portability course while wearing encapsulation configuration and other individual combat equipment.

3. Firing live rounds with rifles while wearing encapsulation configuration.

4. Wearing a mask and other protective equipment for a 3 to 4 hour period, which includes the cross-country course, road march, IMT, grenade throw, and sandbag carry.

Benefits

There are no personal benefits to you for being in this experiment, however the results will help verify and explore methodology to measure sensitivity for dismounted warrior encapsulation effects and determine procedures for comparison.

Risks

Risks associated with this evaluation are minimal and are less than those encountered by war-fighters during their normal operational field trials. Frost Bite, Heat related injuries and dehydration are considered the leading risks. Other risks include physical fatigue, muscle strains, sprains, cuts, abrasions, skin irritations, broken bones and injuries which may result from trips or falls. You are advised that there are wild animals, snakes, and (poisonous) insects in the vicinity of some of the test sites and to take the appropriate precautions. There is risk of tick bites and the potential for Lyme disease at Aberdeen Proving Ground.

You will be encouraged to use insect repellent, which will be available at the test site, and we will ask you to inspect yourself frequently for ticks. All masks will be cleaned with sanitary respirator wipes before use. Also, mask drinking system components will be sanitized before and after use.

Members of the test administration staff will be close to you throughout all evaluation trials to assist you should a problem arise. If you ask to terminate the test, begin to have problems with your equipment or if the equipment becomes damaged, the evaluation will be stopped and your mask will be removed.

Care will be taken to minimize risks using the following precautions. At all times and at all test sites, the wearers, observers and test personnel will be encouraged to drink water freely to prevent dehydration. The guidelines from TB Med 507 will be used to determine acceptable work rest schedules. Wet Bulb Globe Thermometer reading plus 10 degrees will be used in correspondence to work rest schedules.

A copy of TB Med 507 will be kept available at all times. Daily meteorological records will be obtained from the Meteorological Service at Phillips Army Airfield. Also, the wet-bulb globe temperature (WBGT) and dry bulb temperature will be monitored at all test sites using portable WBGT monitors. If the heat index equals or exceeds 75°F testing will be halted for the day.

Outdoor activities will be suspended during any weather conditions that are inherently dangerous or will cause evaluation trials to be dangerous. If it is raining or snowing, or if there is an accumulation of water or snow on the ground, outdoor test activities will be delayed or canceled, if conditions are believed to be unsafe. Water will be available and you will be instructed to drink often. Water breaks will occur at least every 30 minutes for all trials that exceed 30 minutes in duration. You will be given at least a 20-minute break between the cross-country course and mobility-portability course trials. Test trials will be limited to one per day. As applicable, air conditioned or heated buildings will be available for breaks during inclement weather conditions. All personnel will wear hearing protection during all small arms compatibility trials at M Range. Safety procedures are well established at M Range in SOP#385-H-188 and will be closely followed.

Confidentiality

All data and information obtained about you will be considered privileged and held in confidence. Photographic or video images of you taken during this data collection will not be identified with any of your personal information (name, rank, or social security number). Complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or command authorities. In addition, applicable regulations note the possibility that the U.S. Army Medical Research and Materiel Command (MRMC-RCQ) officials may inspect the records.

Participant's Rights

Any published data will not reveal your identity. Your participation in this evaluation is voluntary. If you choose not to participate in this evaluation or if later, you wish to withdraw from any portion of it; you may do so without penalty. Military personnel are not participant to punishment under the Uniform Code of Military Justice for choosing not to take part as human research participants. No administrative sanctions can be taken against military or civilian personnel for choosing not to participate as human research participants. The furnishing of your social security number and home address is mandatory and necessary for identification and locating purposes to contact you if future information indicates that your health may be adversely affected. Failure to provide the information may preclude your voluntary participation in this experiment. Information derived from this experiment will be used to document the evaluation, to implement medical programs, to adjudicate claims, and for the mandatory reporting of medical conditions as required by law. Information may be furnished to Federal, State, and local agencies. Collection of this information is authorized by 10 USC 3013, 44 USC 3101, and 10 USC 1071-1087.

Under the provisions of AR 40-38 and AR 70-25, volunteers are authorized all necessary medical care for injury or disease which is the proximate result of their participation in this experiment.

<u>Cautions</u>: During this evaluation, photographs and videos may be taken. The photographs and videos will be used to document the evaluation. They will be edited to ensure that your name is not shown. If you would like to be in this experiment, please sign one of the following statements and then complete the rest of this form:

I **AUTHORIZE** you to photograph and videotape me during this evaluation.

____

(Your Signature)

I **DO NOT AUTHORIZE** you to photograph and videotape me during this evaluation

____

(Your Signature)

Obtaining of ASVAB Scores

IF YOU ARE AN ACTIVE DUTY ENLISTED MILITARY VOLUNTEER, we would like to obtain your Armed Services Vocational Aptitude Battery (ASVAB) scores for potential data analysis. The ASVAB scores would be used strictly for research purposes. The results of any such analyses would be presented for the group of participants as a whole; and no names will be used. With your permission, we will obtain these scores by sending a copy of this signed consent form along with your Social Security Number to the Defense Manpower Data Center (DMDC) in Seaside, CA where ASVAB scores may be obtained from their databases in Arlington, VA or Seaside, CA. If you do not wish your ASVAB scores to be released to the principal investigator, you will still be allowed to participate in the research.

If you would like to participate in this research, please sign one of the following statements, and then complete the information requested at the end of this form:

I **DO AUTHORIZE** you to obtain my ASVAB scores. ____________________
(Your Signature)

I **DO NOT AUTHORIZE** you to obtain my ASVAB scores. ________________
(Your Signature)

Compensation

You will receive no compensation from participating in the project, other than the personal satisfaction of impacting future warrior performance research and ultimately help guide the design of future dismounted warrior systems.

Disposition of Volunteer Agreement Affidavit

The Principal Investigator will retain the original signed Volunteer Agreement Affidavit and forward a photocopy of it to the Chair of the Human Use Committee after the data collection. The test administrator will provide a copy to the volunteer.

Contacts for Additional Assistance

If you have questions concerning your rights on research-related injury, or if you have any complaints about your treatment while participating in this research, you can contact

Chair, Human Use Committee U.S. Army Research Laboratory Human Research and Engineering Directorate Aberdeen Proving Ground, MD 21005 (410) 278-0612 or (DSN) 298-0612	**OR**	Office of the Chief Counsel U.S. Army Research Laboratory 2800 Powder Mill Road Adelphi, MD 20783-1197 (301) 394-1070 or (DSN) 290-1070

Date of preparation of current version: 20030308
Date of Human Use Committee Review: TBD
Expiration Date: TBD   Volunteer Initials______ Administrator
Initials_________

Appendix B. Medical Health Questionnaire

Test Participant #______________________ Date: ______________________________

Research participant: Please answer all questions honestly and completely. Although we are asking your name on this form, this document will be kept strictly confidential. It will not be entered into your official health records.

1. Have you ever been treated by a physician for any of the following ailments, that would preclude your participation in this experiment? (Please circle your response)

Dizziness or fainting spells	Yes	No
Chronic respiratory illness	Yes	No
Asthma	Yes	No
Shortness of breathe	Yes	No
High or low blood pressure	Yes	No
Chest pain with exercise	Yes	No
Diseases of the arteries	Yes	No
Diabetes	Yes	No
Headaches	Yes	No
Cardiovascular Disease	Yes	No
Diabetes	Yes	No

Other (describe the ailment below)

____
____
____
____
____

2. Do you have any back, leg, or foot injury now? Yes ______ No ______

If yes, please describe.____

3. Have you had any surgery in the last two months? Yes ______ No ______

If yes, please describe.____

4. Are you presently on a profile of any type? Yes ______ No ______

If yes, please describe your current limitations. __________________________________

5. If the APFT (Army Physical Fitness Test) were held today, could you complete it?

Yes ______ No ______

6. Do you have any medical concerns about carrying your combat fighting load while performing this experiment?

Yes ______ No ______

If yes, please describe your concerns. ____

____

____

____

7. Are you taking any medication that could adversely affect your ability to participate in this experiment?

Yes ______ No ______

Appendix C. Demographics and Vision Summary

Table C-1. Demographic data summary.

Soldier ID No.	Age (years)	Time in Service (months)	Grade	MOS
1	20	32	E-5	11B
2	24	26	E-4	11B
3	22	42	E-4	11B
4	20	24	E-4	11B
5	23	34	E-4	11B
6	26	24	E-3	11B
7	21	31	E-4	11B
8	20	30	E-4	11B
9	20	28	E-4	11B
10	23	24	E-4	11B
11	24	29	E-4	11B
12	35	120	E-5	11B

All Soldiers had expert rifleman qualification per Army standards.

Table C-2. Vision screening summary.

Soldier ID No.	Corrective Eye Wear	Dominant Eye	Far Visual Acuity Both Eyes	Far Visual Acuity Right Eye	Far Visual Acuity Left Eye	Color Vision
1	No	R	20/17	20/25	20/35	Normal
2	No	R	20/15	20/20	20/35	Normal
3	No	R	20/15	20/13	20/17	Normal
4	No	L	20/18	20/40	20/35	Normal
5	No	R	20/13	20/13	20/15	Normal
6	No	R	20/22	20/15	20/25	Normal
7	No	R	20/17	20/13	20/50	Normal
8	No	R	20/18	20/20	20/35	Normal
9	No	R	20/13	20/13	20/13	Normal
10	No	R	20/15	20/15	20/15	Normal
11	Yes	R	20/13	20/17	20/30	Normal
12	No	R	20/20	20/20	20/20	Normal

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Appendix D. Anthropometric Measurements

Table D-1. Anthropometric measurements summary.

Soldier ID No.	Stature cm	Stature percent	Weight kg	Weight percent	Bizygomatic Breadth cm	Bizygomatic Breadth percent	Head Breadth cm	Head Breadth percent	Head Length cm	Head Length percent	Hand Length cm	Hand Length percent	Hand Breadth cm	Hand Breadth percent
1	187.3	95th	91.6	88th	15.4	95th	16.2	93rd	19.9	66th	20.0	75th	9.2	47th
2	170.2	21st	80.6	62nd	13.9	49th	14.8	38th	18.9	15th	20.3	75th	9.0	47th
3	178.0	64th	76.8	47th	13.1	30th	15.1	38th	19.9	66th	20.8	94th	8.9	47th
4	183.6	89th	74.4	36th	14.0	49th	15.2	38th	18.2	10th	21.4	94th	9.8	99th
5	175.0	47th	99.8	96th	14.1	49th	15.2	38th	19.7	66th	20.4	75th	9.0	47th
6	182.6	86th	96.4	93rd	14.6	95th	16.2	93rd	20.0	66th	21.9	99th	9.2	47th
7	180.7	79th	102.3	97th	14.3	49th	15.6	93rd	20.9	97th	22.4	99th	9.2	47th
8	166.5	8th	67.8	17th	14.7	95th	15.5	93rd	19.9	66th	19.2	36th	8.7	47th
9	174.1	41st	78.4	51st	14.5	49th	15.6	93rd	19.6	66th	21.4	94th	9.3	47th
10	183.3	86th	80.2	58th	14.9	95th	16.0	93rd	20.8	97th	20.8	94th	9.3	47th
11	169.4	16th	75.6	44th	13.7	49th	14.6	38th	20.3	66th	19.8	75th	9.0	47th
12	180.8	79th	117.6	99th	15.3	95th	15.6	93rd	20.2	66th	22.0	99th	9.5	99th

Soldier ID No.	Head Circumference cm	Head Circumference percent	Neck Circumference cm	Neck Circumference percent	Bitragion Chin Arc cm	Bitragion Chin Arc percent	Bitragion Coronal Arc cm	Bitragion Coronal Arc percent	Interpupillary Breadth cm	Interpupillary Breadth percent	Menton – Sellion-Length cm	Menton – Sellion-Length percent
1	59.0	92nd	43.6	99th	36.5	99th	38.0	98th	6.95	91st	12.1	39th
2	55.4	13th	40.9	93rd	33.3	63rd	34.6	40th	6.40	10th	13.3	89th
3	57.0	57th	39.7	85th	31.0	12th	35.7	70th	6.20	10th	12.1	39th
4	53.4	10th	39.0	71st	31.0	12th	35.5	70th	6.05	10th	11.8	39th
5	56.5	31st	43.5	99th	33.3	63rd	35.0	40th	6.45	10th	12.1	39th
6	58.0	79th	43.5	99th	32.2	33rd	37.5	98th	6.20	10th	13.5	99th
7	57.5	79th	42.8	99th	33.7	85th	34.7	40th	6.60	91st	12.8	89th
8	57.0	57th	38.9	71st	33.5	85th	35.5	70th	6.50	10th	12.8	89th
9	56.5	31st	42.1	97th	32.9	63rd	36.5	70th	6.35	10th	11.3	3rd
10	59.3	92nd	40.3	85th	33.5	85th	38.3	98th	6.40	10th	12.0	39th
11	56.8	57th	39.3	71st	32.5	33rd	35.1	40th	6.30	10th	11.3	3rd
12	58.6	92nd	44.2	99th	35.0	96th	36.0	70th	6.75	91st	12.5	39th

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Appendix E. Load Configurations Experimental Conditions and Total Fighting Load

Item description	Weight (lb)	Weight (kg)
A **Base Line**		
PASGT helmet (medium)	3.81	1.73
M40 mask with hood and outserts in carrier	4.34	1.97
M4 Carbine rubber training rifle	8.50	3.86
Battle dress uniform, boots	3.86	1.73
Underclothing and socks	0.60	0.27
Belt with buckle	0.20	0.09
Individual first aid kit	0.17	0.08
Canteen with cover, and 1 quart of water (two each)	6.60	3.00
Hand grenades (two each, inert)	2.00	1.00
30-round small arms magazines (six mock-ups each)	6.30	2.86
Total Fighting Load Weight	**45.88**	**20.85**
B **Current**		
Battle Dress Overgarment	5.75	2.61
PASGT helmet (medium)	3.81	1.73
M40 mask with hood and outserts in carrier	4.34	1.97
M4 Carbine rubber training rifle	8.50	3.86
Gloves, chemical protective	0.20	0.09
BVO	3.40	1.54
Battle dress uniform, boots	3.86	1.73
Underclothing and socks	0.60	0.27
Belt with buckle	0.20	0.09
Individual first aid kit	0.17	0.08
Canteen with cover, and 1 quart of water (two each)	6.60	3.00
Hand grenades (two each, inert)	2.00	1.00
30-round small arms magazines (six mock-ups each)	6.30	2.86
Total Fighting Load Weight	**54.53**	**24.79**
C **Future Warrior**		
JSLIST	6.30	2.86
MICH Helmet	2.71	1.23
M45 Mask	4.00	1.82
Gloves, chemical protective	0.20	0.09
BVO	3.40	1.54

M4 Carbine rubber training rifle	6.65	3.02
Battle dress uniform, boots	3.86	1.73
Underclothing and socks	0.60	0.27
Belt with buckle	0.20	0.09
Individual first aid kit	0.17	0.08
Combat Drinking System, and 2 quart of water	6.60	3.00
Combat Arms Earplug	0.11	0.01
Hand grenades (two each, inert)	2.00	3.86
30-round small arms magazines (six mock-ups each)	6.30	2.86
Total Fighting Load Weight	**51.50**	**23.41**

Appendix F. Sample Questionnaires

Individual Equipment Compatibility (Mobility-Portability Course) Questionnaire

Participant Number: _____   Mask Type: ___________   Date: __________

Equipment Configuration: _____

For the following questions place a check in the box next to the response that best describes your opinion of the equipment you wore during this trial.

1. Negotiating the obstacles was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

2. Seeing the obstacles was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

3. The impact of this equipment configuration on your obstacle course performance was:

- ☐ Extreme Impact
- ☐ Moderate Impact
- ☐ Slight Impact
- ☐ No Impact

4. Overall, the fit of the equipment condition was:

- ☐ Very Tight
- ☐ Tight
- ☐ Slightly Tight
- ☐ Slightly Loose
- ☐ Loose

5. Overall this equipment condition was:

- ☐ Very Comfortable
- ☐ Comfortable
- ☐ Slightly Comfortable
- ☐ Slightly Uncomfortable
- ☐ Uncomfortable
- ☐ Very Uncomfortable

6. Depth Perception while wearing the mask was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

7. Moving your head and neck was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

8. Moving your arms was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

9. Moving your torso was:

10. Moving your legs was:

☐ Very Easy	☐ Very Easy
☐ Easy	☐ Easy
☐ Slightly Easy	☐ Slightly Easy
☐ Slightly Difficult	☐ Slightly Difficult
☐ Difficult	☐ Difficult
☐ Very Difficult	☐ Very Difficult

11. The most difficult obstacle(s) to negotiate while encapsulated were:

____

____

11a. What made the obstacle(s) the most difficult:

____

____

12. The easiest obstacle(s) to negotiate while encapsulated were:

____

____

12a. What made the obstacle(s) the easiest:

____

____

13. Please discuss in detail any compatibility problems you may have experienced between the equipment configurations you wore during this trial:

____

____

14. Please add any comments you have concerning the encapsulation configurations you just wore, the equipment effect on obstacle course performance or any other comments you may have at this point:

____

____

Small Arms Compatibility Questionnaire

Participant Number: _____ Mask Type: ___________ Date: __________

Weapon Configuration (Circle One): M16 M4

Equipment Configuration (Circle One): A B C

For the following questions put a check in the box next to the response that best describes your opinion.

1. Acquiring targets was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

2. Obtaining a clear shot picture was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

3. Maintaining a consistent shot picture was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

4. The position of your head while sighting the weapon was:

- ☐ Very Comfortable
- ☐ Comfortable
- ☐ Slightly Comfortable
- ☐ Slightly Uncomfortable
- ☐ Uncomfortable
- ☐ Very Uncomfortable

5. Maintaining a steady hold of your weapon was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

6. Shouldering your weapon was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

7. Overall, firing your weapon accurately while wearing this equipment condition was:

- ☐ Very Easy
- ☐ Easy
- ☐ Slightly Easy
- ☐ Slightly Difficult
- ☐ Difficult
- ☐ Very Difficult

8. Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point:

____

____

9. Which side of the combat arms earplug was placed into your ear? (Circle One):

Green
Yellow

10. The combat arms earplug was:

- ☐ Very Comfortable
- ☐ Comfortable
- ☐ Slightly Comfortable
- ☐ Slightly Uncomfortable
- ☐ Uncomfortable
- ☐ Very Uncomfortable

11. Your situational awareness while wearing the combat arms earplug was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

12. Your perceived hearing protection during this trial was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

13. Please add any comments you may have concerning the combat arms earplug.

____

____

____

Completion Questionnaire

Participant Number: _____ Mask Number: ___________ Date: __________

Equipment condition (Circle one): A B C

For the following questions put a check in the box next to the response that best describes your opinion.

1. Overall, the fit while wearing this equipment was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

2. Overall, your field of view while wearing this equipment condition was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

3. Overall, the design of this equipment was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

4. Overall, the comfort of this equipment was:

- ☐ Very Good
- ☐ Good
- ☐ Slightly Good
- ☐ Slightly Poor
- ☐ Poor
- ☐ Very Poor

5. What are the best features of this equipment?

____
____
____

6. What are the worst features of this equipment condition?

____
____
____

7. Please list any other comments you have regarding, the effects this equipment condition had on your performance during the evaluation?

____
____
____

Table F-1. Results of mobility-portability course questionnaire.

Individual Equipment Compatibility	**Configuration A**		**Configuration B**		**Configuration C**	
	Mean	**SD**	Mean	SD	**Mean**	**SD**
1. Negotiating the obstacles	2.00	0.82	3.73	1.08	4.64	0.91
2. Seeing the obstacles	**1.36**	**0.66**	**3.27**	**1.32**	**3.36**	**1.35**
3. The impact of this equipment configuration on your obstacle course performance	2.82	0.73	1.73	0.55	1.32	0.48
4. Overall, the fit of the equipment condition	3.91	1.41	3.41	1.53	3.48	1.26
5. Overall this equipment condition	2.91	1.02	4.50	0.80	4.76	0.97
6. Depth Perception while wearing the mask	5.82	2.26	3.91	1.31	3.48	1.09
7. Moving your head and neck	2.68	2.19	3.91	0.97	4.40	1.00
8. Moving your arms	2.09	1.69	2.91	1.34	3.16	1.07
9. Moving your torso	2.59	2.02	2.86	1.39	3.08	1.08
10. Moving your legs	2.32	1.96	2.73	1.39	2.96	1.17

Bold text denotes significantly different ratings at the 0.05 alpha level
Note: Questions 1,2, and 7 thru 10 used the first rating scale
Question 3 used the second rating scale
Question 4 used the third rating scale
Question 5 used the forth rating scale
Question 6 used the fifth rating scale

Scale 1: 1=Very Easy 2=Easy 3=Slightly Easy 4=Slightly Difficult 5= Difficult 6=Very Difficult
Scale 2: 1=No Impact 2=Moderate Impact 3=Slightly Impact 4=Extreme Impact
Scale 3: 1=Loose 2=Slightly Loose 3=Slightly Tight 4= Tight 5= Very Tight
Scale 4: 1=Very Comfortable 2=Comfortable 3=Slightly Comfortable 4=Slightly Uncomfortable 5= Uncomfortable 6= Very Uncomfortable
Scale 5: 1=Very Good 2=Good 3=Slightly Good 4=Slightly Poor 5= Poor 6= Very Poor

Note: See Appendix G for additional Soldier comments from questions 11 thru 14
Note: Results of questions 1, 3, 6, 7, and 8 of the ANOVA reveal significantly differences in questionnaire responses in the Baseline configuration, than with either the Current or Future Warrior System ($p < .001$); however, no differences in responses when comparing the Current and Future Warrior System

Table F-2. Results of small arms compatibility questionnaire.

Small Arms Compatibility	**Configuration A**		**Configuration B**		**Configuration C**	
	Mean	**SD**	Mean	SD	**Mean**	**SD**
1. Acquiring targets	1.78	0.52	4.00	1.11	4.04	1.25
2. Obtaining a clear shot picture	1.65	0.78	4.05	1.17	4.15	1.22
3. Maintaining a consistent shot picture	1.91	0.90	4.32	1.09	4.23	1.18
4. The position of your head while sighting the weapon	2.39	1.62	4.36	0.85	4.15	1.19
5. Maintaining a steady hold of your weapon	1.70	0.47	3.27	0.94	3.19	1.33
6. Shouldering your weapon	1.83	0.58	3.32	1.32	3.62	1.39
7. Overall, firing your weapon accurately while wearing this equipment condition	2.22	1.59	3.91	1.27	4.12	1.14
8. The combat arms earplug	1.17	0.49	1.18	0.66	1.23	0.65
9. Your situational awareness while wearing the combat arms earplug	1.00	0.00	1.00	0.00	1.00	0.00
10. Your perceived hearing protection during	1.09	0.29	1.05	0.21	1.12	0.33

this trial

Bold text denotes significantly different ratings at the 0.05 alpha level

Note: Questions 1 thru 3, 5, 6, and 7 used the first rating scale
Question 4 and 10 used the second rating scale
Question 9 reveals no differences in responses when comparing the three equipment configurations
Question 11 and 12 used the third rating scale

Scale 1: 1=Very Easy 2=Easy 3=Slightly Easy 4=Slightly Difficult 5= Difficult 6=Very Difficult
Scale 2: 1=Very Comfortable 2=Comfortable 3=Slightly Comfortable 4=Slightly Uncomfortable 5= Uncomfortable 6= Very Uncomfortable
Scale 3: 1=Very Good 2=Good 3=Slightly Good 4=Slightly Poor 5= Poor 6= Very Poor

Note: Results of questions 1 thru 7 of the ANOVA reveal significantly differences in questionnaire responses in the Baseline configuration, than with either the Current or Future Warrior System ($p < .001$); however, no differences in responses when comparing the Current and Future Warrior System
Note: See Appendix G for additional Soldier comments from questions 8 and 13

Table F-3. Results of completion questionnaire.

Equipment Compatibility	**Configuration A**		**Configuration B**		**Configuration C**	
	Mean	**SD**	Mean	SD	**Mean**	**SD**
1. Overall, the fit while wearing this equipment	2.25	1.26	3.33	0.91	3.78	1.17
2. Overall, your field of view while wearing this equipment condition	2.38	1.91	3.95	0.97	3.65	0.98
3. Overall, the design of this equipment	2.88	1.80	3.76	0.89	4.00	1.28
4. Overall, the comfort of this equipment	2.83	1.79	4.33	1.11	4.30	1.33

Bold text denotes significantly different ratings at the 0.05 alpha level

Scale 1: 1=Very Good 2=Good 3=Slightly Good 4=Slightly Poor 5= Poor 6= Very Poor

Note: See Appendix G for additional Soldier comments from questions 5 thru 7
Note: Results of questions 1 thru 4 of the ANOVA reveal significantly differences in questionnaire responses in the Baseline configuration, than with either the Current or Future Warrior System ($p = .001$); however, no differences in responses when comparing the Current and Future Warrior System

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Appendix G. Soldier Comments

Mobility-Portability Course Questionnaire Comments

Participant	Equipment Configuration A
3	The most difficult obstacle(s) to negotiate while encapsulated were: Cargo net
4	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl What made the obstacle(s) the most difficult: It took to long to negotiate
7	The most difficult obstacle(s) to negotiate while encapsulated were: Cargo net What made the obstacles (s) the most difficult: The log balance
9	The most difficult obstacle(s) to negotiate while encapsulated were: Over and under
11	The most difficult obstacle(s) to negotiate while encapsulated were: Cargo net What made the obstacles (s) the most difficult: The bulk of the equipment

Participant	Equipment Configuration B
3	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl and Low crawl What made the obstacle(s) the most difficult: Mask
5	The most difficult obstacle(s) to negotiate while encapsulated were: Low crawl What made the obstacle(s) the most difficult: Equipment
	Please discuss in detail any compatibility problems you may have experienced between the equipment configurations you wore during this trial: Their no drinking system with this configuration, outside of the canteen and the hood is very hot
7	The most difficult obstacle(s) to negotiate while encapsulated were: Cargo net
9	The most difficult obstacle(s) to negotiate while encapsulated were: Over and Under The easiest obstacle(s) to negotiate while encapsulated were: The house
11	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl, low crawl and cargo net The easiest obstacle(s) to negotiate while encapsulated were: The knee high walls Please discuss in detail any compatibility problems you may have experienced between the equipment configurations you wore during this trial: I didn't get enough oxygen, causing me to experience headaches

Participant	Equipment Configuration C
3	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl and low crawl
4	The most difficult obstacle(s) to negotiate while encapsulated were: The equipment was poorly designed What made the obstacle(s) the most difficult: Equipment
5	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl and low crawl What made the obstacle(s) the most difficult: The equipment being loose
6	The most difficult obstacle(s) to negotiate while encapsulated were: Low crawl Please discuss in detail any compatibility problems you may have experienced between the equipment configurations you wore during this trial: The mask is hot and pinch my nose
7	The most difficult obstacle(s) to negotiate while encapsulated were: Cargo net What made the obstacle(s) the most difficult: The restriction of your equipment to maneuver and the mask
9	The most difficult obstacle(s) to negotiate while encapsulated were: The over and under
10	Please discuss in detail any compatibility problems you may have experienced between the equipment configurations you wore during this trial: Mask pinch the bridge of nose and it hard to sling your weapon with the cords attachments
11	The most difficult obstacle(s) to negotiate while encapsulated were: High crawl, low crawl and

	cargo net What made the obstacle(s) the most difficult: Cargo net, it hard to see; high crawl and low crawl hard to perform, due to in part to the mask Please add any comments you have concerning the encapsulation configurations you just wore, the equipment effect on obstacle course performance or any other comments you may have at this point: The "V" in the top of the LVB is to high up and digs into the back of the your neck, you can't move your neck and you can't adjust it. The filter on the mask is to large and it hard to perform the high crawl and low crawl with the mask on and you can't low crawl in mud or you end up choking yourself, by blocking the airflow of the filter on the mask.

Small Arms Questionnaire Comments

Participant	Equipment Configuration A
5	Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point: The LBV could fit better

Participant	Equipment Configuration B
6	Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point: The mask make it hard to obtain a good shot picture

Participant	Equipment Configuration C
4	Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point: The mask is not design for left handed firing
5	Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point: Mask fogging up
7	Please add any comments you may have concerning the uniform configuration effect on your weapon performance or any other comments you may have at this point: Acquiring target with this mask was pretty easy, however maintaining a consistent shot picture with this mask on is difficult

Completion Questionnaire Comments

Participant	Equipment Configuration A
7	What are the best features of this equipment: Grenade pouch and LBV

Participant	Equipment Configuration B
3	What are the worst features of this equipment condition: Hood
4	What are the best features of this equipment: Mask doesn't fog up What are the worst features of this equipment condition: Too hot Please list any other comments you have regarding, the effects this equipment condition had on your performance during the evaluation: Too hot
5	What are the best features of this equipment: Drinking system What are the worst features of this equipment condition: LVB, too bulky
6	What are the worst features of this equipment condition: Mask lenses affords poor vision and is hard to breathe though; the hood is hot and uncomfortable
7	What are the best features of this equipment: The boots What are the worst features of this equipment condition: The mask

Participant	Equipment Configuration C
3	What are the worst features of this equipment condition: The hood
4	What are the best features of this equipment: Combat Drinking System What are the worst features of this equipment condition: Mask vision
5	What are the best features of this equipment: Combat drinking system and the mask has better vision for acquiring targets; the chemical protective suit was cool What are the worst features of this equipment condition: The rest of the equipment
7	What are the worst features of this equipment condition: All the different cords that attached to the weapon
8	What are the best features of this equipment: The ear plugs, because they are small and don't interfere
9	What are the best features of this equipment: The way the chemical protective suit is made
10	What are the best features of this equipment: Outer Velcro pockets on the chemical protective suit What are the worst features of this equipment condition: Don't like the knee and elbow pads, mask felt as if, it was pinching my nose

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Appendix H. Comments From the Exit Interview

The following are excerpted comments from the Exit Interview:

Configuration A

Advantages

- Fine, great configuration
- BDU affords better mobility
- Allows full range of motion

Disadvantage

- No protection against Nuclear, Biological, and Chemical Weapons

Configuration B

Advantages

- Provided protection against Nuclear, Biological, and Chemical Weapons
- The suspenders were fine.

Disadvantages

- Lenses – Felt like wearing contact lenses. Had a hard time with peripheral vision. The chinstrap did not cover correctly.
- Breathing – The rubber hood became very hot and uncomfortable.

Configuration C

Advantage

- System has potential to provide new technology to Soldiers' about enemy activity and situation understanding of battlefield.

Disadvantages

- Drinking Tube – The tube would drain into the mask. A shut off valve is needed.
- Mask - Gage needed on mask to keep it from moving.
- Mask was fogging up.
- Helmet Mich – GPS, needs to be cut higher at ears, on Future Warrior (Version 1.0).
- The cord that connects the helmet to the back of the load-bearing equipment was frequently caught in branches during the cross-country course.
- Could use better padding. Big metal box on hip "hurts".
- Future Warrior Mask – Was hard to breathe in. Could not suck in as much air.

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Mobility-Portability Obstacle Course

Configuration A

Advantage

There were some small injuries such as bruises, etc. after a week.

Disadvantages

Obstacles – The most difficult to negotiate was the cargo net and the low crawl.

The Future Warrior helmet, without thick padding the chinstrap would move, especially during the low-crawl.

The comments were similar to the ones expressed regarding the cross-country course.

Test – 6 runs – By Thursday some participants were wearing out. Others felt that they could have done another week.

Configuration B

Advantage

None

Disadvantages

Could not see very well with mask on.

Encapsulation felt very dramatic.

Really felt the effects when going over the cargo net.

Felt hotter in configuration B then in configuration C.

Configuration C

Advantages

New technology

Disadvantages

Knee pads would get caught.

Grenades might slip because of gloves being wet.

In the Future Warrior configuration all of the weight is in the front.

Body armor would have slowed them down.

Sand Bags – OK if you keep up a steady pace. After 15 sand bags task becomes strenuous. Capsulated against base line.

Road March – OK if you keep steady pace. Future Warrior was better. Configuration B was very hot.

Shooting Performance Facility (M-Range)

Advantages

CCO shoots better.

Easier to identify and engage target with CCO.

Easier to shot with C than B, both with the Iron Sights and CCOs.

Disadvantages

Shooting Performance – “A” Wide angle.

Participants were trained and experienced. M4 Carbine.

Base Line – Iron Sights/CCOs, had to aim low, no complains.

Far right target was hard to detect.

Earmuffs – Could not get head low enough. Do not wear earmuffs with mask.

Jacket – Neck needs to be longer on the jacket, too restrictive.

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