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THE EFFECTS OF LAYERS OF COLD WEATHER CLOTHING AND TYPE OF LINER ON THE PSYCHOMOTOR PERFORMANCE OF MEN

June 1977

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UNITED STATES ARMY
NATICK RESEARCH and DEVELOPMENT COMMAND
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This study was conducted to determine the differential effects on men's motor performance of wearing the clothing layers comprising the Army cold weather system, including both nylon polyester (Std. A) and mohair frieze (Std. B) liners. The dependent variables investigated were body flexibility, rate of movement, psychomotor coordination, manual dexterity, and effort exerted for task performance. Sixteen Army enlisted men, outfitted in winter underwear, performed the battery of 14 tasks under each of the following conditions: (1) wool shirt

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and trousers, (2) plus field jacket and trousers, (3) plus Std. A liners or Std. B liners in the field layer, (4) plus parka and arctic trousers, (5) plus Std. A or Std. B liners in the arctic layer. In general, Std. B liners impaired certain aspects of psychomotor performance, particularly body flexibility, to a greater extent than the Std. A liners did. In addition, the Std. A liners were rated more favorably by the users and resulted in a somewhat lower level of physical exertion, as represented by heart rate, than did the Std. B liners. Psychomotor performance level and user acceptance also decreased as the number of clothing layers was increased, but the layers were not equally deleterious in their effects on performance nor were all aspects of performance equally impaired by wearing a certain combination of layers. Interference with specific flexibility movements was attributed to such design characteristics as clothing weight, bulk, garment waist lengths, and garment waist dimensions.

PREFACE

The study reported here was conducted by the Human Factors Group, Clothing, Equipment, and Materials Engineering Laboratory. This work was carried out as part of NARADCOM Project No. 1L762716AH70–02, Army Human Factors Engineering – Man/Environment Compatibility Research. The authors wish to thank the following individuals who reviewed this paper for their helpful comments: Mr. James H. Flanagan, Dr. Robert S. Smith, Mr. Leonard F. Campbell, Ms. Edna S. Albert, Dr. Richard F. Johnson, Ms. Sirvart A. Mellian, and Mr. Norbet Rodil.

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INTRODUCTION

The principal purpose of the present study was to evaluate the differential effects on men's motor performance of the clothing layers comprising the Army cold-dry system, including both nylon polyester (Std. A) and mohair frieze (Std. B) liners. This research was part of a larger program the goals of which are: (1) to develop techniques to evaluate the effects on human performance of existent clothing and personal equipment systems, and (2) to assemble a catalogue of design criteria or guides aimed at minimizing the adverse effects of future clothing and equipment systems on motor performance. In the present experiment, as in the other studies comprising this program, no attempt was made to simulate parameters of clothing and equipment. Instead, existent items were employed and, over the course of the program of experiments, inductions regarding design criteria for minimum performance interference will be made from the items being tested and applied to a larger universe of clothing and personal equipment.

Independent Variables

The clothing items worn by the men participating in this study were components of the Army cold weather uniform, excluding the appropriate handwear, headwear, and footwear. The men wore elements of the cold weather uniform both with and without Std. A and Std. B liners. The two types of liners differed in weight, material, and design characteristics with the Std. A being lighter. The experimental design was such that comparisons could be made between these two types of liners in terms of their relative effects on performance. The men in the study performed while wearing the wool, cold weather shirt and trousers alone and in combination with the field jacket and trousers, with and without liners, and the parka and arctic trousers, with and without liners. Therefore, the effects of adding layers of clothing to the body could also be evaluated.

Dependent Variables

The dependent variables on which the effects of clothing layers and types of liners were determined were divided into five categories: (1) body flexibility, (2) rate of movement, (3) psychomotor coordination, (4) manual dexterity, and (5) effort exerted for task performance. These measures were part of a larger list proposed by Siegel, Bulinkis, Hatton, and Crain[1] to be used in evaluations of pressure suits and other flight apparel. A number of tasks within each category were selected to comprise the performance battery used in this study.

[1]Siegel, A. I., Bulinkis, J., Hatton, R., & Crain, K. *A technique for the evaluation of operator performance in pressure suits and other flight apparel* (Tech. Rep. NAMC-ACEL-435). Philadelphia: Naval Air Material Center, 1960.

The **flexibility tasks** have been employed in previous clothing evaluation studies and evolved principally from an investigation by Saul and Jaffe.[2] The purpose of their study was to develop and analyze quantitative techniques for measuring movement interference due to clothing and equipment. The flexibility tasks were used to measure the limits of movement of various parts of the body, including the arm and shoulder, trunk and waist, and leg and hip. They also involved movement of segments in the frontal, the sagittal, and the transverse planes of the body.[3] The flexibility tasks used in the present experiment were the following: (1) Standing and (2) Sitting Trunk Flexion, (3) Upper Arm Abduction, (4) Upper Arm Forward Extension, (5) Upper Arm Backward Extension, (6) Upper Leg Abduction, (7) Upper Leg Forward Extension, and (8) Upper Leg Backward Extension. The first two of the tasks involved bending of the upper trunk at the waist in the body's sagittal plane. Upper Arm and Upper Leg Abduction required movement in the frontal plane, while Forward and Backward Upper Arm and Upper Leg Extension were movements in the body's sagittal plane.

Saul and Jaffe (reference 2) employed all of these flexibility tasks, excluding the Upper Leg Forward Extension Test, in an investigation of the effects on body movement of the following three clothing ensembles: (1) T-shirt, athletic supporter, track shorts, athletic socks, and wrestling sneakers; (2) winter underwear, wool shirt, wool trousers, suspenders, wool socks, and cold-wet boots; and (3) clothing listed under (2) plus field jacket with Std. B liner and arctic trousers. They found Upper Leg Abduction and Upper Arm Abduction, Forward Extension, and Backward Extension movements to be increasingly restricted with each addition of clothing. That is, these tasks systematically discriminated among the clothing conditions studied. Standing and Sitting Trunk Flexion and Upper Leg Backward Extension discriminated in a less consistent fashion between two of the three clothing combinations.

Dusek[4] applied some of the Saul and Jaffe flexibility tasks in a study designed to measure the restrictive effects of the standard Army arctic uniform and to reveal those body movements most affected by such restrictions. He found that, compared to wearing shorts, the complete arctic uniform with Std. B liners impaired Standing Trunk Flexion, Upper Arm Forward Extension, Upper Arm Abduction, and Upper Leg Backward Extension.

[2] Saul, E. V. & Jaffe, J. *The effects of clothing on gross motor performance* (Tech. Rep. EP–12). Natick, MA: Quartermaster Research and Development Center, June 1955.

[3] Roebuck, J. A. A system of notation and measurement for space suit mobility evaluation. *Human Factors*, 1968, *10*, 79–94.

[4] Dusek, E. R. *Encumbrance of arctic clothing* (Tech. Rep. EP–85). Natick, MA: Quartermaster Research and Engineering Center, April 1958.

In addition to the eight flexibility tasks included in the performance battery for the present study, two **rate of movement tasks**, the Front and the Side Horizontal Striking Tasks, were used. These tasks were chosen primarily to measure the speed with which subjects could accomplish a given movement or series of movements. The Front Horizontal Striking Test was similar to one used by McKee[5] in an experiment to determine the effect of clothing upon the speed of movement in the arm and shoulder girdle. The arm movement involved in McKee's Horizontal Striking Task, as well as in the Front Striking Task of the present study, was continual shoulder adduction and abduction with the arm fully extended at approximately shoulder level. Therefore, the arm moved across the body at shoulder height in a transverse plane. The arm movement required in the Side Horizontal Striking Task was in the same plane. However, the arm moved toward the back and away from the body. McKee simulated clothing restriction by use of a harness placed across the shoulders and tightened to allow only 4.0 to 10.0 cm (1.57 to 3.94 inches) of forward, upper arm movement. It was found that Front Horizontal Striking was significantly impaired by the wearing of the restrictive harness.

The **psychomotor tasks** used in the present study, the Pursuit Rotor and Railwalking, have been included in other performance batteries. Saul and Jaffe (reference 2) found that the latter showed high test-retest reliability and was affected by the addition of clothing, but it did not discriminate between the two winter clothing conditions used in their study. Kiess and Lockhart[6] used Railwalking in an experiment on the effects of adding one, two, or four layers of Army cold weather clothing to the standard fatigues. Railwalking performance was greatly impaired by the addition of the field jacket and trousers with Std. B liners and decreased further when the parka and arctic trousers with Std. B liners were also used. In a second unpublished study, Kiess and Lockhart[7] attached weights of either 0.0, 2.27, 4.54, or 6.82 kg (0.0, 5.0, 10.0, or 15.0 lb, respectively) to a webbing harness worn by the subject on his chest and waist. Weight on the torso had a significant effect on Railwalking with optimum performance associated with weights of 2.27 and 4.54 kg.

[5] McKee, M. E. *The effect of clothing on the speed of movement in the upper extremity* (Tech. Rep. EP–48). Natick, MA: Quartermaster Research and Engineering Center, June 1957.

[6] Kiess, H. O. & Lockhart, J. M. *Levels of clothing and components of psychomotor performance.* Unpublished manuscript, US Army Natick Laboratories, 1967.

[7] Kiess, H. O. & Lockhart, J. M. *Upper torso weight and components of psychomotor performance.* Unpublished manuscript, US Army Natick Laboratories, 1967.

The other psychomotor coordination task included in the present performance battery, the Pursuit Rotor, required that the subject use a stylus to track a target which moved in a circle. The stylus was grasped in the hand and tracking was effected by movement of the arm and shoulder. Kiess and Lockhart (reference 6) used this task in their study of arctic clothing layers and found that time on target decreased when the field jacket and trousers with Std. B liners were worn over the standard fatigues. Performance levels decreased further when the parka and arctic trousers with Std. B liners were also used.

The fourth category of tasks used in the present study was **manual dexterity.** This was represented by the Purdue Pegboard Assembly Test, which involved simultaneous movement of both hands, and the O'Connor Finger Dexterity Test, which was done with one hand. Therefore, possible differential effects of the present clothing conditions on a one- vs. a two-handed task could be assessed. Kiess and Lockhart (reference 7) found the Purdue Pegboard Test to be unaffected by the addition of weights to the torso and, in another of their studies (reference 6), obtained a slight performance decrement when the complete cold-dry uniform was worn.

In the present study, **heart rate** was employed as a measure of the effort exerted under the various clothing conditions. It was recorded at selected intervals during the performance of the task battery in order to determine whether higher rates would be associated with some conditions than with others.

In addition to the quantitative measures of performance on the task battery, a **questionnaire** was devised to obtain subjective reports regarding each clothing condition. A similar approach was used by Scheetz, Corona, Ellis, Jones, and Randall[8] who had subjects perform a series of movements representative of combat-relevant tasks while wearing different types of body armor. The subjects then rated each armor vest on scales consisting of pairs of bipolar adjectives, such as loose-tight, balanced-unbalanced, and comfortable-uncomfortable. The Sheetz et al. study also employed subjective report techniques to determine the location of binding and restriction when two different types of body armor were worn while simple body movements were being performed. A similar approach was incorporated into the questionnaire devised for the present study. Subjects were asked to indicate those tasks in the battery on which the clothing interfered with performance and to rate the impact of various clothing design characteristics on

[8]Scheetz, H. A., Corona, B. M., Ellis, P. H., Jones, R. D., & Randall, R. B. *Human factors evaluation of the USMC M1955 armored vest and the proposed titanium nylon improved conventional munitions protective armored vest (48 plate)* (Tech. Memo 8–73). Aberdeen Proving Ground, MD: US Army Human Engineering Laboratory, March 1973.

performance. By combining, in a single study, objective measures of physiological exertion and of motor performance on tasks which form a basic repertoire of human movement with subjective responses to the clothing being tested, it is the aim of this experiment to determine the effects of the clothing systems on performance and user opinion. It is anticipated that user opinion impacts upon employment of the systems.

METHOD

Subjects. The subjects were 16 Army enlisted men who served as volunteers in the Climatic Research Chamber Test Subject Platoon at the US Army Natick Research and Development Command. They ranged in age from 18 to 29 with the mean age being 21 years. The stature, crotch height, chest circumference, waist circumference, and weight were obtained for each man in order to properly fit him with the clothing systems being tested. Descriptive statistics for these measures are presented in Table 1. Also included in Table 1 are comparable data for a sample of over 6600 US Army men.[9]

Clothing. The clothing items worn by the subjects over the course of the experiment are listed in Table 2 and pictured in Appendix A. Information regarding the physical characteristics of the items is presented in Appendix B. These are the prescribed finished measurements for the various sizes of clothing as found in the military specification for each item. Detailed descriptions of their design are included in Appendix C. The items comprised a modified version of the Army cold-wet and cold-dry clothing systems. The suspenders were worn over the wool, cold weather shirt and attached to the field trousers and to the arctic trousers as well, when the latter were worn. When only the cold weather shirt and trousers were used, no suspenders were worn. The field jacket and the parka were zipped to the neck and all front snaps and the sleeve cuffs were closed. The waist and hemline drawcords of the parka were secured. The collar of the field jacket was turned down. No hood or fur ruff was worn with the parka. The footwear used throughout the study was gym shoes and standard Army dress socks. Regardless of the clothing condition being tested, each man always wore the undershirt and drawers and the cold weather shirt and trousers.

Tasks. Fourteen tasks were used to assess the performance of the men in this experiment. A goniometer was used on eight tasks to measure angular displacement of various parts of the body. The goniometer was an instrument consisting of a rotatable pendulum mounted in front of a moveable 360° scale. Both the scale and the pendulum were mounted on a thin block which was attached to a long strap. Accurate use of the goniometer demanded that the scale remain in an almost vertical plane so that the pendulum could rotate freely to the vertical. As generally used in this study, the goniometer was strapped in a vertical position to a part of the body and set to zero by turning the moveable scale until the 0° mark coincided with the pendulum. The subject was then instructed to move his body in a certain fashion and, when the maximum amplitude of movement was reached, the degrees of arc through which the body part had passed were read directly from the point on the scale aligned with the pendulum.

[9]White, R. M. & Churchill, E. *The body size of soldiers: US Army anthropometry – 1966* (Tech. Rep. 72–51–CE). Natick, MA: US Army Natick Laboratories, December 1971.

Table 1

Selected Body Dimensions of the Study Sample vs. Those of a Larger Sample of US Army Men

Measure	Mean	s.d.	Range	Min.	Max.	n	t	
Stature (cm)								
Study	174.90	7.55	27.94	160.02	187.96	16	0.1948	
Large Sample	174.52	6.61	48.00	151.64	199.64	6682		
Crotch Height (cm)								
Study	79.06	5.28	17.78	71.12	88.90	16	3.5764	$p < .01$
Large Sample	83.94	4.67	36.83	64.77	101.60	6682		
Chest Circum. (cm)								
Study	93.03	8.99	40.64	78.74	119.38	16	0.3229	
Large Sample	93.78	6.69	52.58	71.63	124.21	6682		
Waist Circum. (cm)								
Study	78.90	8.37	33.02	68.58	101.60	16	0.6425	
Large Sample	80.29	8.18	69.09	58.67	127.76	6681		
Weight (kg)								
Study	73.32	13.18	60.23	55.45	115.68	16	0.2936	
Large Sample	72.32	10.60	83.63	45.23	128.86	6677		

TABLE 2

List of Clothing Items

Item	Federal Stock No.
Drawers, Mens, Cotton/Wool	8415–904–5120,–5121,–5122
Undershirt, Mens, Cotton/Wool	8415–904–5135,–5136,–5137
Trousers, Cold Weather, Wool Serge	8415–231–7200,–7203,–7206
Shirt, Cold Weather, Wool/Nylon Flannel	8415–188–3792,–3791,–3798
Suspenders, Trousers	8440–221–0852
Trousers, Mens, Cotton/Nylon Wind Resistant (field)	8415–265–0380,–0383,–0386
Liner Trousers, Nylon Quilted (field) (Std. A)	8415–782–2924,–2926,–2928
Liner Trousers, Mohair Wool Frieze (field) (Std. B)	8415–261–6854,–6856,–6858
Coat, Mens, Cotton/Nylon Wind Resistant (field)	8415–782–2936,–2939,–2942
Liner Coat, Mens, Nylon Quilted (field) (Std. A)	8415–782–2887,–2888,–2889
Liner Coat, Mens, Mohair Wool Frieze (field) (Std. B)	8415–261–6591,–6592,–6593
Trousers, Mens, Cotton/Nylon (arctic)	8415–782–2951,–2954,–2957
Liner Trousers, Nylon Quilted (arctic) (Std. A)	8415–782–2924,–2926,–2928
Liner Trousers, Mohair Wool Frieze (arctic) (Std. B)	8415–261–6845,–6847,–6849
Parka, Mens, Cotton/Nylon Oxford	8415–782–3217,–3218,–3219
Liner Parka, Mens, Nylon Quilted (Std. A)	8415–782–2882,–2883,–2884
Liner Parka, Mens, Mohair Wool Frieze (Std. B)	8415–240–2460,–2461,–2462

The first eight of the tasks comprising the present performance battery were used to measure the amplitude of movement of various body joints. The remaining tasks also involved such a flexibility component, as well as rate of movement, manual dexterity, and psychomotor coordination factors. The tasks were administered in a standard manner and in the same order for all subjects. There were four trials on the first 10 tasks and one trial on each of the remaining tasks. The tasks are briefly described below in order of presentation. Additional information regarding the battery and directions for administering the tests are presented in Appendix D along with photographs of a subject performing each of the tasks.

Task 1. Standing Trunk Flexion.[10] The subject stood straight and the goniometer was placed on the right side of the body at chest height and set to zero. The subject then did a toe-touch while keeping his knees straight. The task was used to measure how far the subject could bend toward his toes, with higher scores indicating greater distances. Angular displacement was also recorded, in degrees, from the goniometer.

Task 2. Sitting Trunk Flexion (reference 10). The subject sat on a bench with his legs straight out in front of him. The goniometer was placed on the right side of the body at chest height and set to zero. The subject then touched his toes while keeping his knees straight. The task was used to measure how far the subject could bend toward his toes, with lower scores indicating greater distances. Angular displacement, in degrees, was also recorded.

Task 3. Upper Arm Abduction (reference 4). The goniometer was placed on the right arm above the elbow. The subject stood with his body touching the corner of a wall and the goniometer was set to zero. Both arms were raised sideward and upward as far as possible, and the angular displacement was read, in degrees, from the goniometer.

Task 4. Upper Arm Forward Extension (reference 10). The goniometer was placed on the right arm above the elbow. The subject stood erect with his arms against his side and his elbows stiff. The goniometer was set to zero. The right arm was then raised as far forward and up as possible with the elbow being kept stiff, and the angular displacement was read, in degrees, from the goniometer.

[10] Dusek, E. R. & Teichner, W. H. *The reliability and intercorrelations of eight tests of body flexion* (Tech. Rep. EP–31). Natick, MA: Quartermaster Research and Development Center, May 1956.

Task 5. Upper Arm Backward Extension (reference 2). The goniometer was placed on the right arm above the elbow. The subject stood erect with part of his back against a wall, his arms at his side, and his elbows stiff. He rotated his right arm until the palm was facing out and the thumb was pointed dorsally. The goniometer was set to zero. The right arm was then raised backward as far as possible, with the elbow being kept stiff, and the angular displacement was read, in degrees, from the goniometer.

Task 6. Upper Leg Abduction (reference 2). The goniometer was placed on the right leg above the knee. The subject stood erect with feet together and facing an upright support about one foot in front of him which he grasped with both hands. The goniometer was set to zero. The subject raised his right leg sideward and up as far as possible while keeping his leg straight and the angular displacement, in degrees, was read from the goniometer.

Task 7. Upper Leg Forward Extension. The subject stood erect with his back against a wall and his feet together. The goniometer was placed on the right leg above the knee and set to zero. Supporting himself with the left hand on the back of a chair, the subject raised his right leg forward while keeping his knee stiff, and angular displacement was read, in degrees, from the goniometer.

Task 8. Upper Leg Backward Extension (reference 10). The goniometer was placed on the right leg above the knee. The subject stood facing and touching a wall with his right hip and leg at the edge of the wall and the goniometer was set to zero. The right leg was then moved as far backward as possible while the subject maintained contact with the wall. The maximum angular displacement was read, in degrees, from the goniometer.

Task 9. Pursuit Rotor.[11] This was a test of psychomotor coordination involving the arm and the shoulder. The subject was required to keep the tip of a stylus, which was held in his preferred hand, in contact with a disc which was 1.25 cm (.49 in.) in diameter. The stylus tip was 0.4 cm (.16 in.) in diameter. The disc was embedded in the surface of a turntable which rotated at a speed of 60 rev/min and was 26 cm (10.24 in.) in diameter. The score was the total time on target during a 30-sec trial.

Task 10. Railwalking.[12] This was a test of psychomotor coordination involving several sensorimotor groups. A rail 635 cm (250.00 in.) long and 1.90 cm (.75 in.) wide

[11] Melton, A. W. (Ed.). *Apparatus tests* (AAF Aviation Psychology Program Research Report No. 4). Washington, D.C.: Government Printing Office, 1947.

[12] Dusek, E. R. *Standardization of tests of gross motor performance* (Tech. Rep. EP–81). Natick, MA: Quartermaster Research and Engineering Center, January 1958.

was marked at intervals of 1.0 cm (.39 in.). While grasping his hands behind his back, the subject was to walk the rail in heel-to-toe fashion. His score was the distance from the start of the rail to the toe of the last foot that remained on the rail when he lost his balance.

Task 11. O'Connor Finger Dexterity Test.[13] In this test of manual dexterity, the subject was required to put three pins in each of 20 holes using only one hand. The pins were 2.5 cm (.98 in.) long and 0.1 cm (.04 in.) in diameter. The holes were 0.5 cm (.20 in.) in diameter. The score was the time required, in seconds, to complete to task.

Task 12. Purdue Pegboard Assembly Test.[14] In this test of manual dexterity, the subject was required to construct 12 pin-washer-collar-washer assemblies in a pegboard using both hands simultaneously. His score was the time required, in seconds, to complete the assemblies.

Task 13. Front Horizontal Striking. This test was used as a measure of rate of movement. The height of a horizontally-mounted cable was adjusted to the subject's shoulder height and the distance between two stops mounted on the cable was such that the movement of the preferred arm subtended a 30° angle when the subject was positioned in front of one stop and an arm's length from the cable. Facing the cable, the subject stood an arm's length from it with the shoulder of his preferred hand in front of one stop and moved a striker between the stops as rapidly as possible. His score was the number of times in 60 sec than he struck the stop in front of him after striking the far stop. The subject was to move only his shoulder and arm while striking across his body and was to keep his arm straight at all times.

Task 14. Side Horizontal Striking. This test was used as a measure of rate of movement. As in Front Horizontal Striking, the height of a horizontally-mounted cable was adjusted to the subject's shoulder height and the distance between two stops mounted on the cable was such that the movement of the preferred arm subtended a 30° angle when the subject was positioned in front of one stop and an arm's length from the cable. The subject stood with the side of his body facing the cable and an arm's length from it with the shoulder of his preferred hand in front of one stop. He was to move a striker between the stops as rapidly as possible. His score was the number of times in 60 sec that he struck the stop in front of him after striking the far stop. The subject was to move only his shoulder and arm while striking back away from his body and was to keep his arm straight at all times.

[13] Hines, M. & O'Connor, J. A measure of finger dexterity. *Journal of Personnel Research,* 1926, *4*, 379–382.

[14] Purdue Research Foundation. *Examiner manual for the Purdue pegboard.* Chicago: Science Research Associates, 1948.

In addition to employing this task battery to obtain quantitative performance data, a questionnaire was devised and administered to the men in order to elicit their subjective opinions regarding those tasks comprising the battery which were most affected by the clothing conditions. They were also asked to rank and to rate the extent to which a number of clothing design characteristics may have aided or impaired their performances. A complete copy of the questionnaire is presented in Appendix E.

Heart rate was recorded at two intervals during the performance of the task battery. A silver cup electrode for monitoring heart rate was affixed to the ventral surface of each lower arm and connected to a wide-band, a.c. preamplifier (Grass Instruments, Model 7P3), the output of which was recorded on a polygraph (Grass Instruments, Model 7).

Procedure. Before testing began, measurements of selected body dimensions were obtained for each man (Table 1) and he was issued appropriately-sized clothing items (Table 2). The subjects, wearing the standard Army garrison uniform, then received practice on four tasks in the test battery, Railwalking, the Pursuit Rotor, the O'Connor Finger Dexterity, and the Purdue Pegboard Assembly Tests. The practice phase generally extended over four days and included two sessions per day. At each session, the subject received five trials on each of the above tasks with the exception of the Pursuit Rotor, on which he received 10 trials. During this time, the men were also familiarized with all the tasks in the battery, the questionnaire, and the general procedure to be followed during the experimental sessions.

For the experimental sessions, the test chamber was maintained at 10°C (50°F). Each man participated at the same time each day, either in the morning or in the afternoon, for four consecutive days. At each session, he performed all tasks in the battery under two of the eight clothing conditions. Photographs of the clothing are presented in Appendix A. The clothing conditions and the approximate weight of each, based upon measuring the medium-regular sizes of the garments, were as follows:

1. One layer: Wool, cold weather shirt and trousers (Wool) -- 2.580 kg (5.69 lb)

2. Two layers: Wool shirt and trousers, field jacket and trousers (Wool + Field) -- 5.170 kg (11.39 lb)

3. Three layers: Wool shirt and trousers, field jacket and trousers with Std. A liners (Wool + Field/A) -- 5.825 kg (12.84 lb)

4. Three layers: Wool shirt and trousers, field jacket and trousers with Std. B liners (Wool + Field/B) -- 7.060 kg (15.56 lb)

5. Four layers: Wool shirt and trousers, field jacket and trousers with Std. A liners, parka and arctic trousers (Wool + Field/A + Arctic) -- 7.355 kg (16.21 lb)

6. Four layers: Wool shirt and trousers, field jacket and trousers with Std. B liners, parka and arctic trousers (Wool + Field/B + Arctic) -- 8.590 kg (18.93 lb)

7. Five layers: Wool shirt and trousers, field jacket and trousers with Std. A liners, parka and arctic trousers with Std. A liners (Wool + Field/A + Arctic/A) -- 8.195 kg (18.06 lb)

8. Five layers: Wool shirt and trousers, field jacket and trousers with Std. B liners, parka and arctic trousers with Std. B liners (Wool + Field/B + Arctic/B) -- 10.950 kg (24.13 lb)

Before beginning the first task in the battery, the subject was outfitted in the cold weather underwear, gym shoes, and the appropriate clothing for the condition. His heart rate was recorded for 60 sec (reading 1) and he then performed the first task, Standing Trunk Flexion. The subject performed the other tasks in sequence. After completing the final one, Side Horizontal Striking, the subject stood while his heart rate was again recorded for 60 sec (reading 2) and he was then given a rest of approximately 5 min. During this rest, the subject completed the questionnaire. In responding to the questionnaire, he was instructed to analyze the clothing he was wearing and to indicate how these items may have affected his performance. This procedure was repeated for the subsequent clothing conditions. Approximately 40 min was required to complete all the tasks in the battery.

For the experimental sessions, the 16 men were divided into eight groups of two men each. Each pair of men received a different sequence of exposure to the clothing conditions. The eight sequences, presented in Table 3, were based upon a Random Square. Of the two men in a group, one participated in the morning and the other in the afternoon.

After completion of all data collection, three separate forms of analysis of variance were applied to each of the 14 tasks of the battery. The first form of analysis of variance compared the effects on performance of one through five layers of clothing with Std. A liners being used when liners were required. In the second form of analysis, one through five clothing layers were again compared, but Std. B liners were used. The third form of analysis compared the effects of those layer conditions with liners and of Std. A vs. Std. B liners. The analyses of variance were according to the following designs:

1. Std. A Analysis: Subjects (1–16) by layers (Wool, Wool + Field, Wool + Field/A, Wool + Field/A + Arctic, Wool + Field/A + Arctic/A)

Table 3

Order in Which the Eight Clothing Conditions Were Presented to Each Subject

Sequence No.	Subject No.	Wool	Wool + Field	Wool + Field/A	Wool + Field/B	Wool + Field/A + Arctic	Wool + Field/B + Arctic	Wool + Field/A + Arctic/A	Wool + Field/B + Arctic/B
1	1,9	8	5	6	7	2	3	4	1
2	2,10	5	1	4	2	3	7	6	8
3	3,11	1	6	3	8	7	5	2	4
4	4,12	6	7	2	3	1	4	8	5
5	5,13	7	4	1	5	6	8	3	2
6	6,14	4	3	5	1	8	2	7	6
7	7,15	2	8	7	6	4	1	5	3
8	8,16	3	2	8	4	5	6	1	7

2. Std. B Analysis: Subjects (1–16) by layers (Wool, Wool + Field, Wool + Field/B, Wool + Field/B + Arctic, Wool + Field/B + Arctic/B)

3. Layer by Liner Analysis: Subjects (1–16) by layers (Wool + Field/Liners, Wool + Field/Liners + Arctic, Wool + Field/Liners + Arctic/Liners) by liners (Std. A, Std. B)

Because of equipment difficulties, the data for only 11 men were available for analysis on the Pursuit Rotor Test. The raw data used in the analyses of tasks 1 through 10 of the battery were the mean scores obtained by summing over the four trials on each task. On the remaining tasks, the raw data were the scores obtained on the single trial administered.

For the heart rate measure, two sets of data were analyzed. One was the raw data from the two readings taken under each clothing condition. The other was a difference score obtained by subtracting the first heart rate reading from the second. Both sets of data were analyzed according to the same three forms of analysis of variance used for the task data with the exception that the heart rate raw data analysis included the reading (1, 2) variable. For the questionnaire, the responses of all men to each question under each clothing condition were compiled and summarized.

RESULTS

Body Dimension Data

Selected body dimensions of the men participating in the present study were compared with those of 6682 US Army men, including basic trainees, infantrymen, armored crewmen, and aviation personnel, in order to determine whether the study sample was representative of the population for which the clothing was designed (reference 9). It can be seen in Table 1 that the ranges of the dimensions of the present sample were not as great as those of the larger, Army group. However, based upon t-tests, there was a significant difference between the means of the groups only on one body dimension, crotch height ($t(6696) = 3.5764$, $p < .01$). The value for the study sample on this measure was significantly lower than that for the larger sample of Army men.

The mean dimensions of the men wearing each clothing size are presented in Table 4. With the exception of a size "Large", all clothing sizes were required to accommodate the subjects. The percentiles appearing in Table 4 under the means of each body dimension indicate where the means of the present subjects fell on distributions of the dimensions of 6682 Army males (reference 9).

Task Battery Data

The results of the first analysis of variance performed on each of the 14 tasks comprising the battery, the Std. A Analysis, are presented in Table 5. In this form of the analysis, the clothing source of variance consisted of the two clothing conditions without liners (Wool and Wool + Field) and the three clothing conditions in which Std. A liners were used (Wool + Field/A, Wool + Field/A + Arctic, and Wool + Field/A + Arctic/A). The analysis of the first seven of the eight flexibility tests and the Pursuit Rotor Task (Task 9) yielded significant main effects attributable to clothing. Clothing condition also approached significance ($p < .10$) in the analysis of the Front Horizontal Striking Task (Task 13). The results of the Newman-Keuls multiple comparisons tests performed on the means of the tasks, which were significantly affected by clothing, are presented in Table 6.

The results of the second form of analysis of variance performed on the 14 tasks, the Std. B Analysis, are presented in Table 7. In this analysis the clothing source of variance consisted of the two conditions without liners (Wool and Wool + Field) and the three clothing conditions in which Std. B liners were worn (Wool + Field/B, Wool + Field/B + Arctic, and Wool + Field/B + Arctic/B). Significant main effects attributable to clothing were obtained for the first seven flexibility tests, the Pursuit Rotor (Task 9), and the Side Horizontal Striking Task (Task 14). The clothing variable approached significance ($p < .10$) on the O'Connor Finger Dexterity and the Front Horizontal Striking Tasks (Tasks 11 and 13). Table 8 is a presentation of the results of the Newman-Keuls multiple comparisons tests performed on the means of the tasks for which significant clothing effects were obtained.

Table 4

Mean Dimensions of Subjects for Each Clothing Size

Size	n	Stature (cm)	Crotch Height (cm)	Chest Circum. (cm)	Waist Circum. (cm)	Weight (kg)
Short	3	164.47	71.97			
Percentile		13.55	1.26			
Regular	11	175.67	80.24			
Percentile		72.43	30.00			
Long	2	186.37	83.19			
Percentile		98.50	55.40			
X-Small	1			78.74	68.58	55.45
Percentile				<1.00	5.21	3.00
Small	8			88.90	74.30	68.07
Percentile				32.67	31.00	37.98
Medium	6			96.52	82.97	76.23
Percentile				75.85	71.90	67.22
Large	0			—	—	—
X-Large	1			119.38	101.60	115.68
Percentile				over 99th	98.40	over 99th

Table 5

Std. A Analyses of Variance of Task Battery Data

Task Number

Source of Variance	df	1[a] MS	1[a] F	1[a] p	1[b] MS	1[b] F	1[b] p	2[a] MS	2[a] F	2[a] p
Subjects (Ss)	15	45.70			590.42			44.81		
Clothing (C)	4	11.30	6.82	.001	600.84	12.25	.001	16.78	11.05	.001
Ss x C	60	1.66			49.06			1.52		

Source of Variance	df	2[b] MS	2[b] F	2[b] p	3 MS	3 F	3 p	4 MS	4 F	4 p
Subjects (Ss)	15	331.02			494.38			583.21		
Clothing (C)	4	113.24	5.01	.005	1,404.77	20.10	.001	441.75	3.74	.01
Ss x C	60	22.61			69.90			118.08		

Source of Variance	df	5 MS	5 F	5 p	6 MS	6 F	6 p	7 MS	7 F	7 p
Subjects (Ss)	15	94.95			153.66			226.93		
Clothing (C)	4	121.26	2.90	.05	128.85	4.44	.005	137.65	2.80	.05
Ss x C	60	41.77			29.05			49.10		

Source of Variance	df	8 MS	8 F	8 p	9[c] MS	9[c] F	9[c] p	10 MS	10 F	10 p
Subjects (Ss)	15	120.14			54.70			11,485.01		
Clothing (C)	4	18.99	<1.00		5.73	2.90	.05	870.37	<1.00	
Ss x C	60	19.12			1.98			2,441.35		

Source of Variance	df	11 MS	11 F	11 p	12 MS	12 F	12 p	13 MS	13 F	13 p
Subjects (Ss)	15	420.03			143.38			2,474.27		
Clothing (C)	4	15.54	<1.00		20.47	<1.00		394.05	2.38	.10
Ss x C	60	25.95			22.15			165.28		

Source of Variance	df	14 MS	14 F	14 p
Subjects (Ss)	15	1,805.74		
Clothing (c)	4	270.08	1.38	
Ss x C	60	196.31		

[a]Analysis of distance measure

[b]Analysis of angular displacement measure

[c]df = 10,4,40, respectively

Table 6

Mean Score for Tasks under Each Std. A Clothing Condition

Task		Clothing Condition*				
1a.	Standing Trunk Flexion (Distance) (cm)	1	2	3	5	7
		33.8	32.5	29.7	29.5	29.0
1b.	Standing Trunk Flexion (Angle) (deg)	1	2	3	7	5
		118.6	115.4	113.9	105.2	105.1
2a.	Sitting Trunk Flexion (Distance) (cm)	1	2	3	5	7
		8.1	9.4	12.2	13.7	14.0
2b.	Sitting Trunk Flexion (Angle) (deg)	1	2	3	7	5
		27.6	24.6	23.6	22.2	20.5
3.	Upper Arm Abduction (deg)	1	2	3	5	7
		139.8	126.6	126.0	117.0	116.9
4.	Upper Arm Forward Extension (deg)	2	1	3	5	7
		157.3	157.0	151.8	147.8	145.7
5.	Upper Arm Backward Extension (deg)	1	2	3	5	7
		38.6	36.4	34.3	32.3	32.2
6.	Upper Leg Abduction (deg)	1	2	3	7	5
		50.2	49.3	47.0	46.4	42.9
7.	Upper Leg Forward Extension (deg)	1	3	2	5	7
		58.8	56.6	54.1	52.9	51.5
9.	Pursuit Rotor (sec)	1	2	5	7	3
		16.01	15.93	14.95	14.70	14.43

*1 = Wool; 2 = Wool + Field; 3 = Wool + Field/A; 5 = Wool + Field/A + Arctic; 7 = Wool + Field/A + Arctic/A

NOTE: Clothing conditions not connected by the same line are significantly different ($p < .05$)

Table 7

Std. B Analyses of Variance of Task Battery Data

Task Number										
		1[a]			1[b]			2[a]		
Source of Variance	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	15	42.21			488.38			45.43		
Clothing (C)	4	22.78	20.58	.001	672.47	12.59	.001	28.35	16.60	.001
Ss x C	60	1.11			53.40			1.71		
		2[b]			3			4		
Source of Variance	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	15	299.42			391.52			455.75		
Clothing (C)	4	209.65	5.75	.001	2,338.87	65.03	.001	738.75	8.83	.001
Ss x C	60	36.45			35.97			83.63		
		5			6			7		
Source of Variance	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	15	160.06			127.13			189.52		
Clothing (C)	4	174.43	4.09	.01	174.17	4.83	.005	168.48	4.93	.005
Ss x C	60	42.64			36.03			34.15		
		8			9[c]			10		
Source of Variance	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	15	134.86			64.55			16,400.14		
Clothing (C)	4	29.79	1.39		6.52	2.44	.05	1,338.10	<1.00	
Ss x C	60	21.39			2.44			1,935.89		
		11			12			13		
Source of Variance	df	MS	F	p	MS	F	p	MS	F	P
Subjects (Ss)	15	360.10			147.41			2,436.64		
Clothing (C)	4	83.63	2.13	.10	20.98	<1.00		298.73	2.47	.10
Ss x C	60	39.19			25.69			120.77		
		14								
Source of Variance	df	MS	F	p						
Subjects (Ss)	15	1,602.21								
Clothing (C)	4	520.73	4.03	.01						
Ss x C	60	129.22								

[a]Analysis of distance measure

[b]Analysis of angular displacement measure

[c]df = 10,4,40, respectively

Table 8

Mean Score for Tasks under Each Std. B Clothing Condition

Task		Clothing Condition*				
		1	2	4	6	8
1a.	Standing Trunk Flexion (Distance) (cm)	33.8	32.5	30.0	28.2	26.4
		1	2	4	6	8
1b.	Standing Trunk Flexion (Angle) (deg)	118.6	115.4	114.1	107.6	102.5
		1	2	4	6	8
2a.	Sitting Trunk Flexion (Distance) (cm)	8.1	9.4	11.7	15.2	15.7
		4	1	2	8	6
2b.	Sitting Trunk Flexion (Angle) (deg)	29.1	27.6	24.6	21.6	20.8
		1	2	4	6	8
3.	Upper Arm Abduction (deg)	139.8	126.6	119.5	115.0	108.1
		1	2	4	6	8
4.	Upper Arm Forward Extension (deg)	157.3	157.0	147.8	144.8	142.9
		1	2	6	8	4
5.	Upper Arm Backward Extension (deg)	38.6	36.4	33.2	31.8	30.7
		1	2	4	6	8
6.	Upper Leg Abduction (deg)	50.2	49.3	45.3	43.5	43.1
		1	2	4	6	8
7.	Upper Leg Forward Extension (deg)	58.8	54.1	53.4	51.8	50.3
		1	2	4	6	8
9.	Pursuit Rotor (sec)	16.01	15.93	14.82	14.48	14.47
		1	2	4	6	8
14.	Side Horizontal Striking	120.4	120.4	118.8	109.8	109.3

*1 = Wool; 2 = Wool + Field; 4 = Wool + Field/B; 6 = Wool + Field/B + Arctic; 8 = Wool + Field/B + Arctic/B.

NOTE: Clothing conditions not connected by the same line are significantly different ($p < .05$).

The clothing variable in the third analysis of variance consisted only of those conditions which included liners. This form of analysis, the Layer by Liner Analysis, permitted assessments to be made regarding the effects of Std. A versus Std. B liners, three (Wool + Field/Liners), four (Wool + Field/Liners + Arctic), and five (Wool + Field/Liners + Arctic/Liners) clothing layers, and the interaction between clothing layers and type of liner. The results of this analysis for each of the 14 tasks are presented in Table 9. There was a significant main effect of layers in the analysis of Standing Trunk Flexion (Angle) (Task 1b), Sitting Trunk Flexion (Angle and Distance) (Task 2), Upper Arm Abduction (Task 3), Upper Arm Forward Extension (Task 4), and Upper Leg Forward Extension (Task 7). The effect of layers approached significance ($p < .10$) on Standing Trunk Flexion (Distance) (Task 1a). The liners variable significantly affected performance on Standing Trunk Flexion (Distance) (Task 1a), Upper Arm Abduction (Task 3), and the O'Connor Finger Dexterity Test (Task 11). Liners approached significance ($p < .10$) on Sitting Trunk Flexion (Distance and Angle) (Tasks 2a and 2b). The results of the Newman-Keuls multiple comparisons tests performed on the means of those tasks which yielded significant main effects attributable to clothing layers are presented in Table 10.

Figures 1 through 14 are presentations of the mean scores obtained on each of the 14 tasks as a function of the five clothing layer conditions and the two types of liners, which were considered in one or more of the analyses performed on the data. Descriptions of the specific results obtained in this study will include integration of the findings from all three forms of analyses applied to each task. The findings related to Standing and Sitting Trunk Flexion (Tasks/Figures 1 and 2) will emphasize only the distance scores since the angular displacement scores did not discriminate as well among the conditions.

The distance reached on the Standing Trunk Flexion Test (Task/Figure 1a) was greatest when the wool shirt and trousers were worn alone and the addition of the field jacket and trousers did not significantly reduce the score. The use of Std. A liners in the field clothing did result in significantly lower scores, but additional layers of clothing, with or without Std. A liners, had no further effects on performance (Table 6). The use of Std. B liners in the field jacket and trousers also resulted in scores significantly lower than those achieved when no liners were worn in the field layer and the addition of the arctic layer without liners did not significantly affect the Standing Trunk Flexion scores. However, when Std. B liners were used in the arctic parka and trousers, performance levels were significantly reduced relative to those for the field clothing with Std. B liner condition (Table 8).

To assess the differences on the Standing Trunk Flexion Task which were attributable to the type of liner used, a mean distance score was obtained by summing over those clothing conditions in which Std. A liners were used. This was compared with a similar mean for Std. B liners. The mean score was significantly lower when Std. B liners were

Table 9

Layer by Liner Analyses of Variance of Task Battery Data

Task Number

Source of Variance	df	1[a] MS	1[a] F	1[b] MS	1[b] F	2[a] MS	2[a] F	2[b] MS	2[b] F
Subjects (Ss)	15	51.20		777.56		54.77		344.91	
Layers (L)	2	6.42	3.03*	888.26	16.74***	12.99	7.02**	284.98	9.30***
Liners (l)	1	5.38	12.64**	0.003	<1.00	3.14	4.30*	68.43	3.20*
Ss x L	30	2.12		53.05		1.85		30.65	
Ss x l	15	0.43		18.62		0.73		21.40	
L x l	2	2.22	3.43**	53.15	<1.00	1.79	1.88	86.80	2.93*
Ss x L x l	30	0.65		56.15		0.95		29.58	

Source of Variance	df	3 MS	3 F	4 MS	4 F	5 MS	5 F	6 MS	6 F
Subjects (Ss)	15	658.06		544.57		116.90		160.25	
Layers (L)	2	868.45	19.39***	251.51	4.47**	4.64	<1.00	69.30	1.98
Liners (l)	1	799.84	10.26**	255.13	1.68	26.25	<1.00	54.45	2.31
Ss x L	30	44.79		56.23		38.57		35.02	
Ss X l	15	77.96		151.88		47.84		23.53	
L x l	2	93.23	1.51	2.93	<1.00	42.88	<1.00	29.53	1.35
Ss x L x l	30	61.71		155.94		63.39		21.95	

Source of Variance	df	7 MS	7 F	8 MS	8 F	9[c] MS	9[c] F	10 MS	10 F
Subjects (Ss)	15	275.44		166.85		69.91		11,867.62	
Layers (L)	2	137.08	3.92**	0.66	<1.00	0.09	<1.00	2,899.68	1.11
Liners (l)	1	81.95	1.91	14.22	1.18	0.19	<1.00	2,901.80	<1.00
Ss x L	30	34.94		24.56		1.93		2,610.98	
Ss x l	15	42.84		12.08		3.22		3,489.12	
L x l	2	11.24	<1.00	31.08	2.05	1.08	<1.00	728.77	<1.00
Ss x L x l	30	27.48		15.19		3.72		1,569.34	

Source of Variance	df	11 MS	11 F	12 MS	12 F	13 MS	13 F	14 MS	14 F
Subjects (Ss)	15	451.82		152.54		2,809.54		2,271.98	
Layers (L)	2	80.73	2.35	3.51	<1.00	229.57	1.16	196.91	1.20
Liners (l)	1	128.30	16.21**	0.16	<1.00	6.00	<1.00	3.38	<1.00
Ss x L	30	34.41		13.94		197.68		164.51	
Ss x l	15	7.91		11.04		54.18		81.66	
L x l	2	5.78	<1.00	11.86	<1.00	140.66	1.02	276.84	1.80
Ss x L x l	30	35.90		23.57		138.17		153.60	

*p < .10
**p < .05
***p < .001

[a]Analysis of distance measure.

[b]Analysis of angular displacement measure.

[c]df = 10,2,1,20,10,20, respectively

Table 10

Mean Score for Tasks under Each Clothing Condition with Liners

	Task	Clothing Condition		
		Field/Liners	Field/Liners + Arctic	Field/Liners + Arctic/Liners
1b.	Standing Trunk Flexion (Angle) (deg)	114.0	106.4	103.9
2a.	Sitting Trunk Flexion (Distance) (cm)	11.9	14.5	15.0
2b.	Sitting Trunk Flexion (Angle)(deg)	26.3	20.7	21.9
3.	Upper Arm Abduction (deg)	122.8	116.0	112.5
4.	Upper Arm Forward Extension (deg)	149.8	146.3	144.3
7.	Upper Leg Forward (deg)	55.0	52.4	50.9

NOTE: Clothing conditions not connected by the same line are significantly different ($p < .05$)

STANDING TRUNK FLEXION (DISTANCE)

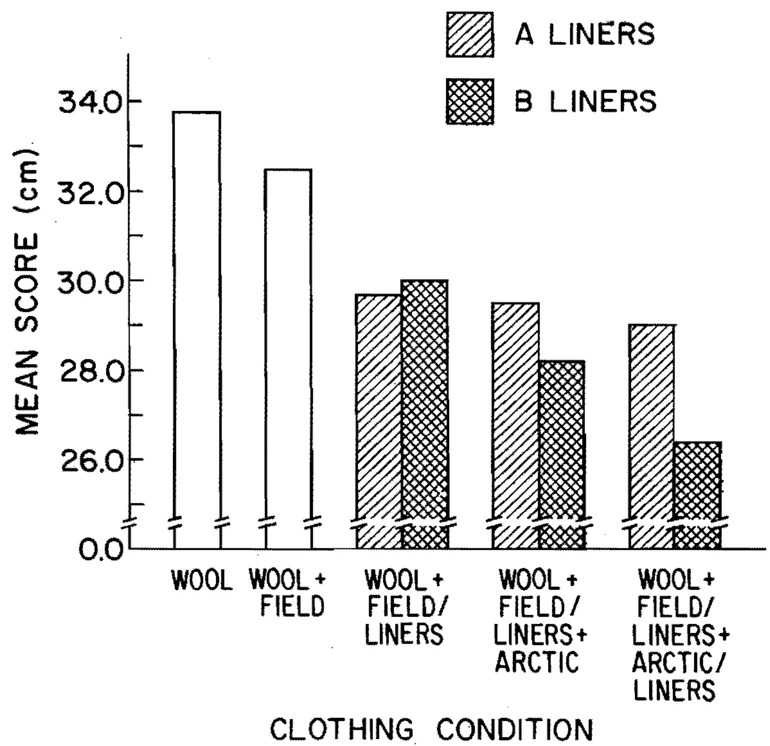

Figure 1a. Mean score on Standing Trunk Flexion (Distance) (Task 1a) as a function of clothing condition.

STANDING TRUNK FLEXION (ANGLE)

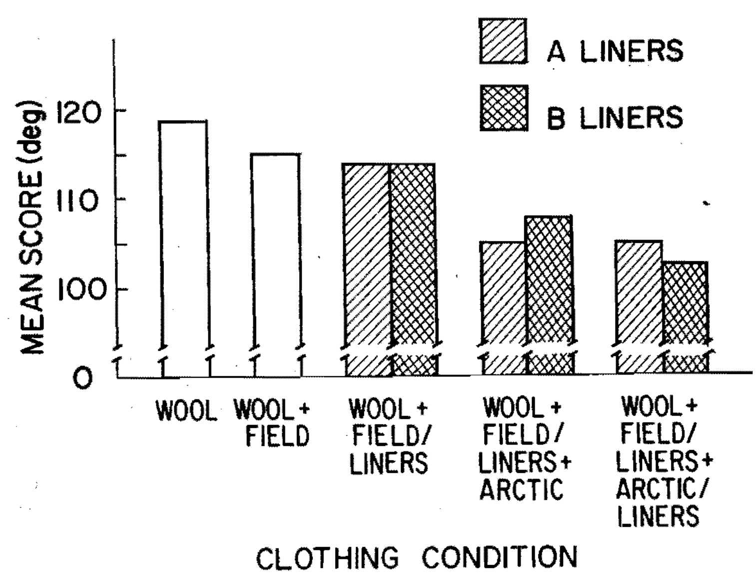

Figure 1b. Mean score on Standing Trunk Flexion (Angle) (Task 1b) as a function of clothing condition.

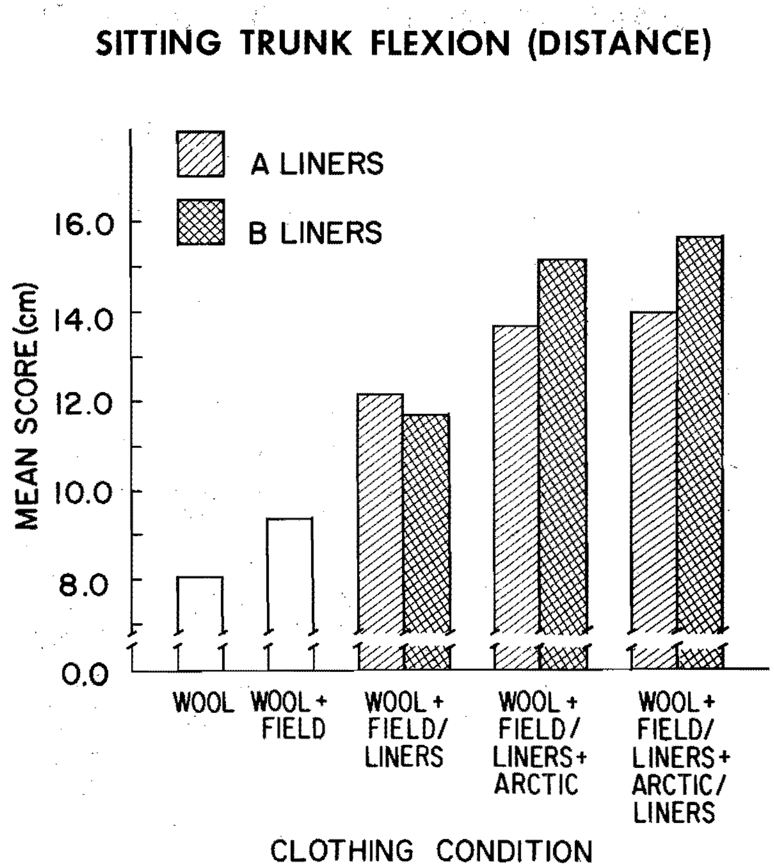

Figure 2a. Mean score on Sitting Trunk Flexion (Distance) (Task 2a) as a function of clothing condition.

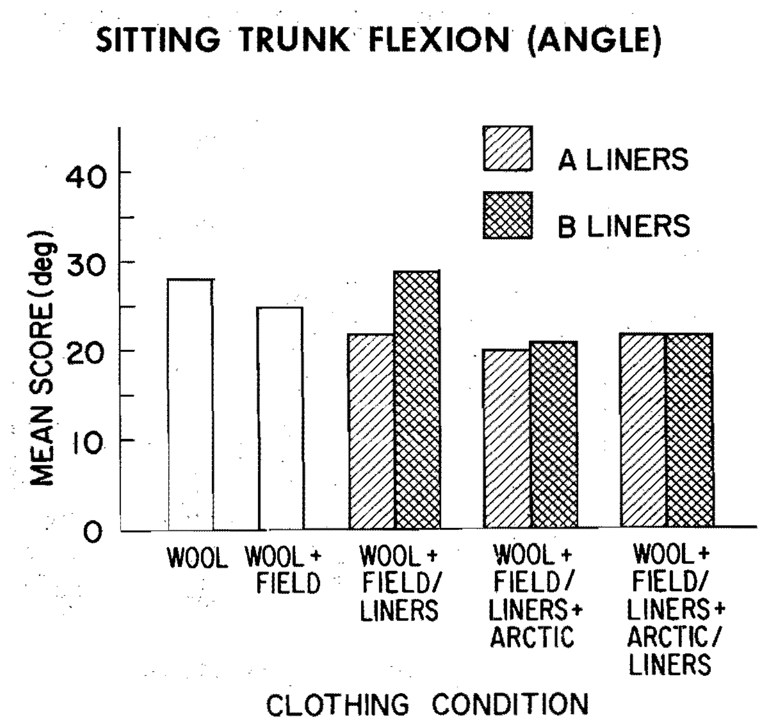

Figure 2b. Mean score on Sitting Trunk Flexion (Angle) (Task 2b) as a function of clothing condition.

worn (28.2 cm, 11.10 in.) than when Std. A liners were used (29.5 cm, 11.61 in.). A Newman-Keuls multiple comparisons test was performed on the significant interaction between clothing layers and type of liner which was obtained in the third form of the analysis of variance (Table 9). This test indicated that the mean distance score achieved on the Standing Flexion Task while all clothing layers with Std. B liners were worn was lower (26.4 cm, 10.39 in.) than the scores for the remaining conditions in which Std. A or Std. B liners were used. The mean scores for these other clothing conditions ranged from 28.2 cm (11.10 in.) to 30.0 cm (11.81 in.) and were not significantly different from each other.

The effects of the clothing variables on the Sitting Trunk Flexion (Distance) (Task/Figure 2a) were similar to those for Standing Trunk Flexion. The subjects, bending forward from a sitting position with their arms outstretched in front of them, were able to reach farthest when wearing the wool shirt and trousers. A slight, but not significant, reduction in performance level occurred with the introduction of the field jacket and trousers. The addition of Std. A liners to the field clothing did result in significant impairment. However, the use of the arctic layer, with or without Std. A liners, did not yield any further, significant performance decrements on the Sitting Trunk Flexion (Distance) measure (Table 6). For those conditions involving Std. B liners, the use of these liners in the field layer resulted in distance scores which were significantly worse than those obtained for the wool shirt and trousers, but they were not significantly different from those for the field clothing condition. The addition of the arctic layer yielded further, significant performance impairment. However, the mean distance score for the arctic condition without Std. B liners did not differ from that with Std. B liners (Table 8). In order to assess the effects of clothing layers, mean scores were obtained on the Sitting Trunk Flexion Task by summing over the two types of liners. The results indicated that performance for the field clothing with liner condition was significantly better than performance for the two conditions involving arctic clothing, while the scores for these latter two conditions did not differ significantly from each other (Table 10).

The next three flexibility tasks included in the performance battery involved movement of the upper arm and the effects of clothing conditions varied among these movements. In the case of Upper Arm Abduction (Task/Figure 3), performance was best when the wool shirt and trousers were worn alone and was significantly worsened when the field jacket and trousers were added. The use of Std. A liners in the field layer did not yield any additional performance impairment. The arctic parka and trousers caused a further significant performance decrement and, again, the wearing of Std. A liners in the arctic layer had no further detrimental effect on performance (Table 6). For those conditions in which Std. B liners were used, Upper Arm Abduction movements were progressively restricted with each addition of clothing (Table 8). Comparable findings were obtained from the third form of analysis of variance applied to these data. When the effects of wearing four, five, and six layers of clothing were compared, scores were

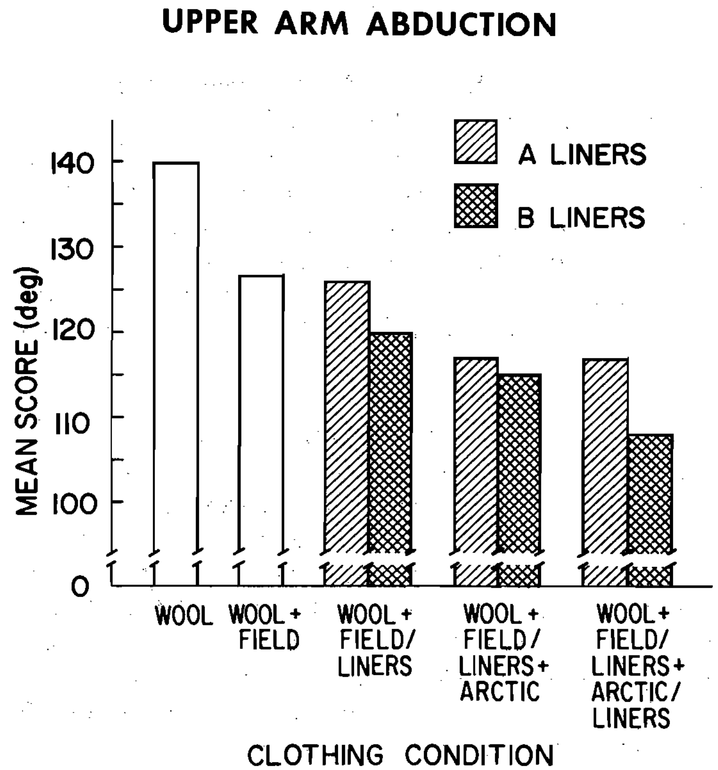

Figure 3. Mean score on Upper Arm Abduction (Task 3) as a function of clothing condition.

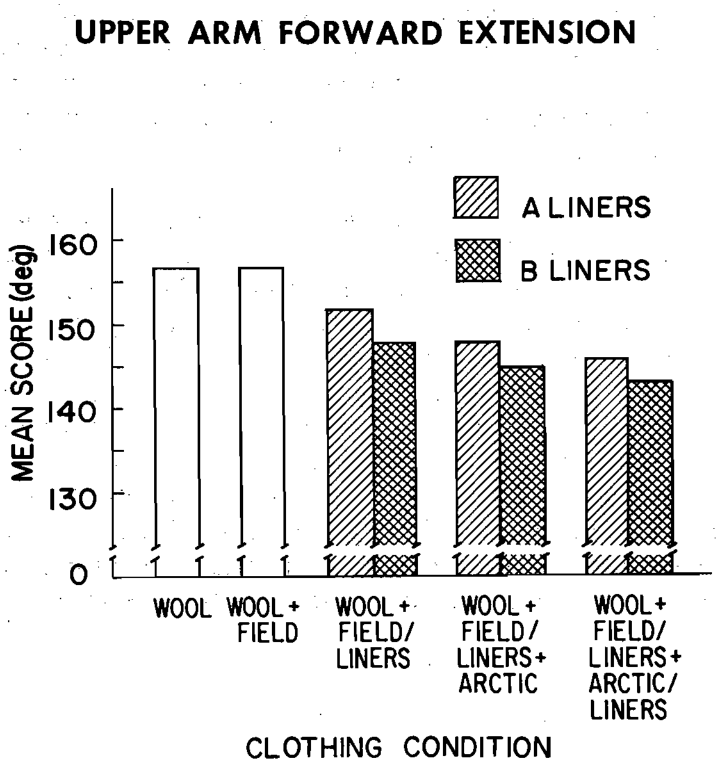

Figure 4. Mean score on Upper Arm Forward Extension (Task 4) as a function of clothing condition.

found to decrease significantly with the addition of each clothing layer (Table 10). The type of liner worn also yielded a significant effect in this analysis (Table 9) with Std. A liners resulting in greater Upper Arm Abduction movement (120.0°) than was achieved with Std. B (114.2°).

The impact of the clothing variable on the Upper Arm Forward Extension Task (Task/Figure 4) was not as great as that on Upper Arm Abduction. The wearing of both the field and the arctic layers with Std. A liners resulted in significantly less forward arm extension relative only to that for the wool shirt and trousers alone or with the field jacket and trousers. Performance levels under the Wool and the Wool + Field conditions were not different from each other or from the remaining conditions (Table 6). The second form of analysis of variance applied to the Upper Arm Forward Extension Task again yielded no difference between the scores achieved when the wool layer was worn alone or with the field layer. However, scores under these two conditions were significantly better than those obtained when Std. B liners were used. There were no differences among the conditions which included Std. B liners (Table 8). In the analysis in which clothing layer and liner effects were tested (Table 9), the field plus arctic clothing with liners (five clothing layers) resulted in poorer performance than did the field clothing with liners (three clothing layers) (Table 10).

Clothing condition had even less of an effect on performance of the Upper Arm Backward Extension Task (Task/Figure 5). The first form of analysis of variance applied to this task, in which Std. A liners were considered, yielded a significant clothing effect (Table 5), although subsequent multiple comparisons tests yielded no significant differences among conditions (Table 6). Thus, the two extreme conditions (Wool clothing only and all layers with Std. A liners) were the only ones to differ significantly from each other. In the analysis involving Std. B liners, scores on the Upper Arm Backward Extension Task were significantly higher under the wool shirt and trouser condition than they were when Std. B liners were worn in the field layer or in the arctic layer (Table 8).

The three remaining flexibility tasks in the battery involved leg movements. Again, the effect of clothing on these tasks varied with the movement required. For example, the clothing effects were significant in various forms of analysis done on the Upper Leg Abduction (Task/Figure 6) and the Forward Extension (Task/Figure 7) Tests. However, the clothing variable did not significantly affect performance in any of the three forms of analysis applied to the Upper Leg Backward Extension data (Task/Figure 8).

For the Upper Leg Abduction movement (Task/Figure 6), the condition in which the arctic layer without liners was worn over the field clothing with Std. A liners resulted in significantly poorer scores than those achieved with the wool shirt and trousers alone or in combination with the field layer (Table 6). When Std. B liners were considered, the two arctic clothing conditions resulted in lower scores than did either the wool layer alone or the wool plus the field layer (Table 8).

UPPER ARM BACKWARD EXTENSION

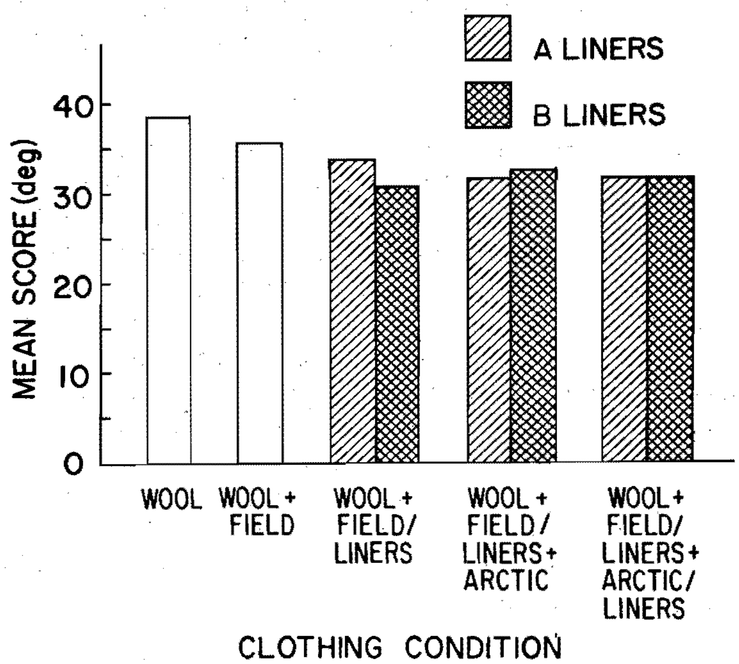

Figure 5. Mean score on Upper Arm Backward Extension (Task 5) as a function of clothing condition.

UPPER LEG ABDUCTION

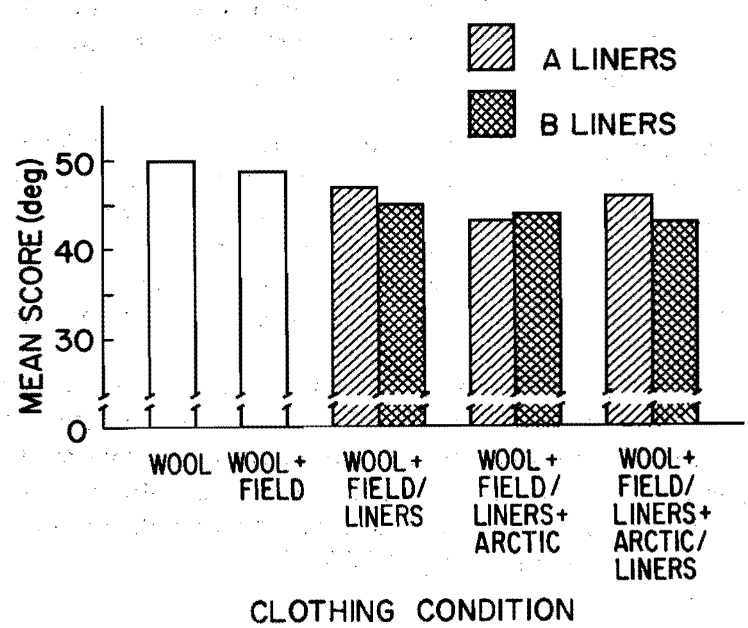

Figure 6. Mean score on Upper Leg Abduction (Task 6) as a function of clothing condition.

UPPER LEG FORWARD EXTENSION

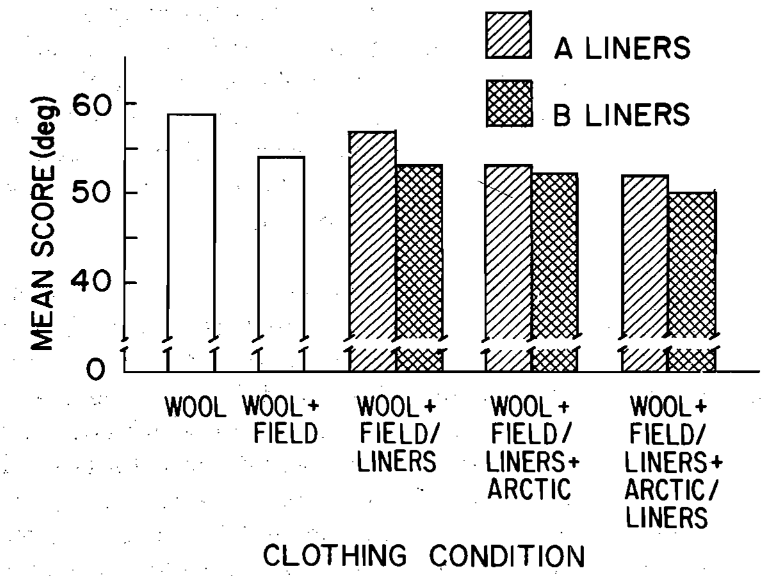

Figure 7. **Mean score on Upper Leg Forward Extension (Task 7) as a function of clothing condition.**

UPPER LEG BACKWARD EXTENSION

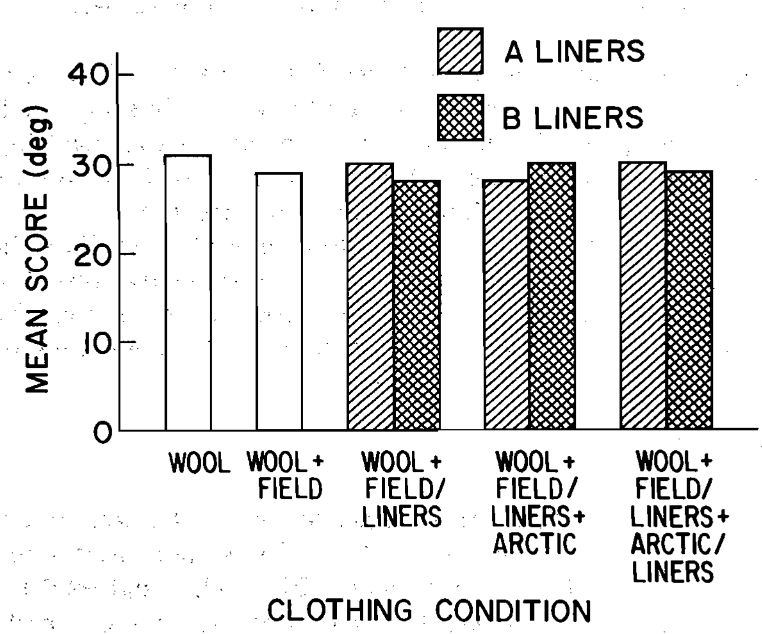

Figure 8. **Mean score on Upper Leg Backward Extension (Task 8) as a function of clothing condition.**

For the Upper Leg Forward Extension movement (Task/Figure 7), the use of Std. A liners significantly impaired performance relative to that achieved under the wool clothing condition only when all clothing layers (Wool + Field/A + Arctic/A) were worn (Table 9). In the case of the analysis of Std. B liners, the addition of field clothing (Wool + Field) restricted leg movement and the use of the remaining clothing items had no additional effects (Table 8). However, in the analysis done on both clothing layers and types of liners, the use of liners in the arctic layer did restrict movement relative to the field clothing with liner condition (Table 10).

When the first form of analysis, which considered Std. A liners, was applied to the remaining tasks in the battery, the Pursuit Rotor Test (Task/Figure 9) was the only one significantly affected by the clothing variable. This finding indicated a significant difference between the two extreme mean scores (Wool and Wool + Field/A), although the Newman-Keuls tests applied to these data did not yield significant differences among conditions (Table 6). The form of analysis which was directed toward Std. B liners also resulted in a significant clothing effect on the Pursuit Rotor Test (Figure 9), as well as on the Side Horizontal Striking Test (Task/Figure 14). In both cases, performance levels for the two extreme clothing conditions (Wool and Wool + Field/B + Arctic/B) were significantly different, but again these differences were not reflected in the multiple comparisons tests (Table 8). The form of analysis in which clothing layers and type of liner were included as sources of variance yielded one significant effect for the remaining tasks in the battery. This was attributable to the type of liner used and occurred on the O'Connor Finger Dexterity Test (Task/Figure 11). Mean scores were significantly faster with Std. A liners (72.41 sec) than with Std. B (74.73 sec).

The clothing variable also approached significance ($p < .10$) in some of the tasks in the battery that were not principally flexibility tests. This occurred on the Front Horizontal Striking Test (Task 13) in both the form of analysis involving Std. A liners (Table 5) and that involving Std. B liners (Table 7), and on the O'Connor Finger Dexterity Test in the analysis of Std. B liners (Table 7). Performance levels on the O'Connor Finger Dexterity (Task/Figure 11) and on the Front Horizontal Striking (Task/Figure 13) Tests tended to be higher when the wool shirt and trousers were worn alone or in combination with the field layer than they were under the remaining conditions. The Railwalking (Task/Figure 10) and the Purdue Pegboard (Task/Figure 12) scores were not significantly affected by the clothing conditions used in this study.

Heart Rate Data

In all three forms of analysis of variance performed on the heart rate absolute scores, the effect of reading was significant (Table 11). The second heart rate reading, taken after completion of the test batery, was higher (97.2, 97.5, and 99.5 beats/minute for the Std. A, the Std. B, and the Layer by Liner Analyses, respectively) than the first

PURSUIT ROTOR

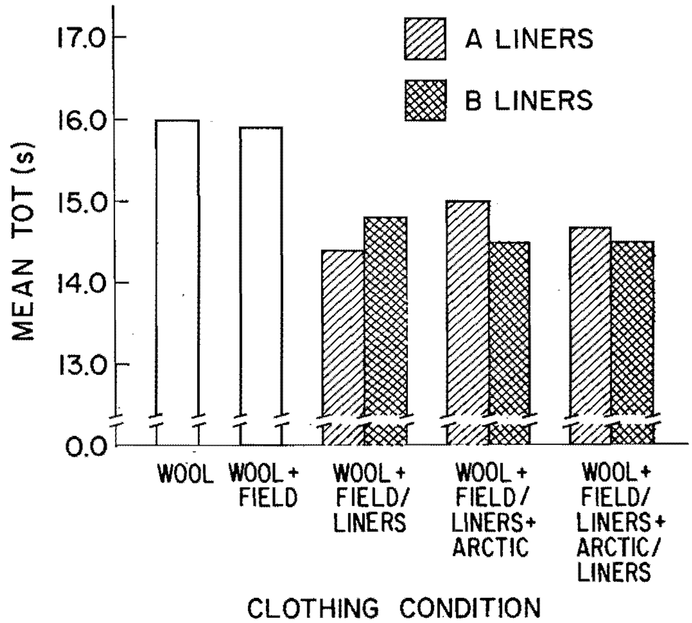

Figure 9. Mean Pursuit Rotor time on target (Task 9) as a function of clothing condition.

RAILWALK

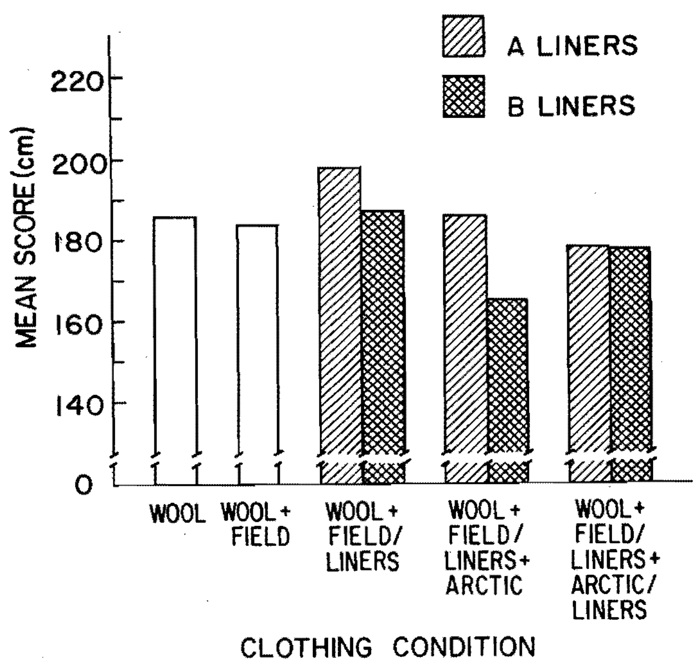

Figure 10. Mean Railwalking score (Task 10) as a function of clothing condition.

O'CONNOR FINGER DEXTERITY

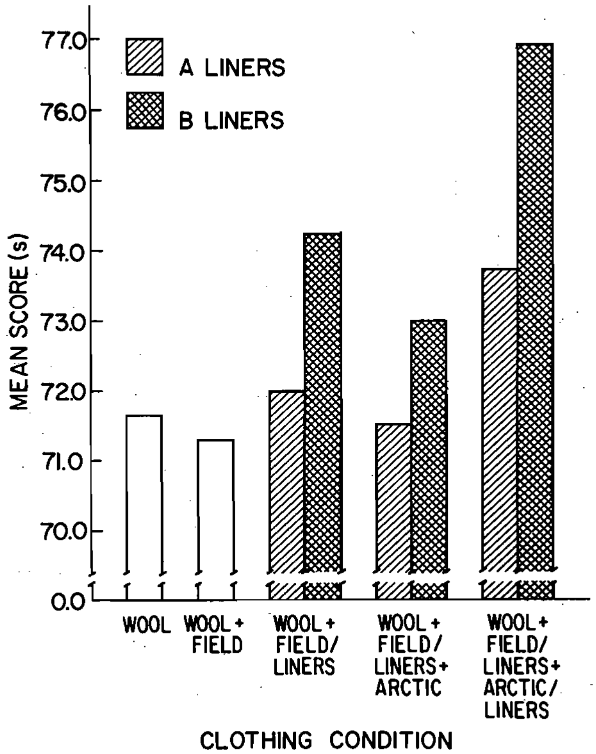

Figure 11. Mean O'Connor Finger Dexterity Test score (Task 11) as a function of clothing condition.

PURDUE PEGBOARD ASSEMBLY

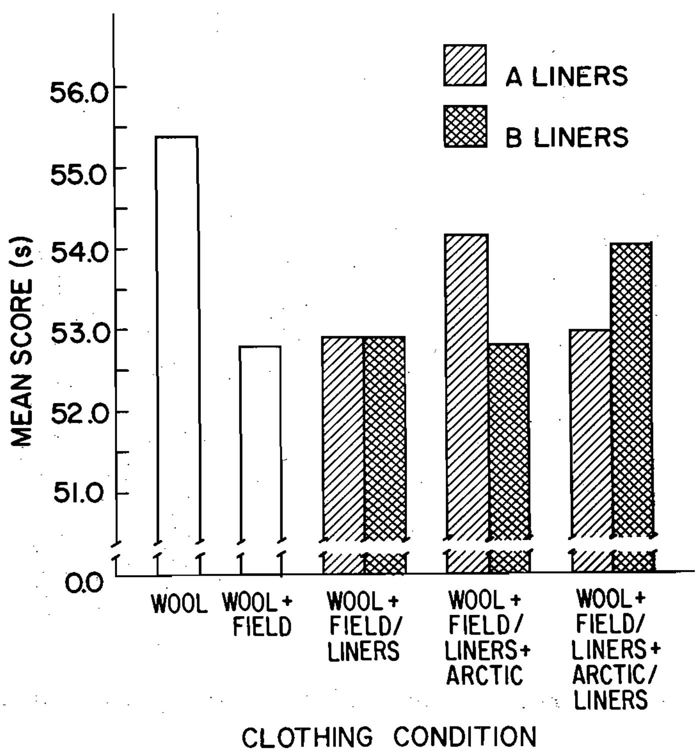

Figure 12. Mean Purdue Pegboard Assembly Test score (Task 12) as a function of clothing condition.

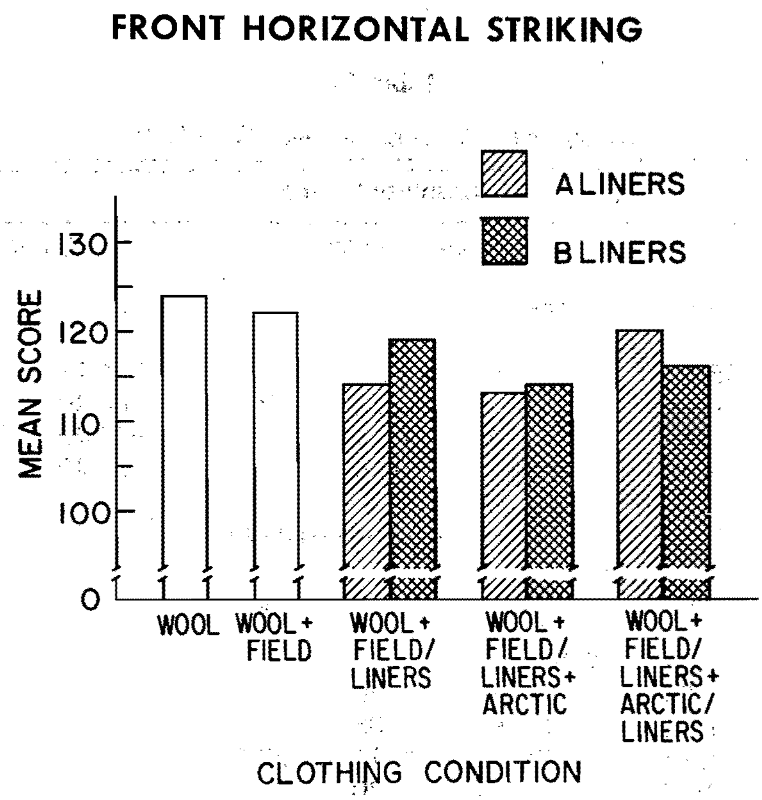

Figure 13. Mean score on Front Horizontal Striking (Task 13) as a function of clothing condition.

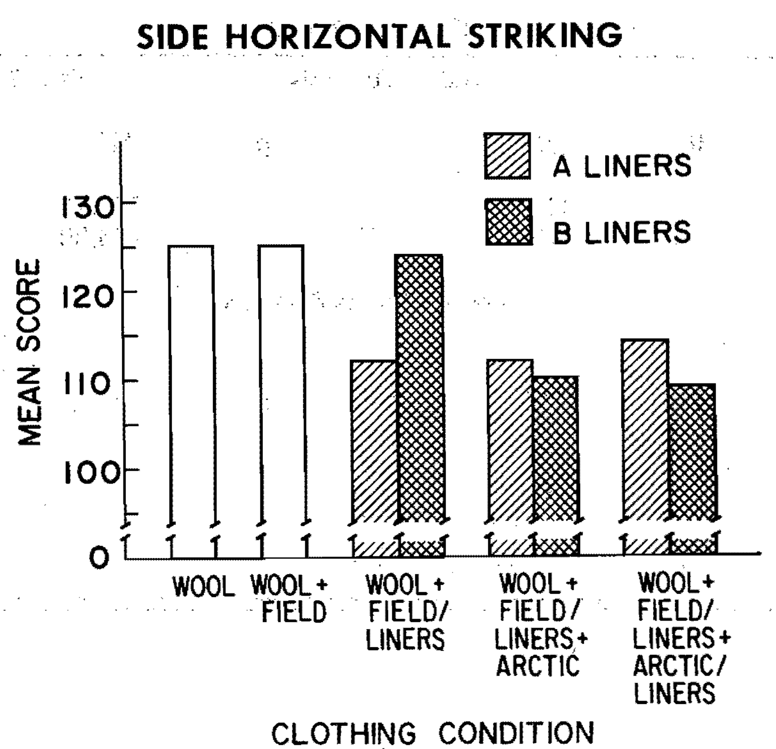

Figure 14. Mean score on Side Horizontal Striking (Task 14) as a function of clothing condition.

Table 11

Analyses of Variance of Heart Rate Data

Absolute Scores

Source of Variance	df	Std. A Analysis MS	F	p	Std. B Analysis MS	F	p
Subjects	15	1,881.38			1,761.25		
Clothing (C)	4/60	206.60	2.32	.10	204.90	2.43	.10
Time (T)	1/15	4,040.10	18.81	.001	5,664.40	15.47	.001
C x T	4/60	36.60	0.49		68.40	1.17	

Layers by Liners Analysis

Source of Variance	df	MS	F	p
Subjects	15	2,491.77		
Layers (L)	2/30	102.33	1.40	
Liners (I)	1/15	60.75	1.05	
Time (T)	1/15	7,350.75	28.71	.001
L x I	2/30	193.00	1.80	
L x T	2/30	25.00	0.33	
I x T	1/15	114.08	1.19	
L x I x T	2/30	24.33	0.52	

Difference Scores

Source of Variance	df	Std. A Analysis MS	F	p	Std. B Analysis MS	F	p
Subjects	15	432.21			732.11		
Clothing	4/60	75.70	0.51		136.80	1.17	

Layers by Liners Analysis

Source of Variance	df	MS	F	p
Subjects	15	515.20		
Layers (L)	2/30	55.17	0.35	
Liners (I)	1/15	240.67	1.27	
L x I	2/30	51.17	0.55	

HEART RATE

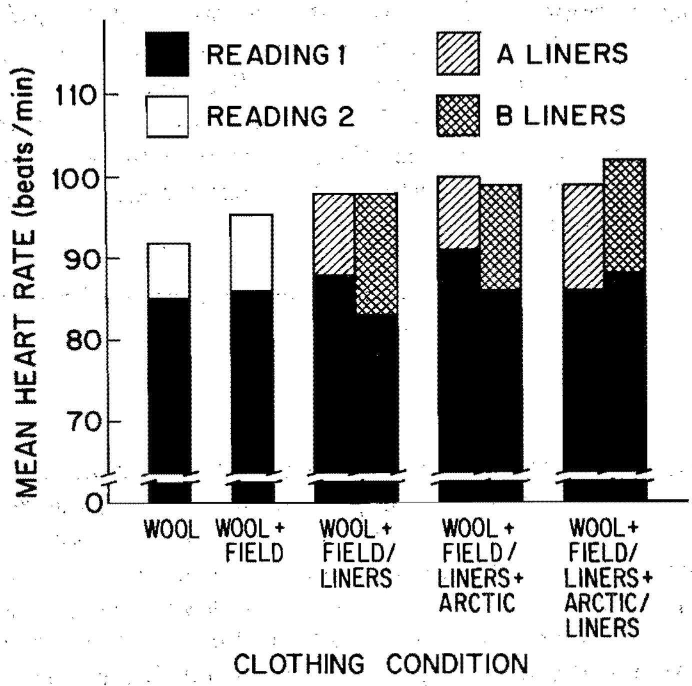

Figure 15. **Mean Heart Rate as a function of clothing condition and reading.**

HEART RATE DIFFERENCE SCORE

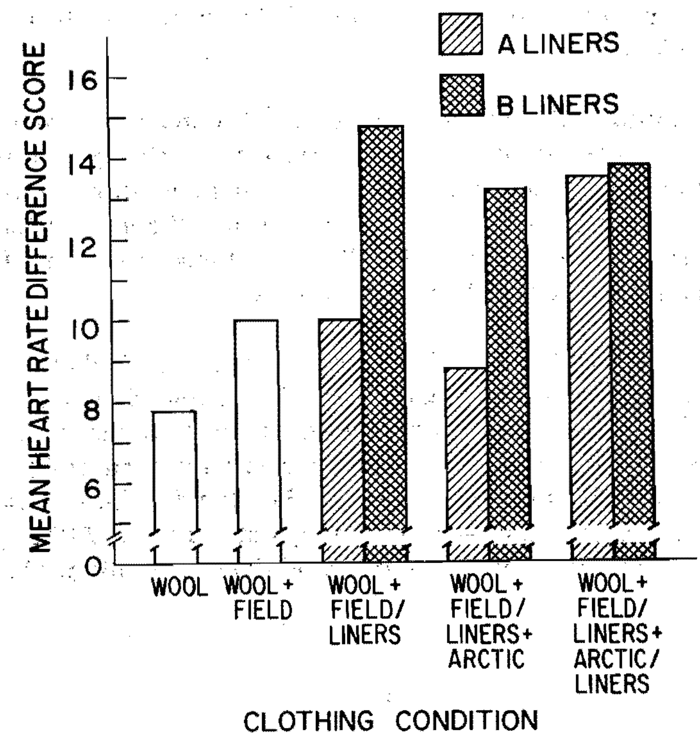

Figure 16. **Mean Heart Rate difference score as a function of clothing condition.**

heart rate reading taken prior to initiation of the test battery (87.2, 85.6, and 87.1 beats/minute for the Std. A, the Std. B, and the Layer by Liner Analyses, respectively). The effect of clothing approached significance ($p < .10$) in the Std. A and the Std. B Analyses (Table 11). The lowest mean heart rate occurred when the wool shirt and trousers were worn and the highest occurred under the arctic clothing without liners condition in the Std. A Analysis and under the arctic clothing with liners condition in the Std. B Analysis (Figure 15).

There were no significant effects in the three analyses of the heart rate difference scores (Table 11, Figure 16).

Questionnaire Data

On the first question of Section I, the subjects were asked to rank from 1 to 3 the three flexibility movements and the three psychomotor tasks which were most impaired by each clothing condition (Appendix E). Scores of 3, 2, and 1 were assigned to ranks of 1, 2, and 3, respectively, and the sums of these scores across subjects for each task and clothing condition are presented in Table 12. There were few, if any, systematic changes in rated difficulty across clothing conditions for either the flexibility or the psychomotor tasks. Among the flexibility tasks, the Sitting Trunk Flexion, Upper Leg Backward Extension, and the Standing Trunk Flexion Tasks were rated as being most affected by the clothing conditions. The rating for the Sitting Trunk Flexion Task increased slightly for the Wool + Field/B + Arctic and the Wool + Field/A + Arctic/A clothing conditions. The ratings on the Upper Leg Backward Extension Task decreased slightly under these same conditions. The Upper Arm Backward Extension Task was rated among those tasks affected by clothing only for the two field clothing with liners conditions (Wool + Field/A and Wool + Field/B).

Among the psychomotor tasks, the two Horizontal Striking Tasks were rated as most affected by the clothing conditions with little systematic change across conditions. Railwalking was also rated as being affected by the clothing conditions with a high rating for the Wool + Field condition and a low rating for the Wool + Field/A condition. Relative to the other tasks and conditions, the O'Connor Finger Dexterity Test was rated as being impaired only by the wool shirt and trousers.

For Question 2 of Section I, the subjects ranked from 1 to 3 those clothing design characteristics which impaired their performance on the flexibility and the psychomotor tasks (Appendix E). Scores of 3, 2, and 1 were assigned to ranks of 1, 2, and 3, respectively, and the sums of these scores across subjects for each design characteristic and clothing condition are presented in Table 13. For the flexibility tasks, the design characteristics of armpit size and bulk received the highest ratings. Although the armpit size ratings showed little systematic change across conditions, the ratings of bulk increased

Table 12

Subjects' Summed Ratings of the Impairment of Each Task by Each Clothing Condition

	Clothing Condition*							
Battery	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Movements								
Standing Trunk Flexion	17	15	13	15	17	16	19	20
Sitting Trunk Flexion	24	19	20	20	25	29	29	24
Upper Arm Abduction	7	11	5	5	7	8	11	11
Upper Arm Forward	7	5	1	8	10	7	3	7
Upper Arm Backward	8	10	14	15	9	11	3	7
Upper Leg Abduction	9	8	14	9	6	11	9	5
Upper Leg Forward	5	7	11	3	4	4	5	2
Upper Leg Backward	19	21	18	21	18	10	14	20
Tasks								
Pursuit Rotor	8	9	14	13	12	8	8	10
Railwalking	15	23	10	13	15	21	17	20
O'Connor	20	11	5	8	12	12	13	10
Purdue Pegboard	10	8	13	5	8	6	10	9
Front Horizontal Striking	23	21	29	29	24	21	21	22
Side Horizontal Striking	20	24	25	28	25	28	24	25

*1 = Wool, 2 = Wool + Field, 3 = Wool + Field/A, 4 = Wool + Field/B, 5 = Wool + Field/A + Arctic, 6 = Wool + Field/B + Arctic, 7 = Wool + Field/A + Arctic/A, 8 = Wool + Field/B + Arctic/B

Table 13

Subjects' Summed Ratings of the Importance of Each Design Characteristic in Impairing Performance for Each Clothing Condition

Design Characteristics	Clothing Condition* 1	2	3	4	5	6	7	8
Movements								
Armpit Size	40	32	25	38	36	21	39	34
Bulk	25	33	36	53	45	48	40	54
Chest Fit	12	10	8	11	4	14	6	0
Chest Flexibility	8	9	14	12	10	14	12	14
Collar Fit	30	13	13	13	10	15	17	18
Collar Flexibility	6	13	10	10	12	14	5	9
Protruding Parts	7	13	7	3	8	10	11	7
Shoulder Fit	18	20	20	20	18	12	14	5
Shoulder Flexibility	17	19	24	31	28	23	20	27
Stability	15	12	10	5	11	5	12	9
Ventilation	9	10	13	5	7	13	19	18
Waist Fit	18	19	13	9	8	16	2	6
Waist Flexibility	19	20	11	12	19	23	9	11
Weight	6	8	12	13	15	12	25	16
Tasks								
Armpit Size	31	28	36	28	32	17	37	35
Bulk	27	34	31	44	44	56	36	58
Chest Fit	9	10	8	7	4	19	9	5
Chest Flexibility	15	13	16	12	14	14	8	10
Collar Fit	15	16	6	19	9	18	10	9

Table 13

Subjects' Summed Ratings of the Importance of Each Design Characteristic in Impairing Performance for Each Clothing Condition (cont'd)

Design Characteristics	Clothing Condition* 1	2	3	4	5	6	7	8
Tasks (cont'd)								
Collar Flexibility	8	10	9	9	10	12	6	4
Protruding Parts	11	17	12	3	10	9	12	9
Shoulder Fit	16	16	26	29	18	12	18	6
Shoulder Flexibility	22	28	22	28	26	18	32	19
Stability	11	10	16	15	8	13	10	21
Ventilation	12	16	9	7	13	13	20	21
Waist Fit	25	10	11	11	7	9	6	3
Waist Flexibility	12	17	7	11	13	5	7	7
Weight	11	7	7	12	23	18	21	20

*1 = Wool, 2 = Wool + Field, 3 = Wool + Field/A, 4 = Wool + Field/B, 5 = Wool + Field/A + Arctic, 6 = Wool + Field/B + Arctic, 7 = Wool + Field/A + Arctic/A, 8 = Wool + Field/B + Arctic/B

as additional layers were worn, particularly for those layers which included Std. B liners. The design characteristic of collar fit was rated high for the wool clothing condition but then dropped somewhat for the remaining conditions. The design characteristics of shoulder fit, stability, waist fit, and waist flexibility received moderate impairment ratings for the wool clothing condition, but the ratings tended to drop as the number of layers was increased. Weight was introduced as a moderate problem area with the introduction of liners. When liners were added to the arctic layer, ventilation received increased ratings.

For the psychomotor tasks, armpit size and bulk received the highest ratings. Armpit size ratings changed very little as a function of clothing condition and bulk ratings increased with the number of layers worn, particularly for those conditions using Std. B liners. The moderate chest flexibility, collar fit, shoulder fit, and waist fit ratings tended to decrease as the number of layers increased. The weight ratings increased with the addition of the arctic clothing layers and the ventilation ratings increased with the addition of liners to the arctic layer.

Questions 1 and 2, Section II, of the questionnaire (Appendix E) were restatements of the previous question. However, the subjects were to rate each design characteristic on a five-point scale from "no importance" to "extreme importance" in impairing or in aiding performance. Mean ratings were obtained for each design characteristic by assigning a numerical value to each point on the scale, from "1" for "no importance" to "5" for "extreme importance", and multiplying the value by the number of subjects choosing that point on the scale. Therefore, the higher the mean rating, the greater the importance of the design characteristic. The mean ratings for each characteristic under each clothing condition are presented in Table 14. There was a tendency for the impairment ratings to increase as layers of clothing were added and for ratings related to the aiding of performance to decrease. Also, for a given number of layers, Std. A and Std. B liners were rated differently with the latter yielding higher ratings for interfering with performance, as well as higher ratings for aiding it. There were no mean ratings of 4.0 ("considerable importance") or higher.

For the Wool, the Wool + Field, and the Wool + Field/A conditions, all design characteristics were rated as being between of no or of moderate importance in interfering with performance. Under the Wool + Field/B, the Wool + Field/B + Arctic, and the Wool + Field/A + Arctic/A combinations, shoulder flexibility was rated as being of moderate to considerable importance in impairing performance. Bulk was rated as a moderately to considerably important interference factor for all four conditions in which the parka and the arctic trousers were worn, as was armpit size when the parka and arctic trousers were worn with liners. Two additional factors, chest flexibility and weight, were given moderate ratings under the Wool + Field/B + Arctic/B condition.

When the wool shirt and trousers were worn alone or with the field jacket and trousers, a number of design characteristics were rated as being moderately to considerably important

Table 14

Mean Rating of the Importance of Each Design Characteristic in Impairing or Aiding Performance for Each Clothing Condition

Design Characteristic	1 Impair	1 Aid	2 Impair	2 Aid	3 Impair	3 Aid	4 Impair	4 Aid	5 Impair	5 Aid	6 Impair	6 Aid	7 Impair	7 Aid	8 Impair	8 Aid
Armpit Size	2.3	2.9	2.8	2.4	2.4	2.4	2.6	2.8	2.9	2.4	2.9	2.6	3.1	2.4	3.1	2.5
Bulk	1.8	3.0	2.4	2.6	2.6	2.0	2.9	2.3	3.2	2.0	3.4	2.0	3.3	1.7	3.6	2.1
Chest Fit	2.1	3.5	2.3	2.9	2.1	2.8	2.6	2.7	2.3	2.8	2.7	3.0	2.4	2.4	2.5	2.9
Chest Flexibility	2.3	3.4	2.4	2.8	2.3	2.6	2.6	2.8	2.6	2.7	2.8	2.9	2.7	2.4	3.0	2.6
Collar Fit	2.4	2.9	2.3	2.7	2.2	2.6	2.4	2.6	2.4	2.4	2.3	2.8	2.4	2.4	2.6	2.4
Collar Flexibility	2.1	3.1	2.3	2.7	2.1	2.8	2.1	2.9	2.2	2.6	2.3	2.7	2.4	2.4	2.6	2.3
Protruding Parts	1.6	2.8	1.6	3.2	1.6	2.8	1.6	3.1	1.7	2.9	1.7	2.8	2.1	2.6	1.8	2.8
Shoulder Fit	2.4	3.3	2.4	3.0	2.4	2.9	2.8	2.8	2.8	2.4	2.7	2.8	2.6	2.1	2.6	2.8
Shoulder Flexibility	2.3	2.9	2.6	2.8	2.6	2.6	3.0	2.7	2.8	2.6	3.1	2.7	3.0	2.3	2.9	2.5
Stability	2.1	3.1	1.9	3.1	2.1	2.9	2.3	3.0	2.4	2.8	2.8	2.8	2.3	2.3	2.9	2.8
Ventilation	2.4	3.2	2.0	2.9	2.4	2.8	2.3	2.9	2.4	2.8	2.9	2.7	2.6	2.4	2.8	2.3
Waist Fit	2.4	3.3	2.1	3.1	2.1	2.9	2.3	2.9	2.4	2.8	2.6	3.1	2.4	2.6	2.3	2.8
Waist Flexibility	2.4	3.1	2.3	2.9	2.3	3.2	2.6	2.9	2.5	2.9	3.1	3.0	2.6	2.4	2.9	2.6
Weight	1.6	3.4	1.8	3.4	2.0	2.9	2.6	3.3	2.3	2.6	2.5	3.1	2.8	2.4	3.1	2.6

Column numbers 1–8 = Clothing Condition*

*1 = Wool, 2 = Wool + Field, 3 = Wool + Field/A, 4 = Wool + Field/B, 5 = Wool + Field/A + Arctic, 6 = Wool + Field/B + Arctic, 7 = Wool + Field/A + Arctic/A, 8 = Wool + Field/B + Arctic/B

in aiding performance, including shoulder and waist fit, garment stability, and weight. At the other extreme, when the parka and arctic trousers were worn with either Std. A or Std. B liners, no characteristics were judged to be more than of no through little importance in aiding performance.

The results for Question 3 of Section II (Appendix E) are presented in Table 15. Mean ratings were obtained as they had been for the previous two questions. As had occurred on the previous two questions, the mean ratings fell on the lower end of the scale. No problem area was rated as being of more than between moderate and considerable importance. The problem areas rated by the subjects were judged to be of no or of little importance in interfering with performance until the parka and arctic trousers were worn. For those conditions in which the arctic layer was used, bulk was judged to be a problem of moderate to considerable importance. For the clothing combinations which involved the wearing of liners in the arctic layer, the heaviness of the clothing was rated as moderately important in impairing performance. The heat experienced by the men while wearing the Wool + Field/B + Arctic, the Wool + Field/A + Arctic/A, or the Wool + Field/B + Arctic/B conditions was rated as a moderately to considerably important problem.

Mean ratings of the bipolar adjectives presented in Section III of the questionnaire (Appendix E) were obtained by assigning a numerical value to each point on the seven-point scale. The extremely negative category was assigned a value of "1", the neutral category a value of "4", and the extremely positive category a value of "7". Each value was multiplied by the number of subjects choosing that point on the scale to obtain the mean ratings which are presented in Table 16. No mean rating was lower than the somewhat negative category nor higher than the somewhat to very positive points on the scale.

The wool shirt and trousers were rated most favorably on every adjective and the Wool + Field/B + Arctic/B combination was rated lowest, with the exception of the flexibility category, where this condition received the same rating as the condition in which Std. A liners were worn in both the field and the arctic layers. In terms of comfort, the mean ratings decreased as the number of clothing layers was increased and the Std. B liners were given lower ratings than the Std. A. The ventilation ratings also generally decreased in this order as did the mean ratings for weight. However, it should be noted that the Wool + Field/B condition was judged slightly less favorably on the weight dimension than was the Wool + Field/A + Arctic condition and equal mean ratings for this adjective were given to both Wool + Field/B + Arctic and Wool + Field/A + Arctic/A. These latter clothing conditions were also rated equally on the balance dimension, as were Wool + Field and Wool + Field/A + Arctic.

On the dimension related to the degree to which the subjects liked the various clothing combinations, the Wool + Field/B + Arctic/B condition was rated lowest. However, the

Table 15

Mean Rating of the Importance of Problem Areas in Impairing Performance for Each Clothing Condition

	Clothing Condition*							
Problem	1	2	3	4	5	6	7	8
Bulky	1.9	2.5	2.5	2.7	3.1	3.6	3.9	3.6
Chaffing	2.0	2.0	1.9	1.8	1.9	2.1	2.5	1.9
Digging In	1.9	1.8	1.9	1.7	2.0	1.9	2.0	2.2
Drafty	1.7	1.5	1.4	1.4	1.6	1.7	1.5	1.6
Heavy	1.9	1.9	2.1	2.3	2.2	2.8	3.1	3.1
Hot	2.3	2.2	2.8	2.6	2.6	3.3	3.1	3.1
Loose	2.3	2.3	2.1	1.8	1.9	1.7	1.9	1.8
Obstructions	2.0	1.8	2.1	2.3	1.8	1.8	2.1	1.9
Pressure	1.5	1.5	1.8	1.4	1.9	1.9	2.1	2.2
Pinching	1.9	1.7	2.1	1.8	2.1	1.6	2.1	1.8
Slipping	1.7	1.9	1.9	1.8	1.8	1.8	1.6	1.6
Tight	1.6	1.5	2.2	1.8	2.3	1.9	2.1	2.3
Unbalanced	2.1	1.9	2.1	2.3	2.4	2.6	2.4	2.4

*1 =Wool, 2 = Wool + Field, 3 = Wool + Field/A, 4 = Wool + Field/B, 5 = Wool + Field/A + Arctic, 6 = Wool + Field/B + Arctic, 7 = Wool + Field/A + Arctic/A, 8 = Wool + Field/B + Arctic/B

Table 16

Mean Rating of Bipolar Adjectives for Each Clothing Condition

Adjective Dimension	Clothing Condition* 1	2	3	4	5	6	7	8
Comfort	5.1	4.9	4.7	4.5	4.3	4.0	3.8	3.4
Flexibility	5.3	4.8	4.8	4.1	4.0	3.7	3.3	3.3
Ventilation	5.3	4.5	4.2	4.0	3.9	3.5	3.6	3.2
Weight	5.6	4.9	4.6	4.1	4.2	3.8	3.8	3.2
Balance	5.4	4.6	4.9	4.1	4.6	4.1	4.1	3.8
Liking	5.6	5.3	5.0	4.7	4.9	4.6	4.7	4.1

*1 = Wool, 2 = Wool + Field,, 3 = Wool + Field/A, 4 = Wool + Field/B, 5 = Wool + Field/A + Arctic, 6= Wool + Field/B + Arctic, 7 = Wool + Field/A + Arctic/A, 8 = Wool + Field/B + Arctic/B mean rating for this condition was approximately neutral, which was higher than its ratings on the other bipolar adjective dimensions. It should also be noted that the degree of dislike did not increase directly as a function of the number of clothing layers. Instead, the Wool + Field/B condition received the same rating as did the Wool + Field/A + Arctic/A and the remaining two conditions involving Std. B liners were rated lowest.

DISCUSSION

Previous studies, in which the impact of cold weather clothing on performance was tested, were aimed primarily at the development of batteries of psychomotor tasks (references 2, 4, and 6). Cold weather clothing was introduced into these studies to assess the validity of the task batteries by determining the extent to which test scores were affected by some limited manipulation of the clothing being worn. The present research, on the other hand, entailed a more exhaustive investigation of the clothing items *per se*. It was directed primarily toward a layer by layer evaluation of the relationship between cold weather clothing components and performance, using tasks developed in the previous studies. The components of the clothing layers differed extensively from each other in terms of function, weight, design, and material. Each was a unique part of a total system. The results of this study with regard to layers cannot be interpreted as a simple test of whether or not it is more advisable, from a human performance standpoint, to wear two or three clothing layers instead of five. Rather, the data reflect the impact on specific psychomotor capabilities of progressively adding assorted items to the torso. Consideration of Std. A and Std. B liners is a different situation. These items are functionally comparable and mutually exclusive in use. Therefore, it is appropriate to examine the efficacy of using one of these types of liners versus the other in order to achieve a higher level of psychomotor performance.

Because of the experimental design employed in the present study and the forms of analysis applied to the data, it was possible to compare the two types of cold weather liners with regard to their effects on task battery scores and to assess the relationship among those clothing conditions which included either Std. A or Std. B liners. A significant difference between liners was obtained on three of the 14 tasks included in the performance battery and, in each instance, performance with Std. A liners was superior to that with Std. B. Among the three tasks which were significantly affected by the type of liner worn was one which involved bending at the waist in the body's sagittal plane, Standing Trunk Flexion. Of the remaining two, Upper Arm Abduction and the O'Connor Finger Dexterity Test, the former required arm movement and the latter was principally a test of manual dexterity capabilities.

The mean Standing Trunk Flexion score for Std. A liners excelled that for Std. B by 4.8%. This finding is most likely attributable to differences in the designs and the materials of the two types of liners which would impact upon the clothing bulk, or thickness, in the waist area. The finished measurements specified for the back lengths of the Std. B field jacket and parka liners were longer than those specified for the comparable Std. A items. The Std. B field and arctic trouser liners were also smaller in the waist than the comparable Std. A sizes. The design differences in the upper torso liners raise the possibility that the Std. B condition did entail more material, or greater bulk, in the waist area than the Std. A did, while the differences in the lower torso liners may have resulted in greater restriction in the waist with the Std. B liners. With regard to materials, the Std. A liners were not only lighter in weight than the Std. B, but, because of their nylon covering, the Std. A liners had a lower coefficient of friction than did the wool frieze and oxford cloth Std. B liners. Because of these differences in material, the Std. A upper torso liners may have moved upward and away from the waist area more easily than the Std. B did as the subjects performed the Standing Trunk Flexion Task by bending forward from the waist and extending both arms toward the feet.

Before assuming that these were the potent liner characteristics affecting Standing Trunk Flexion, it should be noted that the analysis of this task yielded a significant interaction between clothing layers and type of liner. Performance levels with Std. A liners were superior to those with Std. B when the arctic layer was worn. However, when the field layer was used without arctic components, Std. B liners resulted in slightly higher scores than did the Std. A. Therefore, the relationship between liners and the arctic layer was such that the addition of the latter affected the impact of the field liners.

Liners also affected scores on a second flexibility task, Upper Arm Abduction, and here the mean score for the Std. A liners was 4.9% better than that for the Std. B liners. This flexibility task required the simultaneous raising of both arms in the body's frontal plane. The performance of this movement exerted an upward pull on the upper torso clothing in addition to resulting in an overlapping or bunching of material on the shoulders. Since the suspenders secured the lower torso clothing, the trousers as well were pulled upward as the arms were raised. In light of these interactions between clothing and body movement, the differential effects of liners on Upper Arm Abduction scores would seem to be attributable to the relative ease with which the liners moved upward as the arms were raised. The lighter weight of the Std. A liners probably facilitated their movement as did the low coefficient of friction of their nylon covering relative to the wool frieze and oxford cloth of the Std. B. The Std. A field jacket liner also had openings, or cut-outs, under the inset sleeves which may have permitted greater freedom of movement of the sleeve and arm.

The remaining task in the battery affected by the type of liner worn, the O'Connor Finger Dexterity Test, required movements of the lower arm at the elbow with minimal upper arm and shoulder involvement. The movements were short, repetitive displacements of one arm and hand in the body's transverse plane. Scores on this manual dexterity task were 3.1% better when Std. A liners were worn than when Std. B were used. This significant difference may be attributable to the longer sleeves of the Std. B liners since these liners tended to cause a greater offset, or ballooning, of the sleeves of the outer garments than did the Std. A liners, obscuring the task board from the subject's view. However, it should be noted that the Purdue Pegboard Test, the other manual dexterity task in the battery, was not affected by the type of liner worn. The Purdue Test differed from the O'Connor in that the former required simultaneous movements of both hands and lower arms in the body's sagittal plane. The task board was parallel to the midline of the body and, because of this placement, may not have been obscured by the sleeves.

None of the psychomotor coordination or rate of movement tasks included in the battery were significantly affected by the type of liner worn. With the exception of the O'Connor Finger Dexterity Test, the differential impact of liners on performance was limited to two tasks requiring maximum flexion at body joints. In the case of arm and shoulder movement, the liner effect was obtained only on the task in which the arm was displaced in the body's frontal plane. Therefore, based upon direct comparisons between Std. A and Std. B liners, the Std. A liners do appear to be superior within a circumscribed area of psychomotor performance.

The questionnaire responses of the subjects regarding those particular clothing design characteristics which impaired performance on the battery of tasks are also indications of the subjects' preferences for Std. A liners. The Std. B items were judged to interfere with performance more than the Std. A. In particular, the bulk of the Std. B liners was rated as having a greater impact on body movements than the bulk of the Std. A. Also, the Std. A liners were judged higher along the comfort continuum and were judged more favorably in terms of weight.

A principal consideration in this study was the relative effects of each of the five layers of cold weather clothing on task battery scores. To accomplish this analysis, Std. A and Std. B liners were not contrasted with each other, but were treated separately as layers of two different clothing ensembles. Therefore, two comparable forms of analyses were performed, one of which included only Std. A liners and the other only Std. B. Some of the clothing layers which included Std. B liners were identical to the conditions investigated by Saul and Jaffe (reference 2), Dusek (reference 4), and Kiess and Lockhart (reference 6), while the Std. A conditions had not been previously studied in this context.

In general, task battery performance levels for both the Std. A and the Std. B ensembles decreased as the number of clothing layers was increased. However, the decreases were not strictly linear; the deleterious impact of some layers on performance was greater than that of others. The effects of layers also varied as a function of task type and the body part involved in the task. For example, performance on all but one flexibility test and on only a few of the other types of tests was significantly affected by the number of layers.

As would be expected on the basis of the analyses in which liners were directly compared, the relationship of Std. A liners to the other ensemble layers was not the same as that for the ensemble with Std. B liners. On the two tasks involving movement at the waist in the body's sagittal plane, Standing and Sitting Trunk Flexion, performance with the Std. A ensemble was not significantly decreased until liners were used in the field layer. There were no further effects as additional layers were introduced, which represented more than a doubling of bulk in the waist area. The results for the Std. B ensemble on the Standing Flexion Task were similar to those for the Std. A insofar as field liners decreased performance and the arctic layer had no additional impact. However, the addition of Std. B liners to the arctic layer resulted in a decrement relative to the field layer with liners. The use of Std. B liners on the Sitting Flexion Task yielded still different results. Here, scores for the arctic layer, even without Std. B liners, were significantly lower than those for the field layer with Std. B liners.

As mentioned previously with regard to the effects of type of liner on waist flexion, it is possible that the amount of bulk in this area or restriction due to tightness of clothing around the waist determines the extent of flexion. The design of the parka may also have limited flexion of the upper trunk through another means. The hemline drawcords of the parka were tied around each upper leg. When subjects flexed at the waist, the drawcords limited parka movement so that subjects were exerting pulling forces on the back of the garment and waist flexion could be no greater than the back of the garment allowed. Based upon the performance differences between the Std. A and the Std. B ensembles, it seems that the impact of these clothing variables was greater when the components of the Std. B ensemble were worn.

The flexibility tasks involving movement of the arm and shoulder in either the frontal or the sagittal plane of the body again resulted in a worsening of performance as layers of either the Std. A or the Std. B ensembles were added to the torso, and there were also differences between these ensembles. With the Std. B clothing conditions, scores on the Upper Arm Abduction Task decreased significantly as each layer was added to the wool shirt and trousers. However, the liners of the Std. A ensemble did not affect scores. Here, performance decreased initially when the field layer was worn and again when the arctic layer was added, but there was no effect attributable to the addition of Std. A liners to either of these layers. As mentioned previously, this task involves an upward pull on the upper and lower torso clothing. Performance levels would seem to be affected by the ease with which the clothing moves upward as the arms are abducted. The weight and relatively high coefficient of friction of the Std. B liners were probably the factors which interfered with movement of the clothing.

A second arm flexibility movement, Upper Arm Forward Extension, was affected by the number of clothing layers and the results again differed for the two ensembles. This task required movement of the right arm and shoulder in the body's sagittal plane. For the Std. A system, only the scores when all layers were worn were significantly lower than those for wool shirt and trousers alone or with the field clothing. There were no other differences among clothing conditions. With the Std. B ensemble, the deleterious impact on performance occurred when the liners were added to the field layer. There were no subsequent decreases in scores. Apart from these differences between the Std. A and the Std. B components, it should be noted that, for both systems, the impact on performance attributable to adding the arctic parka and trousers was not as great on this task as it was on the Upper Arm Abduction Test. These two arm movements differed with regard to the body plane in which they were made. The arm remained parallel to the body's vertical axis during Upper Arm Forward Extension. On the other hand, when the arm was abducted, an angle was generated between the arm and the vertical axis of the body. Thus, restrictions imposed by the clothing in the arm-shoulder area would be more critical during Upper Arm Abduction than during Upper Arm Forward Extension.

The remaining arm flexibility test included in the battery, Upper Arm Backward Extension, also required movement in the body's sagittal plane and was affected by the clothing layers worn. With the Std. A ensemble, scores decreased as the number of layers was increased, but only the two extreme conditions differed significantly from each other. Performance levels under the clothing conditions comprising the Std. B ensemble did not vary directly as a function of the number of clothing layers. The lowest scores were achieved when the complete ensemble was worn and when the field layer with liners was used. These conditions resulted in significantly lower performance than the wool shirt and trousers. There were no other differences among the clothing conditions. There seems to be no obvious explanation of the finding that scores for the Std. B, three-layer condition were significantly lower than those for the wool shirt and trousers, while scores for the four-layer condition were not. The latter entailed the imposition of greater bulk in the arm and shoulder area and, of course, included all the components of three-layer condition.

One of the psychomotor coordination tasks included in the present battery, the Pursuit Rotor, also involved movement of the arm and shoulder and was affected by the Std. A and the Std. B clothing conditions. For the Std. B ensemble, the findings of Kiess and Lockhart (reference 6) were substantiated. Time on target scores decreased as the number of layers was increased. This was also the case for the Std. A ensemble, with the exception of the field layer with liner condition, which yielded the lowest score. Unlike the flexibility tests included in the battery, the Pursuit Rotor did not require maximum displacement of the arm from the torso in a specified body plane. Instead, the lower arm was maintained in a horizontal position and the upper arm was abducted slightly from the torso. A combination of clothing weight on the lower arm and bulk in the elbow and underarm areas could be expected to influence performance on this task. The bulk of the clothing may have caused the arm to be offset from the body, affecting the normal relationship between the arm and the upper torso. The results obtained with regard to the Std. B ensemble are compatible with these conjectures. However, the Std. A ensemble findings are not since the lowest performance level did not occur when the most clothing layers were worn. In spite of the difficulty in identifying the particular clothing characteristics influencing Pursuit Rotor time on target, it should be noted that performance on this task was affected by cold weather clothing components.

The Horizontal Striking Tasks, included in the performance battery as measures of rate of movement, also required arm and shoulder movements in the body's transverse plane. The Side Striking Test was significantly affected by layers of the Std. B ensemble. Again, scores decreased as the number of clothing layers was increased. Therefore, the results were directly related to both the weight and the bulk of the various clothing conditions. However, the greatest decrease in the mean scores occurred when the arctic layer, with or without liners, was added to the Std. B ensemble. This suggests that some design configuration of the arctic components may have been the potent variable affecting striking performance. Using a similar Horizontal Striking Task, McKee (reference 5) found significant performance impairment in front striking when a restrictive harness was worn across the shoulders. It is possible that the hemline and waist drawcords of the arctic parka acted to limit parka movement and caused a binding or restriction in the shoulder area.

For both the Std. A and the Std. B ensembles, two of the three flexibility tasks in the battery which required movement of the leg at the hip were significantly affected by the number of clothing layers used. The Upper Leg Abduction Task involved movement in the body's frontal plane and, with the Std. B ensemble, the angular displacement of the leg decreased as the number of clothing layers increased. The wool shirt and trousers and the field layers resulted in performance significantly superior to that achieved when the arctic clothing was worn with or without liners. It appears that, on this task as well, the drawcords of the arctic parka may have influenced scores. The Std. A ensemble data support this hypothesis since the arctic layer, without liners, also yielded means significantly lower than those achieved when either one or two clothing layers were worn. The use of the Std. A liners in the arctic clothing resulted in performance levels somewhat superior to those achieved without liners. It is possible that the parka drawcords could not be as tightly secured around the upper leg when the liners were present and, therefore, greater movement of the leg was possible.

Movement of the leg forward in the body's sagittal plane could be expected to have been similarly affected by drawcord restriction. However, this does not appear to have been the case for either ensemble. The two extreme Std. A clothing conditions differed significantly from each other, but there were no other differences. For the Std. B ensemble, the scores with the wool shirt and trousers were significantly superior to all others and the remaining conditions did not differ statistically. Forward extension of the leg could be expected to have been affected by clothing bulk in the form of an overlapping or bunching of material on the dorsal surface of the upper leg. However, bulk does not appear to have been a potent variable on this task.

Heart rate was included in the present study as a measure of the effort exerted in performing the task battery. The analyses performed on these data did yield a significant difference between the resting rate evidenced prior to performance of the task battery and the higher rate achieved after the exercises of the battery had been completed. There was a slight, but not significant, tendency for the difference scores to be higher under Std. B than under Std. A conditions. In addition, the second heart rate reading increased somewhat as the number of clothing layers were increased, but, again, the effect of layers was not significant. The subjects' responses on the questionnaire also varied as a function of the clothing being worn. The judged comfort of the clothing decreased as the number of layers increased, and clothing with Std. B liners was rated less favorably than a comparable number of layers with Std. A liners.

CONCLUSIONS

The major findings of this study, based upon the overall results, are as follows:

1. The Std. B liners impaired certain aspects of psychomotor performance, particularly body flexibility, to a greater extent than the Std. A liners did. On those tasks in which performance levels differed significantly as a function of the type of liner worn, scores were from 3% to 5% better with Std. A liners.

2. The Std. A liners were rated more favorably than the Std. B liners by the test participants and resulted in a somewhat lower level of physical exertion, as represented by heart rate. The mean heart rate difference score was 25% lower for the Std. A liner conditions than for the Std. B liner conditions.

3. Psychomotor performance level and user acceptance decreased as the number of clothing layers worn was increased. However, the layers were not equally deleterious in their effects on performance nor were all aspects of performance equally impaired by wearing a certain combination of layers.

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APPENDIX A

PHOTOGRAPHS OF CLOTHING CONDITIONS

Figure A1. Wool, cold weather shirt and trousers.

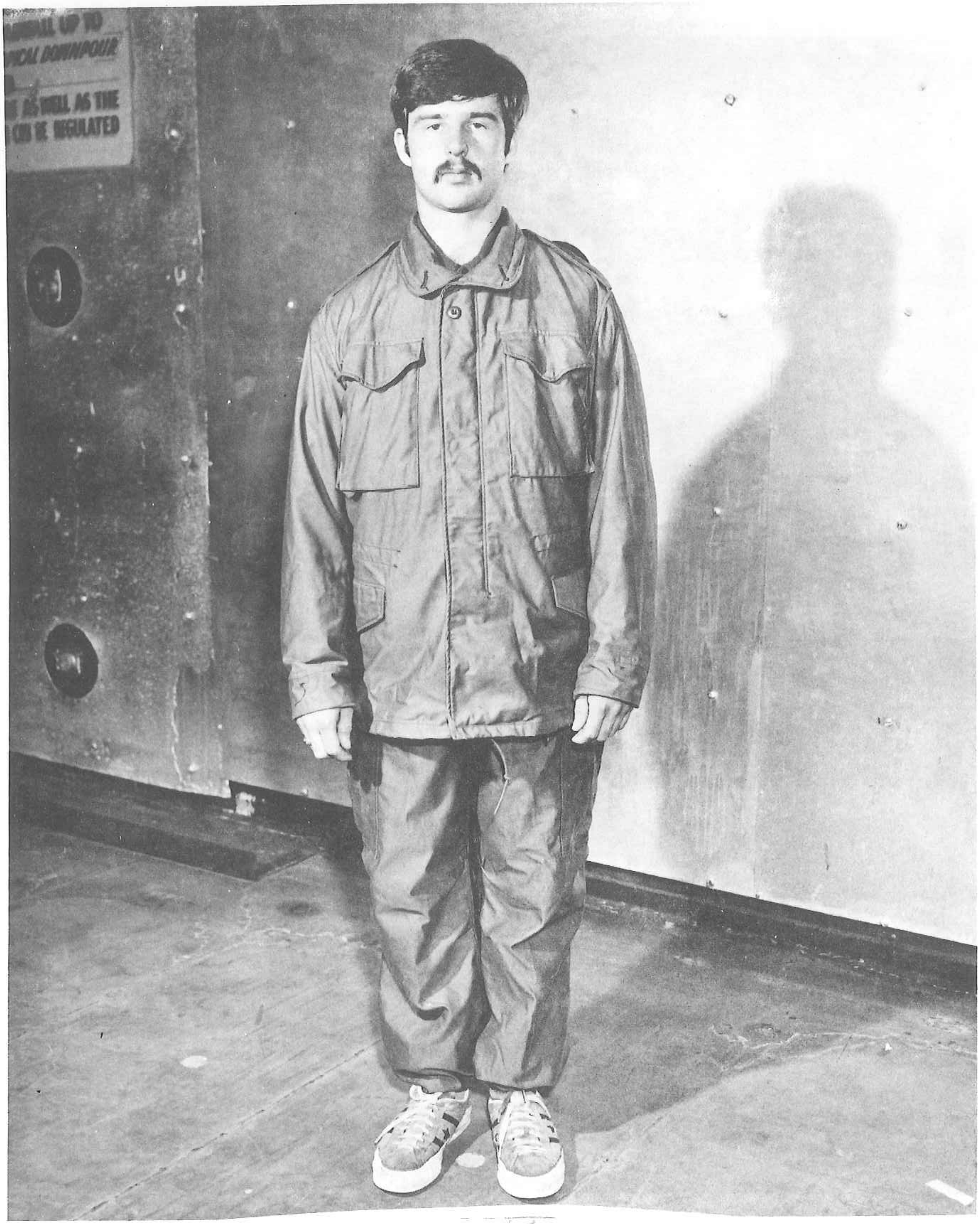

Figure A2. Field jacket and trousers worn over the wool shirt and trousers.

Figure A3. Field jacket and trousers with liners worn over the wool shirt and trousers. The Std. A field liners are displayed on the left and the Std. B on the right.

Figure A4. Parka and arctic trousers with liners worn over the wool shirt and trousers and the field jacket and trousers with liners. The Std. A arctic liners are displayed on the left and the Std. B on the right.

APPENDIX B

FINISHED MEASUREMENTS OF COLD WEATHER CLOTHING ITEMS

Appendix B1

Finished Measurements (mm) for Upper Torso Clothing

Size		Wool	Field	A Liner (Field)	B Liner (Field)	Arctic	A Liner (Arctic)	B Liner (Arctic)
Half Chest[1]								
X-Small	Short	–	527	–	–	–	–	–
	Regular	457	527	565	543	635	635	648
	Long	–	527	–	–	–	–	–
Small	Short	–	578	–	–	–	–	–
	Regular	508	578	616	594	686	686	698
	Long	–	578	–	–	–	–	–
Medium	Short	–	629	–	–	–	–	–
	Regular	559	629	667	645	737	737	749
	Long	–	629	–	–	–	–	–
Large	Short	–	679	–	–	–	–	–
	Regular	610	679	718	695	787	787	800
	Long	–	679	–	–	–	–	–
X-Large	Short	–	730	–	–	–	–	–
	Regular	660	730	768	746	838	838	851
	Long	–	730	–	–	–	–	–
Tolerance		± 13	± 19	± 19	± 19	± 19	± 19	± 19
Back Length[2]								
X-Small	Short	–	749	–	–	–	–	–
	Regular	737	787	698	718	1041	826	857
	Long	–	826	–	–	–	–	–
Small	Short	–	762	–	–	–	–	–
	Regular	749	800	711	730	1054	838	870
	Long	–	838	–	–	–	–	–
Medium	Short	–	775	–	–	–	–	–
	Regular	762	813	724	743	1067	851	883
	Long	–	851	–	–	–	–	–

Appendix B1

Finished Measurements (mm) for Upper Torso Clothing (cont'd)

Size		Wool	Field	A Liner (Field)	B Liner (Field)	Arctic	A Liner (Arctic)	B Liner (Arctic)
Back Length[2] (cont'd)								
	Short	–	787	–	–	–	–	–
Large	Regular	775	826	737	756	1080	864	895
	Long	–	864	–	–	–	–	–
	Short	–	800	–	–	–	–	–
X-Large	Regular	787	838	749	768	1092	876	908
	Long	–	876	–	–	–	–	–
Tolerance		± 19	± 25	± 13	± 25	± 25	± 19	± 19
Sleeve Length[3]								
	Short	–	464	–	–	–	–	–
X-Small	Regular	864	489	559	572	635	597	559
	Long	–	514	–	–	–	–	–
	Short	–	464	–	–	–	–	–
Small	Regular	889	489	565	581	648	610	575
	Long	–	514	–	–	–	–	–
	Short	–	464	–	–	–	–	–
Medium	Regular	914	489	572	591	660	622	591
	Long	–	514	–	–	–	–	–
	Short	–	464	–	–	–	–	–
Large	Regular	940	489	578	600	673	635	603
	Long	–	514	–	–	–	–	–
	Short	–	464	–	–	–	–	–
X-Large	Regular	965	489	584	610	686	648	613
	Long	–	514	–	–	–	–	–
Tolerance		± 19	± 19	±13	± 19	± 19	± 19	± 19

[1] For liners, this measurement is taken with the liner flat and front edges abutting and measurement extends from folded edge to folded edge at the base of the armhole. For all other items, measurement is taken at the base of the armhole, from folded edge to folded edge, with the front closed.

[2] For liners, this measurement is taken along the center of the back from the edge of the neck to the bottom edge of the liner. For all other items, it is taken along the center back from the undercollar seam to the extreme bottom edge of the garment.

[3] For the wool shirt, this is measured from the center back at the collar seam, diagonally across the back, and down the sleeve to the bottom edge of the cuff. For the field coat, this measurement extends from the base of the armhole, along the forearm seam, to the bottom of the sleeve. For the remaining items, it is taken from the top to the bottom of the sleeve.

Appendix B2
Finished Measurements (mm) of Lower Torso Clothing

Size		Clothing Item: Wool	Field	A Liner (Field)	B Liner (Field)	Arctic	A Liner (Arctic)	B Liner (Arctic)
Half Waist[1]								
X-Small	Short	357	368	425	–	406	470	–
	Regular	357	368	425	406	406	470	432
	Long	357	368	425	406	406	470	432
Small	Short	409	419	476	–	457	521	–
	Regular	409	419	476	457	457	521	483
	Long	409	419	476	457	457	521	483
Medium	Short	459	470	527	–	508	572	–
	Regular	459	470	527	508	508	572	533
	Long	459	470	527	508	508	572	533
Large	Short	511	521	578	–	559	622	–
	Regular	511	521	578	559	559	622	584
	Long	511	521	578	559	559	622	584
X-Large	Short	562	572	629	–	610	673	–
	Regular	562	572	629	610	610	673	635
	Long	562	572	629	610	610	673	635
Tolerance		+13,-6	+19,-13	+19,-13	+19,-13	+19,-13	+25,-13	+25,-13
Inseam[2]								
X-Small	Short	711	673	559	–	648	584	–
	Regular	787	749	559	622	724	584	572
	Long	864	826	660	737	800	692	686
Small	Short	711	676	559	–	648	584	–
	Regular	787	753	559	622	724	584	572
	Long	864	829	660	737	800	692	686
Medium	Short	711	679	559	–	648	584	–
	Regular	787	756	559	622	724	584	572
	Long	864	832	660	737	800	692	686
Large	Short	711	683	559	–	648	584	–
	Regular	787	759	559	622	724	584	572
	Long	864	835	660	737	800	692	686
X-Large	Short	711	686	559	–	648	584	–
	Regular	787	762	559	622	724	584	572
	Long	864	838	660	737	800	692	686
Tolerance		+19,-13	±19	±19	±19	±19	±25	±25

Appendix B2
Finished Measurements (mm) of Lower Torso Clothing (cont'd)

Size		Wool	Field	A Liner (Field)	B Liner (Field)	Arctic	A Liner (Arctic)	B Liner (Arctic)
		Clothing Item						
Outseam[3]								
X-Small	Short	991	952	–	–	940	–	–
	Regular	1083	1041	–	–	1029	–	–
	Long	1175	1130	–	–	1118	–	–
Small	Short	1003	965	–	–	952	–	–
	Regular	1096	1054	–	–	1041	–	–
	Long	1187	1143	–	–	1130	–	–
Medium	Short	1016	978	–	–	965	–	–
	Regular	1108	1067	–	–	1054	–	–
	Long	1200	1156	–	–	1143	–	–
Large	Short	1029	991	–	–	978	–	–
	Regular	1121	1080	–	–	1067	–	–
	Long	1213	1168	–	–	1156	–	–
X-Large	Short	1041	1003	–	–	991	–	–
	Regular	1134	1092	–	–	1080	–	–
	Long	1226	1181	–	–	1168	–	–
Tolerance		+19,-13	±19	–	–	±19	–	–
Half Knee[4]								
X-Small	Short	260	298	–	–	353	–	–
	Regular	260	298	–	–	353	–	–
	Long	260	298	–	–	353	–	–
Small	Short	273	311	–	–	368	–	–
	Regular	273	311	–	–	368	–	–
	Long	273	311	–	–	368	–	–
Medium	Short	286	324	–	–	387	–	–
	Regular	286	324	–	–	387	–	–
	Long	286	324	–	–	387	–	–
Large	Short	298	337	–	–	406	–	–
	Regular	298	337	–	–	406	–	–
	Long	298	337	–	–	406	–	–
X-Large	Short	311	353	–	–	422	–	–
	Regular	311	353	–	–	422	–	–
	Long	311	353	–	–	422	–	–
Tolerance		±6	±13	–	–	±13	–	–

Appendix B2
Finished Measurements (mm) of Lower Torso Clothing (cont'd)

Size		Wool	Field	A Liner (Field)	B Liner (Field)	Arctic	A Liner (Arctic)	B Liner (Arctic)
				Clothing Item				
Half Bottom[5]								
X-Small	Short	229	264	–	–	305	–	–
	Regular	229	264	–	–	305	–	–
	Long	229	264	–	–	305	–	–
Small	Short	235	270	–	–	311	–	–
	Regular	235	270	–	–	311	–	–
	Long	235	270	–	–	311	–	–
Medium	Short	241	276	–	–	318	–	–
	Regular	241	276	–	–	318	–	–
	Long	241	276	–	–	318	–	–
Large	Short	248	283	–	–	324	–	–
	Regular	248	283	–	–	324	–	–
	Long	248	283	–	–	324	–	–
X-Large	Short	254	289	–	–	330	–	–
	Regular	254	289	–	–	330	–	–
	Long	254	289	–	–	330	–	–
Tolerance		±6	±6	–	–	±6	–	–

[1] Measurement taken along top of waist from folded edge to folded edge with front snap fastener secured.

[2] Measurement taken from center of crotch seam to bottom of leg.

[3] Measurement taken from top of waist to bottom of leg along the seam.

[4] Measurement taken from folded edge to folded edge.

[5] Measurement taken at bottom edge of trouser from folded edge to folded edge.

APPENDIX C

DESCRIPTIONS OF CLOTHING COMPONENTS

The cold weather underwear is wool and cotton knit. The undershirt is hip length with long sleeves and rib-knit wristlets. It has a high, round neckline with a two-button closure. The drawers are ankle length with rib-knit anklets, a fly-front closure, and an elasticized waistband with suspender loops attached at each side of the front. The wool serge trousers are conventionally-styled and of an 18 oz/yd^2 fabric. These cold weather trousers have two side pockets, two hip pockets with flap closures, belt loops, and a slide-fastened fly closure. Slide buckles on each side of the trousers are used to adjust the waist band, and suspender loops are provided on each side of the front waistband. The cold weather shirt is made of a 16 oz/yd^2, wool and nylon flannel fabric. It is coat-styled with a six-button front closure and one-button cuff closures. There are two patch pockets with button-flap closures on each side of the upper front. The suspenders, which are worn over the wool shirt, are a scissors-back type made of cotton elastic. They have front hooks for lower garment suspension and slide buckles for size adjustment.

The field trousers are made of 50% nylon and 50% cotton sateen which is 8.5 to 9.0 oz/yd^2. They have a slide-fastened fly closure, belt loops, and slide-buckle waist adjustment straps. There is a front pocket with snap-fastened flap closures on each thigh, hip pockets with flaps, and cargo pockets. The knee area is double pleated and drawcords are located at the ends of the trouser legs. Loops on each side of the front waistband are used to attach suspenders, and button tabs are located on the inside waistband for attaching a field trouser liner. The Std. A field trouser liner is a quilted, three-ply garment made of rip-stop, nylon-covered, polyester batting which weighs approximately 5 oz/yd^2. It is three-quarter length with a single button front closure on the waistband and double pleats at the knees. The waistband has six, vertical buttonholes for attaching the liner to the field trousers. The Std. B field trouser liners are mohair frieze lined with nylon oxford cloth. The Std. B liner is also three-quarter length and has buttonholes at the waistband.

The hip-length field jacket is made of the same 8.5 to 9.0 oz/yd^2 material as the field trousers. The jacket has a slide-fastened front closure with a snap-fastened flap. The sleeves have wrist tabs that can be adjusted and hand shield extensions. A bellows-type breast pocket with a snap-fastened flap closure is located on each side of the upper front and an inside hanging pocket with snap-fastened flap closures is on each side of the lower front. The coat has waist and hem drawcords, and buttons are placed along the inside facing of the front closure for attaching a field jacket liner. Both the Std. A and the Std. B field jacket liners have buttonholes at the neck and front edges and buttonhole tabs at the sleeve bottoms for the purpose of attaching the liner to the field coat. The Std. A liner is a quilted, three-ply garment made of rip-stop, nylon-covered, polyester batting weighing approximately 5 oz/yd^2. It is collarless and of hip-length cardigan style with openings under the armholes. The Std. B liner is of mohair frieze lined with nylon oxford cloth. The fabric is cut away at the bend in the arm and in the underarm area and gussets are inserted.

The arctic trousers are made of cotton and nylon oxford cloth which weighs 4.8 to 5.8 oz/yd^2. They have a slide-fastened fly closure, a drawcord at the waist and at the ends of the trouser legs, and cargo pockets. The knees are double-pleated. Loops on each side of the front waistband are used to attach suspenders and the trouser liner is attached to button tabs on the inside of the waistband. Both the Std. A and the Std. B arctic trouser liners have a single-button front closure and an opening on each side for access to undergarment pockets. The Std. A liner is of the same nylon, quilted material used for the field jacket and trouser liners. The Std. B liner is of the mohair frieze material.

The parka is made of the same cotton and nylon oxford cloth material used in the arctic trousers. It is single-breasted and has a slide-fastened front closure with a snap-fastened protective flap. The sleeves have a single-button closure. A slit-type breast pocket with a flap and a snap-fastened closure is on each side of the front. The parka has waist and hemline drawcords and inside buttons and button tabs for attaching the liner. The Std. A liner is made of the nylon, quilted material. The liner is collarless and a three-quarter length cardigan style. Buttonholes along the neck and front edges and button tabs on the sleeves are used for attaching the liner to the parka. The mohair frieze Std. B liner is cut away at the elbow and in the underarm area and gussets are inserted. There are again buttonholes for attaching the liner to the parka.

APPENDIX D

DESCRIPITIONS AND INSTRUCTIONS FOR TASK BATTERY

1. **Standing Trunk Flexion (reference 10).**

a. **Materials:** Box with vertical scale attached which is marked at 0.635-cm intervals and a goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The goniometer is placed on the right lateral surface of the body at chest height and is set to zero when the subject is standing straight. Record to the nearest 0.635 cm the point on the vertical scale that the subject reaches and holds for 5 sec. Record the goniometer reading from this position as well. Make four successive measurements with 15-sec intervals between trials. Be sure the knees do not bend.

c. **Instructions to be read to the subject:**

(1) You will stand on this box with your feet parallel, about four inches apart, and with your toes at the edge of the box facing the upright stick. (Set the goniometer to zero.) Keep your knees stiff and do two preliminary toe touches. Then take a third toe touch. Keeping your hands together and sliding your palms down the outside surface of the board, hold the lowest point you can touch for a few seconds before you straighten up again.

(2) Are there any questions? (Correct the subject if he is not following instructions.)

Figure D1. Standing Trunk Flexion. Final position.

2. **Sitting Trunk Flexion (reference 10).**

a. **Materials:** Bench, goniometer, and horizontal scale marked at 0.635-cm intervals.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The goniometer is placed on the right lateral surface of the body at chest height and is set to zero when the subject is sitting straight. Record to the nearest 0.635 cm the point on the horizontal scale that the subject reaches and holds for 5 sec. Record the goniometer reading from this position as well. Make four successive measurements with 15-sec intervals between trials. Be sure the knees do not bend.

c. **Instructions to be read to the subject:**

(1) You will sit on this bench with your knees stiff and your legs out in front of you. (Set goniometer to zero.)

(2) With your heels braced against the wall, bend forward twice. Then bend forward a third time, reaching as far forward as you can. Keep your knees stiff at all times. Hold the position for five seconds.

(3) Are there any questions? (Correct the subject if he is not following instructions.)

Figure D2. Sitting Trunk Flexion. Final position.

3. **Upper Arm Abduction (reference 4).**

a. **Materials:** Goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Place the goniometer on the right arm just above the elbow with the dial on the posterior side of the arm. Set the goniometer to zero. Be sure that the subject is standing with toes, abdomen, sternum, and nose against the projecting corner of a wall. Watch for contact with the wall, extension of the back, arm rotation, elbow flexion, and movement out of the frontal plane. The reading is taken at the point where a deviation occurs or no further movement is possible. Four trials are given with 15-sec intervals between trials.

c. **Instructions to be read to the subject:**

(1) Start facing the corner with toes, abdomen, sternum, and nose against the corner of the wall, arms hanging at your sides, palms facing in toward the body. (Set the goniometer to zero.)

(2) Raise both arms sideward and upward as far as possible while maintaining the contacts with the wall.

(3) Are there any questions? (Correct the subject if he is not following the instructions.)

Figure D3. Upper Arm Abduction. Final position.

4. **Upper Arm Forward Extension (reference 10).**

a. **Materials:** Goniometer.

b. **Instructions to the tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Place the goniometer on the right arm just above the elbow with the dial on the lateral surface. Be sure that the subject is standing with his arm against his side, elbow stiff and the arm perpendicular to the floor. Set the goniometer to zero. Read the goniometer when the arm is raised as far forward and up as possible. The elbow is kept stiff and the arm parallel to the median plane. The trunk is maintained erect. There are four trials with 15-sec intervals between trials.

c. **Instructions to be read to the subject:**

(1) Stand facing the wall but not quite touching it. Your right shoulder and arm should be just past the edge of the doorway.

(2) Place your right arm against your side with the elbow stiff and the arm straight down. (Set goniometer to zero.)

(3) Now raise your entire arm forward and up as far as possible. Keep you elbow stiff and stand up straight.

(4) Are there any questions? (Correct the subject if he is not following instructions.)

Figure D4. Upper Arm Forward Extension. Final position.

5. **Upper Arm Backward Extension (reference 2).**

a. **Materials:** Goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The subject stands erect with his back against a wall. The entire arm, elbow stiff, is rotated until the palm of the hand faces outward and the thumb points dorsally. The goniometer is placed on the right arm just above the elbow and is set to zero when the arm is perpendicular to the floor. The subject extends his entire arm backward as far as possible while keeping his elbow stiff and his palm out. Read the goniometer when the limit of motion is reached, when the elbow bends, or when the arm moves out of the medial plane. There are four trials with 15-sec intervals between trials.

c. **Instructions to be read to the subject:**

(1) Stand with your back to the wall. Your right shoulder and arm should be just past the edge of the doorway.

(2) Place your right arm against your side with the elbow stiff and the arm straight down. Rotate your arm until your palm faces outward. (Set the goniometer to zero.)

(3) Now raise your entire arm backward as far as possible. Keep your elbow stiff and your palm out.

(4) Are there any questions? (Correct the subject if he is not following instructions.)

Figure D5. Upper Arm Backward Extension. Final position.

6. **Upper Leg Abduction (reference 2).**

a. **Materials:** Goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Place the goniometer on the right leg just above the knee with the dial on the posterior side of the leg. Be sure that the subject is standing erect, feet together, and facing an upright support about one foot in front of him. The subject grasps the support firmly with both hands. Set the goniometer to zero. Watch for bending of the trunk and leg rotation. The reading is taken at the point where a deviation occurs or no further movement is possible. Four trials are given with a 15-sec interval between trials.

c. **Instructions to be read to the subject:**

(1) Start facing this support and about one foot from it. Stand erect with your feet together and grasp the support with both hands. (Set the goniometer to zero.)

(2) Raise your right leg sideward and up as far as possible being careful not to bend your trunk or rotate your leg. Also, keep your knee stiff.

(3) Are there any questions? (Correct the subject if he is not following instructions.)

Figure D6. Upper Leg Abduction. Final position.

7. Upper Leg Forward Extension

a. **Materials:** Goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Place the goniometer on the right leg just above the knee with the dial on the lateral surface. The subject stands erect with his back against a wall and his feet together. Set the goniometer to zero. Read the goniometer when the right leg is raised as far forward and up as possible. The knee is kept stiff and the back is kept against the wall. An upright support is grasped with the left hand to maintain balance. There are four trials with 15-sec intervals between trials.

c. **Instructions to be read to the subject:**

(1) Stand erect with your feet together and your back against this wall. Grasp the support with your left hand. (Set the goniometer to zero.)

(2) Raise your leg forward and up as far as possible. Keep your knees stiff and your back against the wall.

(3) Are there any questions? (Correct the subject if he is not following instructions.)

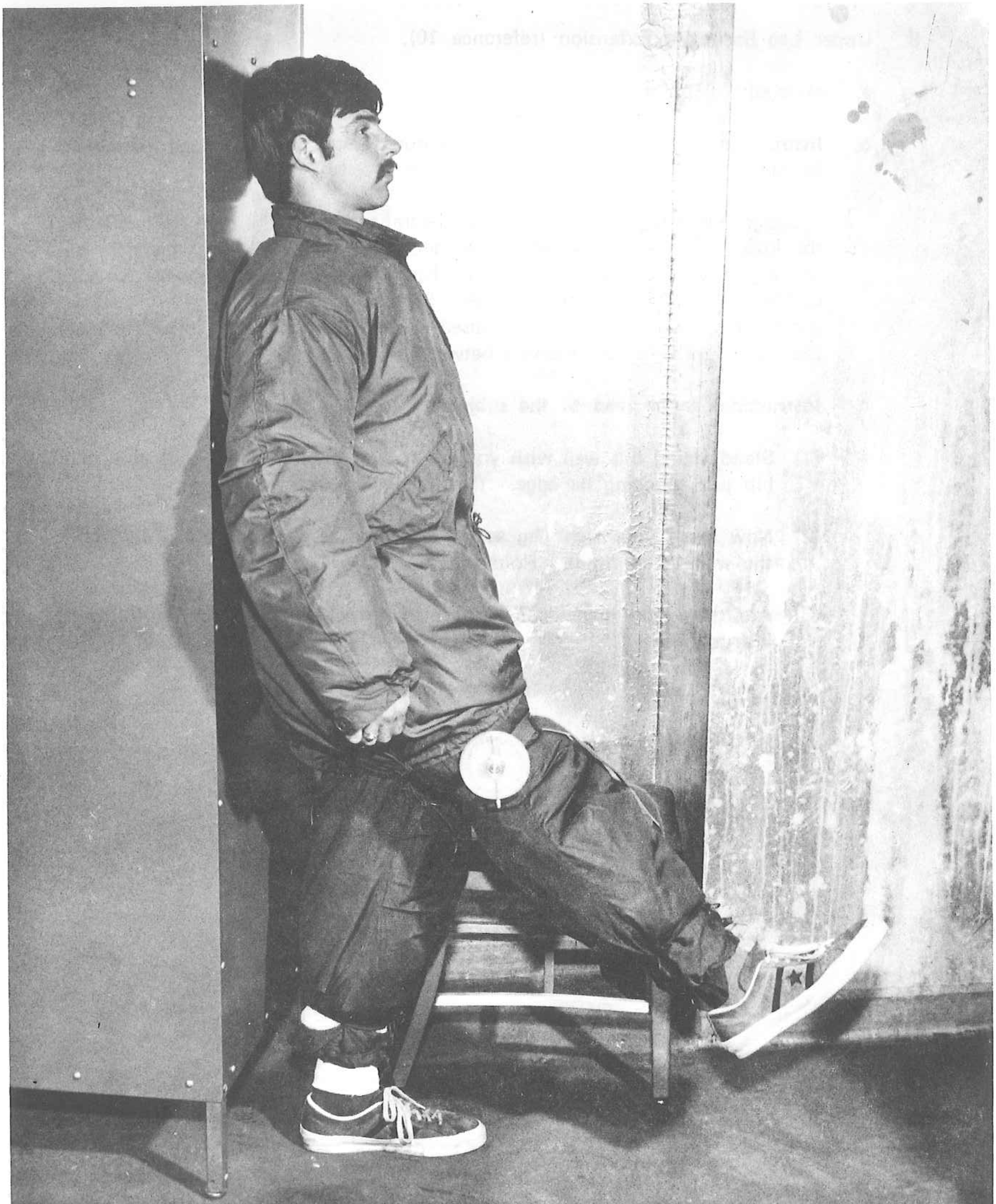

Figure D7. Upper Leg Forward Extension. Final position.

8. **Upper Leg Backward Extension (reference 10).**

a. **Materials:** Goniometer.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Place the goniometer on the lateral surface of the right leg just above the knee. The subject stands facing and touching a wall with his right hip and leg partially extended beyond it. His right hip is pressed against the edge of the wall and his feet are together. Set the goniometer to zero. Read the goniometer when the right leg is raised as far backward as possible. There are four trials with 15-sec intervals between trials.

c. **Instructions to be read to the subject:**

(1) Stand facing this wall with your right foot just beyond it and your right hip just touching its edge. (Set the goniometer to zero.)

(2) Now move your right leg as far backward as possible. Keep up against the wall at all times. Hold that position.

(3) Are there any questions? (Correct the subject if he is not following instructions.)

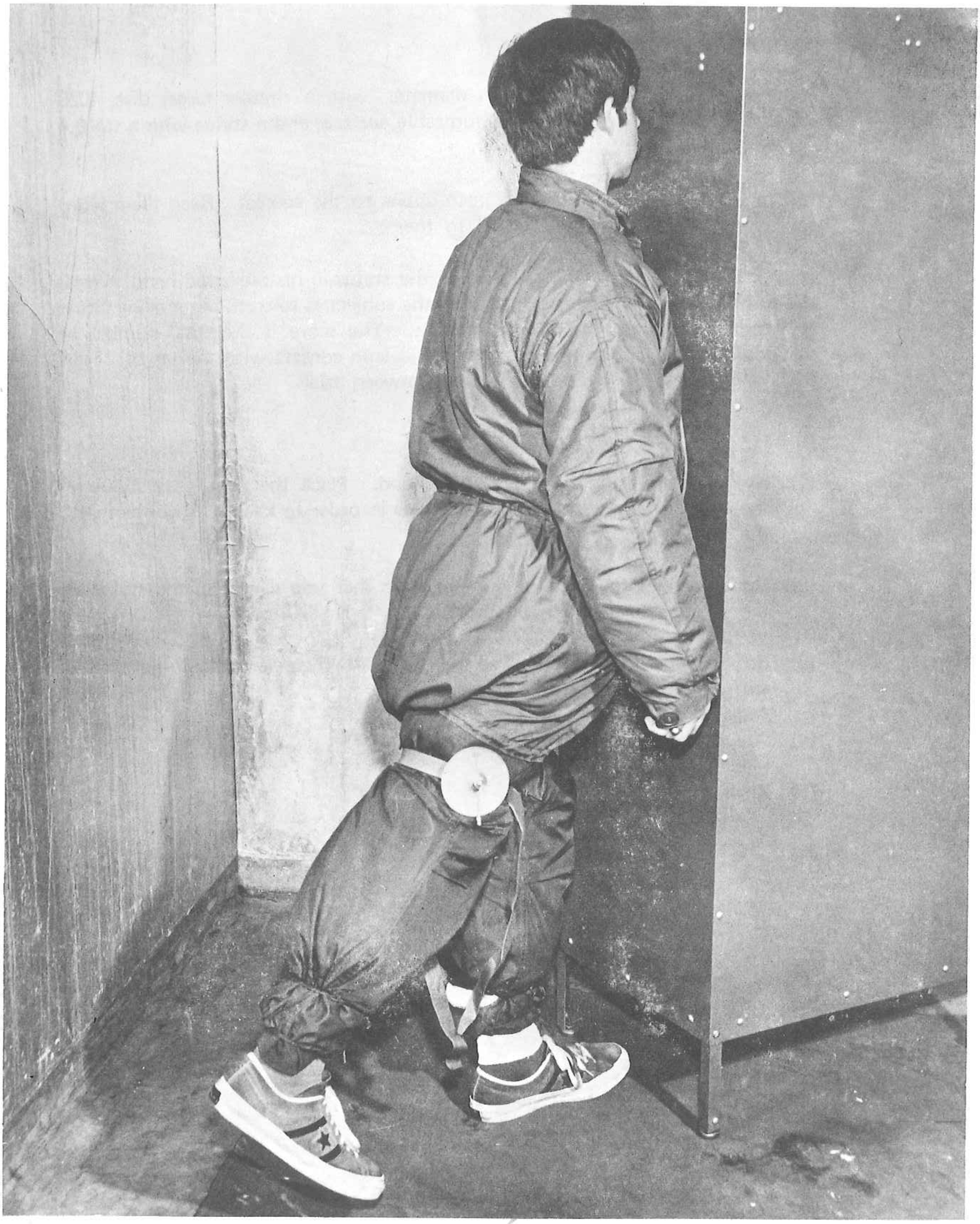

Figure D8. Upper Leg Backward Extension. Final position.

9. **Pursuit Rotor (reference 11).**

a. **Materials:** A turntable, 26 cm in diameter, with a circular target disc, 1.25 cm in diameter, embedded in the turntable surface, and a stylus with a tip 0.4 cm in diameter.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The subject stands and holds the stylus in his preferred hand. While the turntable is revolving at 60 rev/min, the subject is to track the moving target by keeping the stylus in contact with it. The score is the total number of seconds during a 30-sec trial that the stylus is in contact with the target. Four trials are given with a 30-sec interval between trials.

c. **Instructions to be read to the subject:**

(1) Hold the stylus in your preferred hand. Place the tip of the stylus on the moving target and move the stylus in order to keep it in contact with the target.

(2) Your score is the total amount of time that you can keep the stylus on the target during a 30-sec trial.

(3) Begin tracking the target. The trial will start when you make initial contact with the target.

(4) Are there any questions?

(5) Begin tracking.

Figure D9. Pursuit Rotor.

10. Railwalking (reference 12).

a. **Materials:** A rail 365 cm long and 1.90 cm thick, marked at intervals of 1 cm.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: Record to the nearest 1 cm the distance walked before a foot touches the support of the rail or the floor. Walking must be heel to toe and the subject must keep his hands grasped behind his back.

c. **Instructions to be read to the subject:**

(1) Stand at this end of the board ready to begin walking. Start by placing one foot on the board so that the back of the foot is even with the end of the board. Then place your other foot in front of the first so that the heel touches the toe of the first foot. Walk as far as you can in this fashion, heel to toe. Grasp your hands behind your back for this test.

(2) Your score will be the distance to the end of the toe of the last foot that remained on the rail.

(3) Any questions? Begin.

Figure D10. Railwalking.

11. O'Connor Finger Dexterity Test (reference 13).

a. **Materials:** Pegboard equipped with pins and located on a table. The pins are 2.5 cm long and 0.1 cm in diameter. Each hole in the pegboard is 0.5 cm in diameter.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

   Scoring: The time required to place three pins in each of 20 holes is the subject's score. The subject stands to do the task and can use only one hand.

c. **Instructions to be read to the subject:**

   (1) Begin with your preferred hand on the table alongside the board.

   (2) On the "Go" signal, pick up as many as three pins with your preferred hand and place them in a hole on the board. Continue picking up and dropping the pins into the holes with your preferred hand until there are three pins in each hole.

   (3) Your score is the time required to put three pins in every hole.

   (4) Are there any questions? Ready? Go. (Correct the subject if he is not following instructions.)

Figure D11. O'Connor Finger Dexterity Test.

12. **Purdue Pegboard Assembly Test (reference 14).**

a. **Materials:** Pegboard equipped with pins, collars, and washers located on a table.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The time required to complete the construction of 12 pin-washer-collar-washer assemblies is the subject's score. The subject stands to do the task.

c. **Instructions to be read to the subject:**

(1) Begin with your hands on the table alongside the board.

(2) On the "Go" signal, pick up one pin from the right-hand cup with your right hand and, while placing it in the top hole in the right-hand column, pick up a washer with your left hand. As soon as the pin has been placed, drop the washer over the pin. While the washer is being placed over the pin with the left hand, pick up a collar with the right hand. While the collar is being dropped over the pin, pick up another washer with the left hand and drop it over the collar. This completes the first assembly consisting of a pin, a washer, a collar, and a washer.

(3) As the final washer for the first assembly is being placed with the left hand, start the second assembly immediately by picking up another pin with the right hand. Place it in the next hole in the column, drop a washer over it with the left hand; then a collar with the right hand, and so on completing another assembly. Keep both hands busy, always picking up pins and collars with the right hand and washers with the left hand.

(4) Your score is the time required to complete 12 assemblies.

(5) Are there any questions? Ready? Go. (Correct the subject if he is not following instustions.)

Figure D12. Purdue Pegboard Assembly Test.

13. **Horizontal Striking, Front.**

a. **Materials:** A 174-cm long cable strung horizontally and attached at each end to vertically-moveable plates. The cable has two moveable stops and is 0.5 cm in diameter. A straight meal rod, 25 cm long with a 0.75 cm inner diameter circle in one end is looped over the cable between the stops. This serves as the striker.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The cable is adjusted vertically to the shoulder height of the subject. The arm length of the subject is obtained and the distance between the two stops is adjusted such that the movement of the arm from stop to stop subtends a 30° angle when the subject is positioned in front of one stop and is an arm length from the cable. The score is the number of times that the subject can strike both stops in 60 sec using an arm-shoulder movement with the rest of his body remaining stationary.

c. **Instructions to be read to the subject:**

(1) Stand facing the cable with the shoulder of your preferred hand directly in front of a stop. If you are right-handed, line up in front of the right stop. If you are left-handed, line up in front of the left stop.

(2) Move an arm length back from the cable and grasp this striker in your preferred hand, keeping your arm out straight.

(3) On the "Go" signal, move the striker from the stop in front of you to the far stop and back again. This counts as a score of one. Continue this movement of striking across your body as fast as you can.

(4) Move only your shoulder and arm. Do not move the rest of your body. Keep your arm straight at all times as you move it across your body.

(5) Your score is the number of times in one minute that you strike the stop in front of you after striking the far stop.

(6) Are there any questions? Ready? Go. (Correct the subject if he is not following instructions.)

Figure D13a. Front Horizontal Striking. Starting position.

Figure D13b. Front Horizontal Striking. In process.

14. Horizontal Striking, Side.

a. **Materials:** The materials are those used in Horizontal Striking, Front.

b. **Instructions to tester:** Read the instructions to the subject. Read them word for word. Do not change or add to them.

Scoring: The cable is adjusted vertically to the shoulder height of the subject. The subject's arm length is obtained and the distance between the two stops is adjusted such that the movement of the arm subtends a 30° angle from stop to stop when the subject is positioned in front of one stop and an arm length from the cable. The score is the number of times that the subject can strike both stops in 60 sec using an arm-shoulder movement with the rest of his body remaining stationary.

c. **Instructions to be read to the subject:**

(1) Stand with the side of your body facing the cable and the shoulder of your preferred hand directly in front of a stop. If you are right-handed, line up with your right shoulder in front of the left stop. If you are left-handed, line up with the right stop.

(2) Move an arm length away from the cable and grasp this striker in your preferred hand, keeping your arm out straight.

(3) On the "Go" signal, move the striker from the stop nearest your shoulder to the far stop and back again. This counts as a score of one. Continue this movement of striking back as fast as you can.

(4) Move only your shoulder and arm. Do not move the rest of your body. Keep your arm straight at all times as you strike back away from your body.

(5) Your score is the number of times in one minute that you strike the stop in front of you after striking the far stop.

(6) Are there any questions? Ready? Go. (Correct the subject if he is not following instructions.)

Figure D14a. Side Horizontal Striking. Starting position.

Figure D14b. Side Horizontal Striking. In process.

APPENDIX E

CLOTHING AND PERSONAL EQUIPMENT PERFORMANCE QUESTIONNAIRE

CLOTHING AND PERSONAL EQUIPMENT PERFORMANCE QUESTIONNAIRE

Name: ______________________ Clothing Condition: ______________

Section I. Task Performance.

1. Using ranks 1, 2, and 3, rank the three tasks and the three movements most impaired under the present experimental conditions.

Movements		Psychomotor Tasks	
Standing trunk flexion	____	Pursuit rotor	____
Sitting trunk flexion	____	Railwalk	____
Upper arm, abduction	____	O'Connor Finger Dexterity	____
Upper arm, forward extension	____	Purdue Pegboard assembly	____
Upper arm, backward extension	____	Upper arm horizontal striking, front	____
Upper leg, abduction	____	Upper arm horizontal striking, side	____
Upper leg, forward extension	____		
Upper leg, backward extension	____		

2. Choose the five design characteristics which were most important to you in impairing task performance or interfering with your movements. Assign ranks from 1 through 5 to the first through the fifth most important source of interference. Do this for both tasks and movements.

Most Important Characteristic

	Movements	Tasks
Armpit size	____	____
Bulk	____	____
Chest fit	____	____
Chest flexibility	____	____
Collar fit	____	____
Collar flexibility	____	____
Protruding parts	____	____
Shoulder fit	____	____
Shoulder flexibility	____	____
Stability	____	____
Ventilation	____	____
Waist fit	____	____
Waist flexibility	____	____
Weight	____	____

Section II. Importance of Design Characteristics

1. Rate each of the characteristics listed below to show how important they were to you in interfering with the tasks and movements.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Armpit size					
b. Bulk					
c. Chest fit					
d. Chest flexibility					
e. Collar fit					
f. Collar flexibility					
g. Protruding parts					
h. Shoulder fit					
i. Shoulder flexibility					
j. Stability					
k. Ventilation					
l. Waist fit					
m. Waist flexibility					
n. Weight					

Comments: (additional characteristics, etc.)

2. Rate each of the characteristics listed below to show how important they were in helping you to do well on the tasks and movements.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Armpit size					
b. Bulk					
c. Chest fit					
d. Chest flexibility					
e. Collar fit					
f. Collar flexibility					
g. Protruding parts					
h. Shoulder fit					
i. Shoulder flexibility					
j. Stability					
k. Ventilation					
l. Waist fit					
m. Waist flexibility					
n. Weight					

Comments: (additional characteristics, etc.)

3. Rate each of the problems listed below to show how important they were to you in interfering with your performance.

	OF NO IMPORTANCE	OF LITTLE IMPORTANCE	OF MODERATE IMPORTANCE	OF CONSIDERABLE IMPORTANCE	OF EXTREME IMPORTANCE
a. Bulky					
b. Chaffing					
c. Digging in					
d. Drafty					
e. Heavy					
f. Hot					
g. Loose					
h. Obstructions					
i. Pressure					
j. Pinching					
k. Slipping					
l. Tight					
m. Unbalanced					
(Comments: (additional problems, etc.)					

Section III. Preference.

Indicate your opinion, whether neutral, positive, or negative, on each of the following dimensions. Circle the appropriate vertical line.

While performing the tasks, I found the clothing and personal equipment to be:

extremely	very	somewhat	neutral	somewhat	very	extremely
−3	−2	−1	0	+1	+2	+3

1. uncomfortable — comfortable

2. inflexible — flexible

3. poorly ventilated — well ventilated

4. heavy — light

5. poorly balanced — well balanced

In general, my attitude toward the clothing and personal equipment was:

6. dislike — like