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Physical, Anthropometrical, and Body Composition Characteristics of Workers at Kennedy Space Center

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INTRODUCTION

At the Kennedy Space Center, workers are often exposed to cardiovascular and muscular stress in job-related activities which may require a high level of physical fitness in order to safely complete the work task. Similar tasks will be performed at other launch and landing facilities and in space for the Space Station. One such category includes workers who handle toxic propellants and must wear Self-Contained Atmospheric Protective Ensembles (SCAPE) that can weigh 56 lbs with the air pack (Figures 1 and 2). These suits provide a significant physical challenge to many of the workers in terms of carrying this load while moving about and performing work. Furthermore, under some conditions, there is a significant thermal stress. The physical characteristics of these workers are, therefore, of consequence. The purpose of this study was to analyze the anthropometry, body composition, strength, power, endurance, flexibility, aerobic fitness, and blood variables of a representative sample of male KSC SCAPE workers and to compare them with characteristics of other male workers at KSC (total population N=110). Three separate comparisons were made:

1: The Active SCAPE group (N=17) was compared with security workers (N=17), technicians (N=12), engineers (N=30), computer-related employees (N=10), and a miscellaneous group of professional personnel (physicians, scientists, students, analysts, N=24).

2: The Active SCAPE group (N=17) was compared with individuals who had passed all health and training requirements to work in SCAPE but were not actively engaged in work that required SCAPE (Certified-for-SCAPE, N=7) and with the NON-SCAPE workers (N=86).

3: The Active SCAPE group at KSC is comprised of two sub-groups, Propellant Transfer SCAPE Workers and Flight Servicing SCAPE Workers. Both groups handle toxic propellants. The Propellant Transfer SCAPE Workers transport toxic propellants to and from various KSC locations. The Flight Servicing SCAPE Workers fuel and de-fuel the orbiters with the toxic propellants. These two groups (N = 10 and 7 respectively) were compared with each other and with Non-Propellant Workers (N=93).

METHODS

SUBJECTS

One hundred ten male KSC employees, ages 22 to 58 years, participated in the study. SCAPE and Security workers were recruited through questionnaires and advertisements in the KSC news bulletin. The study was fully explained to all prospective subjects, and their informed consent was obtained before participation. Subjects were free of acute or chronic disease as determined by NASA physicians who reviewed the medical history questionnaires. The subjects were not taking any medication. Nonsmokers and smokers were included in the study. Subjects had varying levels of physical activity, from sedentary to regular aerobic exercise.

PROCEDURES

Testing of each subject was completed in a single two-hour morning or afternoon session. After blood was drawn, the subjects were rotated through the various testing stations which included anthropometry, CYBEX, Astrand-Rhyming test with the Sit and Reach test, and hydrostatic weighing.

TECHNIQUES

Anthropometry

An extensive series of anthropometric measurements were taken by a single investigator using the same instruments to ensure consistency and standarization of technique (11). The measurements included nine skinfold thicknesses, nine circumferences, two breadths, two heights, and one acromion-dactylion length. The specific measurement sites are listed in Table 1. A Lange skinfold caliper was used to measure skinfold thicknesses. The body circumferences were assessed using a Keuffel & Esser - Tip Top Wyteface tape (Figure 3). Height was measured with a Seber-Hegner anthropometer. All measurements which pertain to one side of the body were taken on the subjects' dominant side.

Physical characteristics of body build were described according to the Heath-Carter somatotype rating method, which has been shown to provide reliable anthropometric somatotype ratings (8). Measurements of skinfold values, bone diameters, body circumferences, height, and weight were used to determine somatotype ratings with the Heath-Carter method. The somatotype endomorphy refers to relative fatness in individual physiques; mesomorphy refers to relative musculoskeletal development (lean body mass) which includes the soft organs and total body fluids;

and ectomorphy refers to relative linearity of individual physiques, which is based largely on height/$\sqrt[3]{\text{weight}}$. All the ratings of each somatotype theoretically begin at zero and have no arbitrary endpoint (8).

Body Composition

Body density was determined by hydrostatic weighing and converted to percent body fat utilizing the Siri equation of 495/(body density) - 450 (19). Residual lung volumes were measured simultaneously using nitrogen dilution. During hydrostatic weighing each subject had four or more trials to establish familarity with the technique. All subjects wore the same type of light-weight nylon swim wear to minimize formation of air pockets during the procedure (Figure 4). Means were obtained from the last three representative trials.

Strength, Power, and Endurance

For the purpose of this study, an isotonic contraction is defined as a muscle contraction with movement. An isokinetic contraction is defined as an isotonic contraction performed at a constant speed over the full range of motion (13). Isokinetic measurements were made on a Cybex II Dynamometer and Instrumentation System using the methods recommended by The Lumex Corporation (7). Extension and flexion of the dominant knee and shoulder of each subject were tested. Of the subjects tested, 90.9% were right dominant, 5.5% were left dominant, and 3.6% were ambidextrous. The subjects were positioned on the testing table by the same experimenter throughout the study. The dynamometer was calibrated daily throughout the study according to the procedures recommended by the manufacturer (6). A goniometer was used to ascertain the proper knee and shoulder angles with reference to the anatomical zero. Testing of each subject was completed in a single session.

Upon reporting to the laboratory, subjects were briefed as to the nature of the test and allowed several warm-up trials after they were positioned on the testing apparatus. Straps were secured around the chest and pelvis to stabilize the upper body. Isokinetic testing of the knee and shoulder extension and flexion were done at two different velocities. Muscular strength was measured at a velocity of 60° per second during three repetitions of extension and flexion. Muscular power and endurance were assessed at a velocity of 180° per second during fifteen repetitions of extension and flexion. The same velocities for testing strength and endurance have been used by previous investigators (22).

For both knee and shoulder testing, subjects were instructed to move through the complete range of extension and flexion as fast as possible with maximum effort (Figures 5 and 6). Peak torques were recorded at both speeds. A rest period of two to three minutes was allowed between the strength and endurance tests. Maximum torque values were corrected for the effects of gravity by measuring torque output during passive knee movement from full extension to 45 degrees of flexion and during passive shoulder movement from full flexion to 45 degrees of extension (5,7,10). The significance of this correction has been previously documented (23). Calculations were performed on output from these tests to provide all strength data listed in "Results".

Flexibility

Low back and hamstring flexibility were both measured using the Sit and Reach test (13,21,22). A stool with a flat, rectangular surface was positioned on its side against a wall. The subject sat on the floor with his legs extended straight out in front of him and his feet flat against the stool. A yardstick was horizontally secured to the top of the stool with the 20-cm mark crossing the point against which the subject's feet were pressed. The individual was instructed to bend forward and stretch his arms out as far as possible. This exercise was performed three times, and the highest score was used. Values in excess of 20 cm represent the distance the individual can stretch beyond his toes. Values less than 20 cm indicate the individual was unable to reach as far as his toes.

Aerobic Capacity

Maximal oxygen uptake ($\dot{V}O_2max$) is a primary indicator of cardiorespiratory fitness (18). It represents one's ability to consume oxygen and utilize it at a cellular level. Estimated $\dot{V}O_2max$ values were obtained using a stationary bicycle ergometer submaximal work test which was modified from Astrand-Rhyming (1,2,3). The standard submaximal stress test is based on the principle that heart rate under normal conditions rises linearly with increasing work loads, and consequently oxygen utilization increases (13). This method has proved to be an aid in predicting aerobic work capacity (2).

Subjects were tested one at a time in a cool test environment (72°-74°), and the bicycle seat was individually adjusted to allow for optimal leg extension and comfort (Figure 7). A tachometer-monitored pedalling speed of 50 RPM was maintained, with a metronome used for pacing. Heart rate was monitored by electrocardiography. The initial work load and the subsequent work load adjustments are shown in Tables 2 and 3. Estimated $\dot{V}O_2max$ was calculated with an adjusted nomogram after correcting for age (1,2,3,) (Table 4).

Blood Variables

The clinical laboratory at KSC is Certified by the College of American Pathologists, and all laboratory personnel are certified by the American Society of Clinical Pathologists.

Approximately 14 cc of venous blood were drawn from each subject. Hemoglobin was assayed using a Coulter dilutor and hemoglobinometer (4,20). A Clay-Adams hematocrit centrifuge and a micro-hematocrit reader were used to calculate hematocrits (12,20). Haptoglobin levels were determined by radial immunodiffusion utilizing ICL Scientific Haptoglobin Kits (14,17). Testosterone levels were quantitated with Radioassay Systems Laboratories' testosterone (^{125}I) kit (9,15) and total estrogen levels with Radioassay Systems Laboratories' total estrogen (^{125}I) kit (9,16).

Statistical Analyses

Reduction of Multiple Trial Data

For the Sit and Reach test, the highest value of the three trials was used. For the hydrostatic weighing which involved four or more trials, values more than ten percent above or below other values were excluded, and means were obtained from the last three representative trials.

Group Comparisons

The interest of the researchers was in comparing means of sub-populations of the KSC worker population. Three methods of subgrouping were used:

1. Occupational groups (Six groups)
2. Currently Active SCAPE workers (Active SCAPE); workers who had passed physical requirements and had received at least minimal training in the use of SCAPE but did not work in SCAPE (Certified-for-SCAPE); and workers with no SCAPE training (Non-SCAPE).
3. Propellant transfer SCAPE workers; Flight servicing SCAPE workers; and Non-Propellant workers including Certified-for-SCAPE but not Active SCAPE.

One-way analyses of variance (ANOVAs) were used to test the hypotheses that each subpopulation had the same mean. These ANOVAs were performed for each of the three methods of subgrouping and for each variable of interest. Duncan's post hoc test was used for ANOVAs producing significant ($\alpha=0.05$) differences to determine which pairs of groups contributed to the overall significant test.

RESULTS AND DISCUSSION

TOTAL POPULATION

Mean values and standard deviations for all variables for the total population (N=110) are listed in Tables 5A-5D.

COMPARISON OF SIX OCCUPATIONAL GROUPS

1. SCAPE WORKERS
2. SECURITY WORKERS
3. TECHNICIANS
4. ENGINEERS
5. COMPUTER-RELATED EMPLOYEES
6. MISCELLANEOUS PROFESSIONAL PERSONNEL

Results

Mean values and comparisons for the occupational groups are listed in Tables 6A-6H. Duncan's Multiple Range Test results are shown in Table 7. None of the groups were statistically ($p<0.05$) different in height or weight. The Security group was younger than the other five occupational groups with a mean age of 27 years as compared to 37 years for the total group and the SCAPE group was oldest, with a mean age of 41 years.

Percent body fat was not different among the groups; however, the Technicians had the lowest percent of body fat, while the SCAPE group had the highest.

Fat-free mass (lean body mass) was not different among groups. The Computer-Related group had the highest fat-free mass of 68.35 Kg while the Engineer group had the lowest at 60.36 Kg. Residual Volume (RV) was different among groups. The SCAPE group had the highest mean RV and the Security group had the lowest mean RV.

The degree of endomorphic somatotype was different among the groups. Technicians and Engineers had the lowest values while the Computer-related group had the highest values. The mean values for degree of mesomorphy and ectomorphy were similar among all the groups.

Circumferences and breadths were not different among the groups. However, chest, subscapular, and suprailiac skinfold thicknesses were different, with Technicians and Engineers having the lowest values. The SCAPE and Computer-related groups had the highest values.

Five variables indicated a difference in knee strength, work, and endurance. The Technician and Engineer groups were highest in

two areas of knee strength, while the SCAPE and Security groups were lowest. The Security and Computer-related groups were stronger in three areas of knee work and endurance and the SCAPE and Engineer groups were lowest.

The Security and Computer groups were consistently stronger, while the Technicians and Engineer groups were consistently weaker in three variables of shoulder strength, work, and endurance.

Predicted $\dot{V}O_2max$ values were not different among groups. The SCAPE group had the lowest mean value of 35.12 $\pm$ 10.08 ml/kg/min, while the Technician group had the highest at 42.70 $\pm$ 14.18 ml/kg/min. Nor was spinal flexibility as measured by the Sit and Reach Test different among the six occupational groups.

The only blood variable demonstrating a difference among groups was hemoglobin; however, all values were within normal limits.

DISCUSSION

The data did not reveal many major differences in physical characteristics among six occupational groups at KSC. Although percent body fat and aerobic capacity did not differ statistically, the fact that the SCAPE group is highest compared to any group in body fat and lowest in $\dot{V}O_2max$ values is interesting when considering the physical risk imposed upon SCAPE workers. When one is working in SCAPE, their agility, dexterity, and mobility are compromised due to the weight, bulk, and restrictions of the SCAPE garment. Optimally, a person working in SCAPE should be as flexible as possible to counteract the lack of mobility created by the suit; however, flexibility was not statistically higher in SCAPE compared to the other occupational groups.

COMPARISON OF:

1. ACTIVE SCAPE WORKERS
2. CERTIFIED-FOR-SCAPE WORKERS
3. NON-SCAPE WORKERS

Results

Mean values and comparisons by ANOVAs for these three groups are listed in Tables 8A-8D. Duncan's Multiple Range Test results are shown in Table 9. The three groups were not different in age, height, or weight.

In this comparison, two sub-groups of Active SCAPE workers were consolidated, and percent body fat was not different among the groups; however, Active SCAPE had the highest percent body fat,

while the Certified-for-SCAPE group had the lowest. Fat-free mass (lean body mass) and somototype did not differ among the three groups.

Three skinfold thicknessess differed among the groups: subscapular, chest, and mid-axillary (MAX-X) measurements were highest in the Active Scape group and lowest in the Certified-for-SCAPE group. The Active SCAPE group also had a larger waist circumference of 93.1 cm compared to Certified-for-SCAPE who had the smallest, 84.16 cm. All other circumferences and bone breadths were similar among the groups.

The knee flexion peak torque/body weight ratio was the only variable of knee work and endurance which differed among the groups. Active SCAPE had the lowest value of 33.35 compared with Certified-for-SCAPE which had the highest value of 40.43. Shoulder flexion peak torque and extension peak torque were also higher in Certified-for-SCAPE as compared to the other groups. All other shoulder strength variables were similar among these groups.

Predicted $\dot{V}O_2$max values did not differ among the three groups. The Active SCAPE group had a lower average heart rate and lower final work load setting during the Astrand-Rhyming Test as compared with both of the other groups (N=16 since one Active SCAPE worker was unable to complete the test due to premature ventricular contractions). Spinal flexibility was not different among the groups.

Haptoglobin, hemoglobin, hematocrit, estrogen, and testosterone values were similar and within normal ranges for all three groups.

Discussion

The purpose of this analysis was to compare anthropometrical, body composition, and strength characteristics of Active SCAPE workers (N=17), Certified-for-SCAPE workers (N=7), and Non-SCAPE workers (N=86). We observed the Active SCAPE group was older, had the highest percent of body fat, more endomorphy and mesmorphy, less ectomorphy, and the lowest $\dot{V}O_2$ when compared to Certified-for-SCAPE and Non-SCAPE. Although not all of these differences were statistically significant, the pattern may suggest that Active SCAPE workers are older, more overweight and less physically fit when compared other workers.

COMPARISON OF :

1. PROPELLANT TRANSFER SCAPE WORKERS
2. FLIGHT SERVICING SCAPE WORKERS
3. NON-PROPELLANT WORKERS (INCLUDES CERTIFIED-FOR-SCAPE AND NON-SCAPE WORKERS).

Results

Mean values and comparisons by ANOVAs for all variables, divided into these three subject groups, are listed in tables 10A-10D. Duncan's Multiple Range Test results are shown in Table 11. The three groups did not differ in age, height, or weight. The mean age of the Propellant Transfer SCAPE group was the highest at 43 years, while the Non-Propellant group of workers had the lowest mean age of 36 years.

Percent body fat was highest in the Propellant Transfer SCAPE group (26.1%) and lowest in the Flight Servicing SCAPE group (19.2%). The mean weight of body fat was also highest, and the mean body density was lowest in the Propellant Transfer SCAPE group when compared with the other groups. Somatotype mean values did not indicate any differences among groups, although the Propellant Transfer group had the lowest mean value for ectomorphy.

Three skinfold thicknesses differed significantly among the groups: subscapular, chest, and mid-axillary (MAL-X) measurements were highest in the Propellant Transfer group. This group also had larger shoulder and waist circumferences in comparison to the other two groups. All other circumferences and bone breadths were similar among the groups.

None of the shoulder strength, work, and endurance variables differed among the groups. However, knee flexion work peak torque/body weight ratio was lowest in the Propellant Transfer group (30.40%) and highest in the group of Non-Propellant Workers (38.54%). The knee flexion work and endurance peak total accelerated energy were also lowest in the Propellant Transfer group and were highest in the Flight Servicing group. No differences were noted in knee-extension variables.

Predicted $\dot{V}O_2$max values were lower in the Propellant Transfer group at 30.86 ml/kg/min compared with both of the other groups. The final work load setting during the Astrand-Rhyming test was also lowest in this group (N=9 as one of the workers was unable to complete the test secondary to frequent premature ventricular contractions). Spinal flexibility was not different among the groups.

Haptoglobin, hemoglobin, hematocrit, estrogen, and testosterone values were similar and within normal ranges for all three groups.

Discussion

Striking differences were observed in the comparison of the Propellant Transfer SCAPE group, Flight Servicing SCAPE group, and the Non-Propellant group (includes Certified-for-SCAPE and Non-SCAPE).

These data strongly demonstrate that the Propellant Transfer SCAPE Workers have more body fat and less predicted aerobic capacity when compared with the Flight Servicing SCAPE Workers and the Non-Propellant Workers. The Non-Propellant group appeared to have a higher level of physical fitness than the Propellant Transfer SCAPE group and perhaps a lower level of on-the-job physical stress.

CONCLUSION

This study has provided a database on a large population of KSC workers some of whom perform tasks which may be required on Space Station in the future. Thus, their physical characteristics may be useful in designing Space Station. The data revealed few differences among the six different occupational groups who were studied. However, the data trends do suggest that Active SCAPE workers are older, more overweight and less aerobically fit than Certified-for-SCAPE and the Non-SCAPE groups. Furthermore, this study has revealed data concerning a subpopulation of current SCAPE workers (Propellant Transfer Group) at KSC. These workers have potentially hazardous, stressful jobs and may be at excessive risk due to their current physical conditions. Application of these results could possibly benefit this group by modification of the physical fitness criteria for future SCAPE workers.

TABLE 1

ANTHROPOMETRIC MEASUREMENT SITES

SKINFOLDS	CIRCUMFERENCES	BREADTHS, HEIGHTS, AND LENGTHS
Biceps	Shoulder	Elbow breadth
Triceps	Chest	Knee breadth
Subscapular	Waist	Height
Chest	Buttocks	Sitting Height
Mid-Axillary	Thigh	Acromion-dactylion length
Supra-iliac	Calf	
Abdominal	Biceps-relaxed	
Thigh	Biceps-flexed	
Calf	Forearm	

TABLE 2

ASTRAND-RHYMING WORK TEST

SELECTION OF INITIAL WORK LOAD FOR MEN

(Pedalling Speed at 50 RPM)

	SUBJECT WEIGHT		INITIAL WORK LOAD	
	lb	kg	kpm	watts
below	100	44	1.0	49
	101-140	45-63	1.5	74
	141-170	64-77	2.0	98
	171-190	78-86	2.0	98
above	191	86	2.0	98

TABLE 3

ASTRAND-RHYMING WORK TEST

WORK LOAD ADJUSTMENTS

A. Heart Rate at 1 min	Load Adjustments	
	kpm	watts
below 90	+1.0	+49
92-100	+0.5	+25
102-120	---	---
121-140	-0.5	-25
141-150	-1.0	-49

B. Heart Rate at 2 min	Load Adjustments	
	kpm	watts
below 100	+1.0	+49
112-120	+0.5	+25
121-130	+0.5	+25
131-140	---	---
141-150	-0.5	-25
151-160	-0.5	-25
160 & above	Stop test; allow subjects to rest 30 min and begin again at lower work load.	

C. Heart Rate at 3 min	Load Adjustments	
	kpm	watts
below 100	+1.0	+49
112-120	+0.5	+25
121-130	+0.5	+25
131-140	---	---
141-150	---	---
151-160	-0.5	-25
161-165	-0.5	-25
166 & above	Stop test; repeat another day	

TABLE 4

ASTRAND-RHYMING WORK TEST

AGE CORRECTION FACTOR

AGE	FACTOR	AGE	FACTOR
15	1.10	40	0.83
16	1.09	41	0.82
17	1.08	42	0.81
18	1.07	43	0.80
19	1.06	44	0.79
20	1.05	45	0.78
21	1.04	46	0.774
22	1.03	47	0.768
23	1.02	48	0.762
24	1.01	49	0.756
25	1.000	50	0.750
26	0.987	51	0.742
27	0.974	52	0.734
28	0.961	53	0.726
29	0.948	54	0.718
30	0.935	55	0.710
31	0.922	56	0.704
32	0.909	57	0.698
33	0.896	58	0.692
34	0.883	59	0.686
35	0.870	60	0.680
36	0.862	61	0.674
37	0.854	62	0.668
38	0.846	63	0.662
39	0.838	64	0.656
		65	0.650

TABLE 5A.

MEANS AND STANDARD DEVIATIONS OF AGE AND ANTHROPOMETRIC VARIABLES
FOR THE TOTAL STUDY SAMPLE (n=110)

VARIABLE	UNITS	mean +/- s.d.
AGE	YEAR	36.68 +/- 10.00
WEIGHT	KG.	80.40 +/- 12.32
HEIGHT	CM.	177.63 +/- 6.89
SITTING HEIGHT	CM.	92.25 +/- 4.39
ACROMION-DACTYLION LENGTH	CM.	77.64 +/- 3.59

BREADTHS

VARIABLE	UNITS	
ELBOW	CM.	7.07 +/- 0.37
KNEE	CM.	9.57 +/- 0.51

CIRCUMFERENCES

VARIABLE	UNITS	
SHOULDER	CM.	118.99 +/- 7.94
CHEST	CM.	100.90 +/- 10.82
WAIST	CM.	88.27 +/- 9.33
BUTTOCKS	CM.	97.22 +/- 6.85
THIGH	CM.	50.07 +/- 4.40
CALF	CM.	37.31 +/- 2.96
BICEPS - RELAXED	CM.	30.70 +/- 3.10
BICEPS - FLEXED	CM.	33.92 +/- 2.93
FOREARM	CM.	28.52 +/- 1.92

SKINFOLDS

VARIABLE	UNITS	
BICEPS	MM.	5.64 +/- 2.03
TRICEPS	MM.	9.67 +/- 3.01
SUBSCAPULAR	MM.	15.33 +/- 5.51
CHEST	MM.	15.67 +/- 7.67
MID-AXILLARY LINE	MM.	15.70 +/- 7.85
SUPRA-ILIAC	MM.	25.13 +/- 11.26
ABDOMINAL	MM.	19.56 +/- 8.90
THIGH	MM.	14.07 +/- 4.84
CALF	MM.	10.62 +/- 4.25

TABLE 5B.

MEANS AND STANDARD DEVIATIONS OF KNEE CYBEX VARIABLES
FOR THE TOTAL STUDY SAMPLE (n=110)

TORQUE - 60 DEG./SEC. - 3 REPS

VARIABLE	UNITS	mean +/- s.d.
PEAK EXTENSION	FT. LB.	153.18 +/- 32.85
EXTENSION PEAK/BODY WT. RATIO	%	86.13 +/- 16.55
PEAK FLEXION	FT. LB.	88.68 +/- 19.64
FLEXION PEAK/BODY WT. RATIO	%	49.86 +/- 10.06
FLEXION/EXTENSION PEAK RATIO	%	58.75 +/- 10.91

TORQUE - 180 DEG./SEC. - 3 REPS

VARIABLE	UNITS	
PEAK EXTENSION	FT. LB.	103.05 +/- 22.82
EXTENSION PEAK/BODY WT. RATIO	%	57.74 +/- 10.49
PEAK FLEXION	FT. LB.	67.67 +/- 13.92
FLEXION PEAK/BODY WT. RATIO	%	37.74 +/- 8.16
FLEXION/EXTENSION PEAK RATIO	%	66.39 +/- 10.37

WORK AND ENDURANCE - EXTENSION - 15 REPS

VARIABLE	UNITS	
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	18.78 +/- 4.24
TOTAL WORK	FT. LB.	1527.28 +/- 360.98
WORK FIRST 3 REPS	FT. LB.	339.18 +/- 82.25
WORK LAST 3 REPS	FT. LB.	263.37 +/- 66.48
ENDURANCE RATIO	%	78.47 +/- 14.11
WATTS AVERAGE POWER	WATTS	229.35 +/- 54.66

WORK AND ENDURANCE - FLEXION - 15 REPS

VARIABLE	UNITS	
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	9.56 +/- 3.35
TOTAL WORK	FT. LB.	1097.84 +/- 255.81
WORK FIRST 3 REPS	FT. LB.	247.66 +/- 67.69
WORK LAST 3 REPS	FT. LB.	181.61 +/- 48.91
ENDURANCE RATIO	%	74.11 +/- 17.35
WATTS AVERAGE POWER	WATTS	161.78 +/- 42.22

VARIABLE	UNITS	
FLEXION/EXTENSION WORK RATIO	%	72.51 +/- 13.54

TABLE 5C.

MEANS AND STANDARD DEVIATIONS OF SHOULDER CYBEX VARIABLES
FOR THE TOTAL STUDY SAMPLE (n=110)

TORQUE - 60 DEG./SEC. - 3 REPS

VARIABLE	UNITS	mean +/- s.d.
PEAK EXTENSION	FT. LB.	68.92 +/- 17.82
EXTENSION PEAK/BODY WT. RATIO	%	38.69 +/- 8.34
PEAK FLEXION	FT. LB.	54.73 +/- 12.94
FLEXION PEAK/BODY WT. RATIO	%	30.73 +/- 5.63
FLEXION/EXTENSION PEAK RATIO	%	80.78 +/- 12.44

TORQUE - 180 DEG./SEC. - 3 REPS

VARIABLE	UNITS	
PEAK EXTENSION	FT. LB.	53.59 +/- 13.31
EXTENSION PEAK/BODY WT. RATIO	%	30.15 +/- 6.78
PEAK FLEXION	FT. LB.	45.32 +/- 10.59
FLEXION PEAK/BODY WT. RATIO	%	25.46 +/- 4.77
FLEXION/EXTENSION PEAK RATIO	%	86.00 +/- 13.58

WORK AND ENDURANCE - EXTENSION - 15 REPS

VARIABLE	UNITS	
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.64 +/- 2.75
TOTAL WORK	FT. LB.	1438.45 +/- 333.36
WORK FIRST 3 REPS	FT. LB.	319.14 +/- 76.46
WORK LAST 3 REPS	FT. LB.	249.26 +/- 61.15
ENDURANCE RATIO	%	78.68 +/- 11.35
WATTS AVERAGE POWER	WATTS	138.50 +/- 33.05

WORK AND ENDURANCE - FLEXION - 15 REPS

VARIABLE	UNITS	
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.97 +/- 2.68
TOTAL WORK	FT. LB.	1235.51 +/- 252.70
WORK FIRST 3 REPS	FT. LB.	283.44 +/- 57.28
WORK LAST 3 REPS	FT. LB.	211.79 +/- 47.49
ENDURANCE RATIO	%	74.85 +/- 8.92
WATTS AVERAGE POWER	WATTS	117.95 +/- 25.31

VARIABLE	UNITS	
FLEXION/EXTENSION WORK RATIO	%	87.68 +/- 14.65

TABLE 5D.

MEANS AND STANDARD DEVIATIONS OF OTHER VARIABLES
FOR THE TOTAL STUDY SAMPLE (n=110)

ASTRAND-RHYMING TEST VARIABLES

VARIABLE	UNITS	mean +/- s.d.
FINAL WORKLOAD SETTING	KPM/MIN.	160.92 +/- 38.37
AVERAGE HEART RATE	BPM	147.32 +/- 8.55
VO2	ML./MIN.	3598.62 +/- 883.56
AGE CORRECTED VO2	ML./MIN.	3147.64 +/- 867.37
VO2 PER KG	ML./KG./MIN	39.87 +/- 11.71

BLOOD ANALYSIS VARIABLES

VARIABLE	UNITS	
HEMOGLOBIN	GM./DL.	15.19 +/- 0.99
HEMATOCRIT		44.60 +/- 2.65
HAPTOGLOBIN	MG./DL.	139.01 +/- 75.64
TESTOSTERONE	NG./DL.	564.55 +/- 160.80
ESTROGEN	PG./ML.	63.03 +/- 24.81

SOMATIC BODY TYPE VARIABLES

VARIABLE	UNITS	
+ ENDOMORPHY		4.88 +/- 1.53
+ MESOMORHPY		4.44 +/- 1.24
+ ECTOMORPHY		1.85 +/- 1.15

HYDROSTATIC WEIGHING VARIABLES

VARIABLE	UNITS	
PERCENTAGE BODY FAT	%	20.65 +/- 7.01
WEIGHT OF BODY FAT	KG.	17.05 +/- 7.58
FAT-FREE MASS	KG.	63.22 +/- 8.04
BODY DENSITY	GM./CC.	1.0520 +/- 0.0157
RESIDUAL VOLUME	L.	1.37 +/- 0.31

SIT AND REACH TEST VARIABLES - SPINAL FLEXIBILITY

VARIABLE	UNITS	
MAXIMUM OF THREE TRIALS	CM.	7.55 +/- 9.15

+ - ratings of each somatotype theoritically begin at zero and have no arbitrary endpoint

TABLE 6A.

MEANS AND STANDARD DEVIATIONS OF AGE AND ANTHROPOMETRIC VARIABLES
FOR SECURITY, COMPUTER-RELATED, AND ENGINEER GROUPS

VARIABLE	UNITS	SECURITY N=17	COMPUTER-RELATED N=10	ENGINEERS N=30	SIGNIFICANT ANOVA
AGE	YEAR	27.00 +/- 4.23	34.00 +/- 9.92	39.57 +/- 10.29	*
WEIGHT	KG.	82.85 +/- 11.40	86.88 +/- 9.07	76.21 +/- 13.01	
HEIGHT	CM.	179.71 +/- 7.85	179.00 +/- 8.20	176.29 +/- 5.13	
SITTING HEIGHT	CM.	92.69 +/- 4.96	94.34 +/- 3.02	91.34 +/- 4.20	
ACROMION-DACTYLION LENGTH	CM.	78.06 +/- 4.59	78.40 +/- 3.24	77.15 +/- 3.16	
BREADTHS					
ELBOW	CM.	6.98 +/- 0.32	7.28 +/- 0.29	7.04 +/- 0.36	
KNEE	CM.	9.56 +/- 0.42	9.74 +/- 0.55	9.45 +/- 0.53	
CIRCUMFERENCES					
SHOULDER	CM.	121.10 +/- 6.45	122.60 +/- 4.98	115.97 +/- 8.04	*
CHEST	CM.	102.22 +/- 9.03	103.22 +/- 2.88	100.40 +/- 15.65	
WAIST	CM.	88.21 +/- 7.78	90.98 +/- 5.91	85.86 +/- 11.20	
BUTTOCKS	CM.	98.74 +/- 8.07	100.53 +/- 4.91	95.67 +/- 7.45	
THIGH	CM.	51.20 +/- 3.91	53.34 +/- 4.18	49.12 +/- 4.53	
CALF	CM.	37.58 +/- 2.35	38.75 +/- 1.73	36.70 +/- 3.52	
BICEPS - RELAXED	CM.	31.80 +/- 2.22	32.60 +/- 2.59	29.66 +/- 3.12	*
BICEPS - FLEXED	CM.	34.34 +/- 2.17	36.01 +/- 2.72	32.74 +/- 2.80	*
FOREARM	CM.	28.74 +/- 1.46	29.41 +/- 1.77	27.74 +/- 1.74	
SKINFOLDS					
BICEPS	MM.	5.00 +/- 1.56	6.70 +/- 1.89	5.65 +/- 2.70	
TRICEPS	MM.	10.56 +/- 3.81	11.30 +/- 2.76	8.82 +/- 3.41	
SUBSCAPULAR	MM.	16.79 +/- 5.21	18.20 +/- 4.74	13.88 +/- 5.05	*
CHEST	MM.	16.35 +/- 6.39	18.00 +/- 8.00	13.00 +/- 7.26	*
MID-AXILLARY LINE	MM.	16.24 +/- 6.24	18.75 +/- 6.56	14.27 +/- 8.25	
SUPRA-ILIAC	MM.	28.88 +/- 10.84	30.35 +/- 11.34	21.43 +/- 11.98	*
ABDOMINAL	MM.	19.59 +/- 9.08	22.30 +/- 7.09	17.72 +/- 9.47	
THIGH	MM.	15.88 +/- 4.98	16.30 +/- 4.72	12.88 +/- 5.14	
CALF	MM.	11.59 +/- 4.54	12.95 +/- 3.45	9.87 +/- 4.37	

* - signifies a significant one-way ANOVA across 6 occupational groups (see table 6E for means and standard deviations for other 3 groups)

TABLE 6B.

MEANS AND STANDARD DEVIATIONS OF KNEE CYBEX VARIABLES
FOR SECURITY, COMPUTER-RELATED, AND ENGINEER GROUPS

		SECURITY	COMPUTER-RELATED	ENGINEERS	SIGNIFICANT ANOVA
		N=17	N=10	N=30	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	159.82 +/- 27.75	173.70 +/- 25.77	147.03 +/- 33.91	
EXTENSION PEAK/BODY WT. RATIO	%	87.12 +/- 14.12	89.60 +/- 11.31	87.27 +/- 16.48	
PEAK FLEXION	FT. LB.	89.47 +/- 15.46	100.00 +/- 15.93	85.47 +/- 18.28	
FLEXION PEAK/BODY WT. RATIO	%	48.76 +/- 7.51	51.60 +/- 6.11	51.03 +/- 9.64	
FLEXION/EXTENSION PEAK RATIO	%	56.53 +/- 9.48	57.80 +/- 5.45	60.00 +/- 15.12	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	111.88 +/- 18.43	118.10 +/- 26.10	97.90 +/- 24.51	
EXTENSION PEAK/BODY WT. RATIO	%	61.18 +/- 9.87	60.80 +/- 11.37	57.93 +/- 10.94	
PEAK FLEXION	FT. LB.	68.06 +/- 11.45	72.40 +/- 15.65	66.73 +/- 14.74	
FLEXION PEAK/BODY WT. RATIO	%	37.24 +/- 6.93	37.60 +/- 7.89	39.77 +/- 7.78	†
FLEXION/EXTENSION PEAK RATIO	%	61.53 +/- 8.68	62.70 +/- 11.84	69.80 +/- 13.31	†
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	19.57 +/- 4.14	20.87 +/- 4.65	18.24 +/- 4.04	
TOTAL WORK	FT. LB.	1662.47 +/- 265.04	1840.80 +/- 435.39	1436.50 +/- 386.95	†
WORK FIRST 3 REPS	FT. LB.	355.53 +/- 80.05	402.50 +/- 88.44	320.87 +/- 90.66	
WORK LAST 3 REPS	FT. LB.	290.35 +/- 47.68	319.70 +/- 80.09	249.43 +/- 71.36	†
ENDURANCE RATIO	%	84.24 +/- 19.00	79.20 +/- 11.27	78.80 +/- 15.34	
WATTS AVERAGE POWER	WATTS	250.35 +/- 40.44	276.70 +/- 64.42	219.03 +/- 59.00	†
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	9.16 +/- 3.84	10.90 +/- 3.51	9.56 +/- 3.41	
TOTAL WORK	FT. LB.	1110.12 +/- 238.16	1210.80 +/- 221.63	1078.10 +/- 293.80	
WORK FIRST 3 REPS	FT. LB.	242.59 +/- 65.79	275.30 +/- 65.77	244.53 +/- 71.41	
WORK LAST 3 REPS	FT. LB.	191.18 +/- 47.09	197.60 +/- 36.58	183.43 +/- 51.43	
ENDURANCE RATIO	%	82.47 +/- 25.13	73.90 +/- 14.70	75.80 +/- 11.55	
WATTS AVERAGE POWER	WATTS	165.29 +/- 33.87	181.10 +/- 36.59	163.17 +/- 45.17	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	66.76 +/- 8.79	67.90 +/- 12.84	77.13 +/- 19.35	

† - signifies a significant one-way ANOVA across 6 occupational groups (see table 6F for means and standard deviations for other 3 groups)

TABLE 6C.

MEANS AND STANDARD DEVIATIONS OF SHOULDER CYBEX VARIABLES
FOR SECURITY, COMPUTER-RELATED, AND ENGINEER GROUPS

		SECURITY N=17	COMPUTER-RELATED N=10	ENGINEERS N=30	SIGNIFICANT ANOVA
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	73.53 +/- 13.68	78.30 +/- 21.52	62.13 +/- 11.69	
EXTENSION PEAK/BODY WT. RATIO	%	41.18 +/- 8.94	40.40 +/- 10.15	37.00 +/- 5.58	
PEAK FLEXION	FT. LB.	58.53 +/- 10.63	60.20 +/- 8.16	50.10 +/- 8.90	
FLEXION PEAK/BODY WT. RATIO	%	32.41 +/- 5.69	31.30 +/- 4.37	29.80 +/- 3.85	
FLEXION/EXTENSION PEAK RATIO	%	80.47 +/- 11.18	80.70 +/- 18.92	81.37 +/- 9.12	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	57.53 +/- 12.53	60.30 +/- 15.01	50.23 +/- 10.72	
EXTENSION PEAK/BODY WT. RATIO	%	32.18 +/- 8.45	31.20 +/- 7.63	29.90 +/- 5.74	
PEAK FLEXION	FT. LB.	51.35 +/- 11.46	51.70 +/- 8.96	41.33 +/- 7.04	*
FLEXION PEAK/BODY WT. RATIO	%	28.47 +/- 5.87	26.70 +/- 4.55	24.67 +/- 3.55	
FLEXION/EXTENSION PEAK RATIO	%	90.59 +/- 15.63	88.00 +/- 15.71	83.57 +/- 9.60	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	14.45 +/- 2.83	13.96 +/- 3.39	11.96 +/- 2.47	*
TOTAL WORK	FT. LB.	1554.41 +/- 281.12	1609.60 +/- 436.35	1374.33 +/- 331.37	
WORK FIRST 3 REPS	FT. LB.	334.59 +/- 74.58	359.60 +/- 94.05	309.70 +/- 71.77	
WORK LAST 3 REPS	FT. LB.	272.82 +/- 53.16	281.80 +/- 76.93	233.10 +/- 62.80	
ENDURANCE RATIO	%	83.00 +/- 13.99	78.20 +/- 6.37	75.30 +/- 9.93	
WATTS AVERAGE POWER	WATTS	148.76 +/- 26.93	153.50 +/- 41.70	131.53 +/- 32.10	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	14.91 +/- 3.01	14.47 +/- 2.64	12.17 +/- 2.16	*
TOTAL WORK	FT. LB.	1322.88 +/- 201.09	1383.70 +/- 292.55	1168.93 +/- 235.53	
WORK FIRST 3 REPS	FT. LB.	303.47 +/- 45.36	310.30 +/- 65.37	273.07 +/- 53.71	
WORK LAST 3 REPS	FT. LB.	225.65 +/- 40.95	246.80 +/- 58.40	198.13 +/- 44.49	
ENDURANCE RATIO	%	74.71 +/- 10.49	79.20 +/- 7.71	72.63 +/- 8.30	
WATTS AVERAGE POWER	WATTS	125.82 +/- 19.25	130.70 +/- 26.99	110.80 +/- 22.47	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	86.88 +/- 15.87	89.40 +/- 19.93	86.57 +/- 11.75	

* - signifies a significant one-way ANOVA across 6 occupational groups (see table 6B for means and standard deviations for other 3 groups)

TABLE 6D.

MEANS AND STANDARD DEVIATIONS OF OTHER VARIABLES
FOR SECURITY, COMPUTER-RELATED, AND ENGINEER GROUPS

		SECURITY	COMPUTER-RELATED	ENGINEERS	SIGNIFICANT ANOVA
		N=17	N=10	N=30	
ASTRAND-RHYMING TEST VARIABLES					
VARIABLE	UNITS				
FINAL WORKLOAD SETTING	KPM/MIN.	157.35 +/- 31.24	159.80 +/- 43.96	166.97 +/- 37.35	
AVERAGE HEART RATE	BPM	150.94 +/- 8.01	147.60 +/- 7.71	148.43 +/- 8.00	
VO2	ML./MIN.	3372.06 +/- 628.86	3580.00 +/- 1073.2	3665.83 +/- 878.10	
AGE CORRECTED VO2	ML./MIN.	3280.00 +/- 608.84	3257.80 +/- 1170.4	3103.27 +/- 859.37	
VO2 PER KG	ML./KG./MIN	39.76 +/- 6.57	37.28 +/- 12.42	41.78 +/- 12.96	
BLOOD ANALYSIS VARIABLES					
VARIABLE	UNITS				
HEMOGLOBIN	GM./DL.	15.55 +/- 0.82	14.96 +/- 0.91	14.92 +/- 1.04	*
HEMATOCRIT	%	45.24 +/- 1.89	43.50 +/- 3.17	44.23 +/- 2.97	
HAPTOGLOBIN	MG./DL.	156.35 +/- 73.29	126.80 +/- 68.27	126.93 +/- 74.75	
TESTOSTERONE	NG./DL.	540.94 +/- 165.75	510.90 +/- 117.91	568.53 +/- 133.50	
ESTROGEN	PG./ML.	67.88 +/- 28.83	73.80 +/- 29.09	57.07 +/- 19.96	
SOMATIC BODY TYPE VARIABLES					
VARIABLE	UNITS				
+ ENDOMORPHY		5.41 +/- 1.34	5.75 +/- 1.23	4.30 +/- 1.74	*
+ MESOMORHPY		4.26 +/- 1.13	5.05 +/- 0.86	4.22 +/- 1.34	
+ ECTOMORPHY		1.85 +/- 1.09	1.25 +/- 0.79	2.13 +/- 1.40	
HYDROSTATIC WEIGHING VARIABLES					
VARIABLE	UNITS				
PERCENTAGE BODY FAT	%	21.76 +/- 6.37	21.45 +/- 6.49	19.26 +/- 7.79	
WEIGHT OF BODY FAT	KG.	18.55 +/- 7.60	18.57 +/- 5.78	15.20 +/- 8.33	
FAT-FREE MASS	KG.	64.31 +/- 5.68	68.31 +/- 9.75	60.29 +/- 7.11	
BODY DENSITY	GM./CC.	1.0494 +/- 0.0142	1.0501 +/- 0.0145	1.0551 +/- 0.0174	
RESIDUAL VOLUME	L.	1.13 +/- 0.28	1.29 +/- 0.18	1.45 +/- 0.33	*
SIT AND REACH TEST VARIABLES - SPINAL FLEXIBILITY					
VARIABLE	UNITS				
MAXIMUM OF THREE TRIALS	CM.	9.91 +/- 8.50	6.00 +/- 9.53	5.74 +/- 9.41	

* - signifies a significant one-way ANOVA across 6 occupational groups (see table 6H for means and standard deviations for other 3 groups)

+ - ratings of each somatotype theoretically begin at zero and have no arbitrary endpoint

TABLE 6E.

MEANS AND STANDARD DEVIATIONS OF AGE AND ANTHROPOMETRIC VARIABLES
FOR TECHNICIAN, MISCELLANEOUS, AND SCAPE GROUPS

VARIABLE	UNITS	TECHNICIANS n=12	MISCELLANEOUS n=24	SCAPE n=17	SIGNIFICANT ANOVA
AGE	YEAR	35.00 +/- 9.03	38.83 +/- 8.61	41.00 +/- 10.24	‡
WEIGHT	KG.	76.04 +/- 10.31	80.73 +/- 12.22	84.15 +/- 12.94	
HEIGHT	CM.	176.90 +/- 6.34	178.30 +/- 5.69	176.68 +/- 9.55	
SITTING HEIGHT	CM.	91.09 +/- 4.35	92.87 +/- 4.36	92.16 +/- 4.81	
ACROMION-DACTYLION LENGTH	CM.	77.35 +/- 3.96	78.32 +/- 2.76	76.94 +/- 4.36	
BREADTHS					
ELBOW	CM.	7.19 +/- 0.30	7.01 +/- 0.45	7.07 +/- 0.35	
KNEE	CM.	9.55 +/- 0.44	9.55 +/- 0.53	9.72 +/- 0.58	
CIRCUMFERENCES					
SHOULDER	CM.	116.29 +/- 6.01	118.44 +/- 8.13	122.78 +/- 9.24	‡
CHEST	CM.	96.32 +/- 7.27	99.36 +/- 8.02	104.50 +/- 9.99	
WAIST	CM.	83.73 +/- 7.03	89.05 +/- 8.16	93.06 +/- 9.95	
BUTTOCKS	CM.	93.07 +/- 5.99	97.35 +/- 5.45	99.25 +/- 6.48	
THIGH	CM.	48.30 +/- 2.64	50.24 +/- 4.62	49.68 +/- 4.68	
CALF	CM.	36.89 +/- 2.61	38.12 +/- 3.05	36.41 +/- 2.85	
BICEPS - RELAXED	CM.	29.01 +/- 2.02	30.78 +/- 3.33	31.40 +/- 3.51	‡
BICEPS - FLEXED	CM.	32.60 +/- 1.94	34.04 +/- 3.32	35.10 +/- 2.94	‡
FOREARM	CM.	28.34 +/- 1.72	28.55 +/- 2.20	29.20 +/- 2.14	
SKINFOLDS					
BICEPS	MM.	4.54 +/- 1.14	5.83 +/- 1.75	6.15 +/- 1.66	
TRICEPS	MM.	8.75 +/- 2.48	9.88 +/- 2.63	9.68 +/- 1.73	
SUBSCAPULAR	MM.	12.96 +/- 3.91	13.58 +/- 3.22	18.85 +/- 7.90	‡
CHEST	MM.	13.08 +/- 6.05	15.29 +/- 6.96	20.68 +/- 9.19	‡
MID-AXILLARY LINE	MM.	11.79 +/- 5.33	14.85 +/- 7.41	19.88 +/- 9.66	
SUPRA-ILIAC	MM.	19.29 +/- 7.74	25.75 +/- 9.81	28.06 +/- 11.91	‡
ABDOMINAL	MM.	15.21 +/- 5.62	20.58 +/- 8.31	22.79 +/- 10.36	
THIGH	MM.	11.54 +/- 2.73	14.31 +/- 4.82	14.47 +/- 4.68	
CALF	MM.	9.29 +/- 4.16	10.65 +/- 4.18	10.53 +/- 4.12	

‡ - signifies a significant one-way ANOVA across 6 occupational groups (see table 6A for means and standard deviations for other 3 groups)

TABLE 6F.

MEANS AND STANDARD DEVIATIONS OF KNEE CYBEX VARIABLES
FOR TECHNICIAN, MISCELLANEOUS, AND SCAPE GROUPS

		TECHNICIANS	MISCELLANEOUS	SCAPE	SIGNIFICANT ANOVA
		n=12	n=24	n=17	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	155.75 +/- 16.40	145.54 +/- 37.04	154.29 +/- 38.61	
EXTENSION PEAK/BODY WT. RATIO	%	92.92 +/- 10.87	82.13 +/- 20.75	81.94 +/- 17.72	
PEAK FLEXION	FT. LB.	92.42 +/- 20.67	86.38 +/- 20.39	87.53 +/- 25.09	
FLEXION PEAK/BODY WT. RATIO	%	55.00 +/- 12.35	48.63 +/- 11.62	46.00 +/- 10.01	
FLEXION/EXTENSION PEAK RATIO	%	58.92 +/- 9.96	60.46 +/- 10.75	56.82 +/- 7.53	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	100.42 +/- 16.14	99.33 +/- 21.54	101.59 +/- 24.25	
EXTENSION PEAK/BODY WT. RATIO	%	59.58 +/- 7.95	55.67 +/- 11.55	53.76 +/- 9.11	
PEAK FLEXION	FT. LB.	71.17 +/- 11.81	64.83 +/- 14.24	67.69 +/- 15.34	
FLEXION PEAK/BODY WT. RATIO	%	42.17 +/- 5.69	36.50 +/- 8.29	33.35 +/- 9.72	‡
FLEXION/EXTENSION PEAK RATIO	%	71.17 +/- 6.51	65.79 +/- 8.69	64.75 +/- 6.31	‡
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	18.69 +/- 3.30	17.89 +/- 4.14	19.04 +/- 5.14	
TOTAL WORK	FT. LB.	1473.17 +/- 217.75	1485.88 +/- 287.68	1464.53 +/- 427.37	‡
WORK FIRST 3 REPS	FT. LB.	322.92 +/- 48.36	335.50 +/- 67.97	334.59 +/- 92.05	
WORK LAST 3 REPS	FT. LB.	250.42 +/- 44.50	255.17 +/- 56.47	248.59 +/- 73.95	‡
ENDURANCE RATIO	%	78.25 +/- 13.78	76.54 +/- 12.10	74.59 +/- 9.98	
WATTS AVERAGE POWER	WATTS	225.17 +/- 37.39	218.21 +/- 47.30	217.35 +/- 58.96	‡
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	10.94 +/- 3.59	9.37 +/- 2.48	8.45 +/- 3.44	
TOTAL WORK	FT. LB.	1138.00 +/- 223.37	1047.96 +/- 218.84	1095.94 +/- 299.26	
WORK FIRST 3 REPS	FT. LB.	253.58 +/- 42.28	245.75 +/- 51.76	240.53 +/- 97.59	
WORK LAST 3 REPS	FT. LB.	193.33 +/- 43.98	170.38 +/- 42.13	167.00 +/- 62.21	
ENDURANCE RATIO	%	76.08 +/- 11.36	69.96 +/- 12.78	67.35 +/- 23.98	
WATTS AVERAGE POWER	WATTS	171.92 +/- 36.53	152.42 +/- 36.23	150.53 +/- 56.11	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	76.67 +/- 6.97	71.08 +/- 10.98	71.88 +/- 9.05	

‡ - signifies a significant one-way ANOVA across 6 occupational groups (see table 6B for means and standard deviations for other 3 groups)

TABLE 6G.

MEANS AND STANDARD DEVIATIONS OF SHOULDER CYBEX VARIABLES
FOR TECHNICIAN, MISCELLANEOUS, AND SCAPE GROUPS

		TECHNICIANS	MISCELLANEOUS	SCAPE	SIGNIFICANT ANOVA
		n=12	n=24	n=17	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	62.33 +/- 11.92	71.63 +/- 26.29	71.59 +/- 12.77	
EXTENSION PEAK/BODY WT. RATIO	%	37.08 +/- 8.03	39.46 +/- 11.36	38.24 +/- 5.73	
PEAK FLEXION	FT. LB.	52.17 +/- 6.01	54.79 +/- 18.11	57.59 +/- 14.19	
FLEXION PEAK/BODY WT. RATIO	%	31.17 +/- 3.93	30.38 +/- 7.91	30.53 +/- 6.32	
FLEXION/EXTENSION PEAK RATIO	%	85.58 +/- 13.50	78.33 +/- 13.19	80.18 +/- 13.23	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	48.83 +/- 10.89	54.04 +/- 16.31	54.35 +/- 12.94	
EXTENSION PEAK/BODY WT. RATIO	%	29.08 +/- 6.61	30.04 +/- 7.23	28.88 +/- 6.01	
PEAK FLEXION	FT. LB.	41.58 +/- 4.60	43.63 +/- 12.99	47.59 +/- 11.28	‡
FLEXION PEAK/BODY WT. RATIO	%	24.83 +/- 2.52	24.25 +/- 5.62	25.29 +/- 4.69	
FLEXION/EXTENSION PEAK RATIO	%	87.75 +/- 14.16	82.25 +/- 14.82	88.59 +/- 13.62	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	11.90 +/- 2.07	12.17 +/- 2.48	12.46 +/- 2.84	‡
TOTAL WORK	FT. LB.	1360.75 +/- 298.36	1426.21 +/- 315.49	1407.12 +/- 348.62	
WORK FIRST 3 REPS	FT. LB.	300.33 +/- 59.04	314.96 +/- 72.21	315.71 +/- 91.17	
WORK LAST 3 REPS	FT. LB.	238.00 +/- 53.89	249.00 +/- 57.64	243.41 +/- 59.42	
ENDURANCE RATIO	%	79.42 +/- 10.08	79.38 +/- 8.98	79.12 +/- 15.86	
WATTS AVERAGE POWER	WATTS	130.08 +/- 29.12	140.25 +/- 34.98	135.18 +/- 33.36	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.08 +/- 1.71	12.43 +/- 2.91	12.94 +/- 2.37	‡
TOTAL WORK	FT. LB.	1210.00 +/- 201.46	1192.83 +/- 279.01	1256.71 +/- 268.78	
WORK FIRST 3 REPS	FT. LB.	271.83 +/- 40.61	272.50 +/- 58.68	289.53 +/- 71.96	
WORK LAST 3 REPS	FT. LB.	211.92 +/- 41.38	202.88 +/- 50.51	213.94 +/- 43.47	
ENDURANCE RATIO	%	78.00 +/- 9.75	74.29 +/- 8.45	74.94 +/- 8.74	
WATTS AVERAGE POWER	WATTS	114.75 +/- 19.09	116.42 +/- 32.60	119.59 +/- 24.75	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	91.25 +/- 16.49	84.67 +/- 15.39	91.18 +/- 12.97	

‡ - signifies a significant one-way ANOVA across 6 occupational groups (see table 6C for means and standard deviations for other 3 groups)

TABLE 6H.

MEANS AND STANDARD DEVIATIONS OF OTHER VARIABLES
FOR TECHNICIAN, MISCELLANEOUS, AND SCAPE GROUPS

		TECHNICIANS	MISCELLANEOUS	SCAPE	SIGNIFICANT ANOVA
		n=12	n=24	n=17	
ASTRAND-RHYMING TEST VARIABLES					
VARIABLE	UNITS				
FINAL WORKLOAD SETTING	KPM/MIN.	165.75 +/- 43.34	166.92 +/- 42.19	141.44 +/- 32.06	
AVERAGE HEART RATE	BPM	148.75 +/- 9.08	145.42 +/- 8.10	143.00 +/- 9.63	
VO2	ML./MIN.	3662.50 +/- 1003.9	3810.42 +/- 988.19	3359.38 +/- 759.87	
AGE CORRECTED VO2	ML./MIN.	3236.33 +/- 898.15	3251.54 +/- 1003.4	2799.00 +/- 671.83	
VO2 PER KG	ML./KG./MIN	43.37 +/- 13.71	40.69 +/- 12.46	34.15 +/- 9.55	
BLOOD ANALYSIS VARIABLES					
VARIABLE	UNITS				
HEMOGLOBIN	GM./DL.	15.72 +/- 0.94	14.91 +/- 0.78	15.45 +/- 1.15	‡
HEMATOCRIT	%	45.25 +/- 2.34	44.04 +/- 1.76	45.59 +/- 3.36	
HAPTOGLOBIN	MG./DL.	182.75 +/- 81.35	121.17 +/- 72.04	144.47 +/- 78.86	
TESTOSTERONE	NG./DL.	673.75 +/- 173.63	536.58 +/- 152.08	575.12 +/- 204.73	
ESTROGEN	PG./ML.	66.67 +/- 20.54	60.08 +/- 26.85	63.94 +/- 25.50	
SOMATIC BODY TYPE VARIABLES					
VARIABLE	UNITS				
+ ENDOMORPHY		4.13 +/- 1.23	4.88 +/- 1.30	5.41 +/- 1.48	‡
+ MESOMORHPY		4.33 +/- 0.86	4.38 +/- 1.41	4.79 +/- 1.30	
+ ECTOMORPHY		2.00 +/- 0.95	1.88 +/- 0.98	1.53 +/- 1.22	
HYDROSTATIC WEIGHING VARIABLES					
VARIABLE	UNITS				
PERCENTAGE BODY FAT	%	16.69 +/- 5.52	21.56 +/- 6.80	23.09 +/- 7.06	
WEIGHT OF BODY FAT	KG.	13.01 +/- 5.63	17.68 +/- 7.16	19.95 +/- 8.00	
FAT-FREE MASS	KG.	63.03 +/- 6.68	63.06 +/- 9.06	64.59 +/- 8.90	
BODY DENSITY	GM./CC.	1.0608 +/- 0.0125	1.0449 +/- 0.0152	1.0465 +/- 0.0157	
RESIDUAL VOLUME	L.	1.34 +/- 0.34	1.42 +/- 0.25	1.47 +/- 0.34	‡
SIT AND REACH TEST VARIABLES - SPINAL FLEXIBILITY					
VARIABLE	UNITS				
MAXIMUM OF THREE TRIALS	CM.	10.05 +/- 9.39	8.27 +/- 9.77	6.65 +/- 8.31	

‡ - signifies a significant one-way ANOVA across 6 occupational groups (see table 6D for means and standard deviations for other 3 groups)

+ - ratings of each somatotype theoretically begin at zero and have no arbitrary endpoint

TABLE 7.

DUNCAN'S MULTIPLE RANGE TEST FOR SECURITY, COMPUTER-RELATED, ENGINEER, TECHNICIAN, MISCELLANEOUS, AND SCAPE GROUPS

VARIABLE	SECURITY	COMPUTER-RELATED	ENGINEERS	SCAPE	TECHNICIANS	MISCELLANEOUS
AGE	A	A	A	A	A	A
CIRCUMFERENCES						
SHOULDER	AB	A	B	A	B	AB
BICEPS - RELAXED	AB	A	BC	AB	C	ABC
BICEPS - FLEXED	AB	A	B	A	B	AB
SKINFOLDS						
SUBSCAPULAR	AB	A	B	A	B	B
CHEST	AB	AB	B	A	B	AB
SUPRA-ILIAC	AB	A	BC	AB	C	ABC
CYBEX - KNEE						
TORQUE - 180 DEG./SEC. - 3 REPS						
FLEXION PEAK/BODY WT. RATIO	AB	AB	A	B	A	AB
FLEXION/EXTENSION PEAK RATIO	C	BC	AB	ABC	A	ABC
WORK AND ENDURANCE - EXTENSION - 15 REPS						
TOTAL WORK	AB	A	B	B	B	B
WORK LAST 3 REPS	AB	A	B	B	B	B
WATTS AVERAGE POWER	AB	A	B	B	B	B
CYBEX - SHOULDER						
TORQUE - 180 DEG./SEC. - 3 REPS						
PEAK FLEXION	A	A	B	AB	B	B
WORK AND ENDURANCE - EXTENSION - 15 REPS						
PEAK TOTAL ACCELERATED ENERGY	A	AB	BC	BC	C	BC
WORK AND ENDURANCE - FLEXION - 15 REPS						
PEAK TOTAL ACCELERATED ENERGY	A	AB	C	BC	C	C
BLOOD ANALYSIS VARIABLES						
HEMOGLOBIN	AB	B	B	AB	A	B
SOMATIC BODY TYPE VARIABLES						
ENDOMORPHY	A	A	B	A	B	AB
HYDROSTATIC WEIGHING VARIABLES						
RESIDUAL VOLUME	B	AB	A	A	AB	A

-- Groups with different letters for a variable differ significantly for that variable.

TABLE 8A.

MEANS AND STANDARD DEVIATIONS OF AGE AND ANTHROPOMETRIC VARIABLES
FOR ACTIVE SCAPE, CERTIFIED-FOR-SCAPE, AND NON-SCAPE GROUPS

		ACTIVE SCAPE	CERTIFIED-FOR-SCAPE	NON-SCAPE	SIGNIFICANT ANOVA
		n=17	n=7	n=86	
VARIABLE	UNITS				
AGE	YEAR	41.00 +/- 10.24	35.43 +/- 6.70	35.93 +/- 10.05	
WEIGHT	KG.	84.15 +/- 12.94	76.60 +/- 10.01	79.97 +/- 12.32	
HEIGHT	CM.	176.68 +/- 9.55	178.47 +/- 4.37	177.75 +/- 6.49	
SITTING HEIGHT	CM.	92.16 +/- 4.81	92.60 +/- 4.86	92.25 +/- 4.32	
ACROMION-DACTYLION LENGTH	CM.	76.94 +/- 4.36	77.27 +/- 4.08	77.81 +/- 3.41	
BREADTHS					
VARIABLE	UNITS				
ELBOW	CM.	7.07 +/- 0.35	7.30 +/- 0.23	7.05 +/- 0.38	
KNEE	CM.	9.72 +/- 0.58	9.81 +/- 0.40	9.52 +/- 0.50	
CIRCUMFERENCES					
VARIABLE	UNITS				
SHOULDER	CM.	122.78 +/- 9.24	115.87 +/- 5.59	118.50 +/- 7.65	
CHEST	CM.	104.50 +/- 9.99	97.49 +/- 8.92	100.47 +/- 11.04	
WAIST	CM.	93.06 +/- 9.95	84.16 +/- 8.12	87.65 +/- 9.05	‡
BUTTOCKS	CM.	99.25 +/- 6.48	93.64 +/- 5.31	97.12 +/- 6.96	
THIGH	CM.	49.68 +/- 4.68	47.17 +/- 1.73	50.38 +/- 4.43	
CALF	CM.	36.41 +/- 2.85	36.73 +/- 2.14	37.53 +/- 3.03	
BICEPS - RELAXED	CM.	31.40 +/- 3.51	29.60 +/- 2.31	30.65 +/- 3.07	
BICEPS - FLEXED	CM.	35.10 +/- 2.94	32.89 +/- 1.94	33.77 +/- 2.95	
FOREARM	CM.	29.20 +/- 2.14	28.54 +/- 1.84	28.38 +/- 1.88	
SKINFOLDS					
VARIABLE	UNITS				
BICEPS	MM.	6.15 +/- 1.66	4.57 +/- 1.10	5.63 +/- 2.13	
TRICEPS	MM.	9.68 +/- 1.73	8.79 +/- 1.87	9.74 +/- 3.28	
SUBSCAPULAR	MM.	18.85 +/- 7.90	13.64 +/- 4.80	14.77 +/- 4.75	‡
CHEST	MM.	20.68 +/- 9.19	14.00 +/- 7.33	14.81 +/- 7.05	‡
MID-AXILLARY LINE	MM.	19.88 +/- 9.66	12.00 +/- 6.11	15.18 +/- 7.34	‡
SUPRA-ILIAC	MM.	28.06 +/- 11.91	19.71 +/- 6.44	24.99 +/- 11.35	
ABDOMINAL	MM.	22.79 +/- 10.36	18.29 +/- 8.75	19.02 +/- 8.57	
THIGH	MM.	14.47 +/- 4.68	12.71 +/- 2.93	14.10 +/- 5.02	
CALF	MM.	10.53 +/- 4.12	9.64 +/- 1.49	10.72 +/- 4.44	

‡ - signifies a significant one-way ANOVA across groups

TABLE 8B.

MEANS AND STANDARD DEVIATIONS OF KNEE CYBEX VARIABLES
FOR ACTIVE SCAPE, CERTIFIED-FOR-SCAPE, AND NON-SCAPE GROUPS

		ACTIVE SCAPE	CERTIFIED-FOR-SCAPE	NON-SCAPE	SIGNIFICANT ANOVA
		n=17	n=7	n=86	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	154.29 +/- 38.61	147.00 +/- 15.30	153.47 +/- 32.91	
EXTENSION PEAK/BODY WT. RATIO	%	81.94 +/- 17.72	87.43 +/- 12.41	86.85 +/- 16.65	
PEAK FLEXION	FT. LB.	87.53 +/- 25.09	85.86 +/- 19.49	89.14 +/- 18.66	
FLEXION PEAK/BODY WT. RATIO	%	46.00 +/- 10.01	51.29 +/- 14.10	50.51 +/- 9.65	
FLEXION/EXTENSION PEAK RATIO	%	56.82 +/- 7.53	59.00 +/- 14.50	59.12 +/- 11.24	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	101.59 +/- 24.25	97.57 +/- 7.52	103.79 +/- 23.45	
EXTENSION PEAK/BODY WT. RATIO	%	53.76 +/- 9.11	57.71 +/- 5.59	58.52 +/- 10.93	
PEAK FLEXION	FT. LB.	67.69 +/- 15.34	68.14 +/- 11.11	67.63 +/- 13.99	
FLEXION PEAK/BODY WT. RATIO	%	33.35 +/- 9.72	40.43 +/- 6.75	38.38 +/- 7.72	*
FLEXION/EXTENSION PEAK RATIO	%	64.75 +/- 6.31	69.57 +/- 8.26	66.43 +/- 11.11	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	19.04 +/- 5.14	18.01 +/- 1.25	18.79 +/- 4.24	
TOTAL WORK	FT. LB.	1464.53 +/- 427.37	1347.00 +/- 169.74	1554.36 +/- 355.64	
WORK FIRST 3 REPS	FT. LB.	334.59 +/- 92.05	298.43 +/- 28.42	343.41 +/- 82.85	
WORK LAST 3 REPS	FT. LB.	248.59 +/- 73.95	227.86 +/- 45.43	269.19 +/- 65.65	
ENDURANCE RATIO	%	74.59 +/- 9.98	77.00 +/- 17.31	79.36 +/- 14.54	
WATTS AVERAGE POWER	WATTS	217.35 +/- 58.96	209.14 +/- 27.31	233.36 +/- 55.19	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	8.45 +/- 3.44	10.08 +/- 4.09	9.73 +/- 3.27	
TOTAL WORK	FT. LB.	1095.94 +/- 299.26	1052.00 +/- 266.45	1101.93 +/- 249.28	
WORK FIRST 3 REPS	FT. LB.	240.53 +/- 97.59	231.86 +/- 47.96	250.36 +/- 62.31	
WORK LAST 3 REPS	FT. LB.	167.00 +/- 62.21	181.57 +/- 55.11	184.50 +/- 45.54	
ENDURANCE RATIO	%	67.35 +/- 23.98	77.57 +/- 13.83	75.16 +/- 15.90	
WATTS AVERAGE POWER	WATTS	150.53 +/- 56.11	161.43 +/- 40.77	164.03 +/- 39.31	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	71.88 +/- 9.05	77.00 +/- 10.79	72.27 +/- 14.44	

* - signifies a significant one-way ANOVA across groups

TABLE 8C.

MEANS AND STANDARD DEVIATIONS OF SHOULDER CYBEX VARIABLES
FOR ACTIVE SCAPE, CERTIFIED-FOR-SCAPE, AND NON-SCAPE GROUPS

		ACTIVE SCAPE	CERTIFIED-FOR-SCAPE	NON-SCAPE	SIGNIFICANT ANOVA
		n=17	n=7	n=86	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	71.59 +/- 12.77	58.14 +/- 9.99	69.27 +/- 18.94	
EXTENSION PEAK/BODY WT. RATIO	%	38.24 +/- 5.73	34.57 +/- 6.92	39.12 +/- 8.83	
PEAK FLEXION	FT. LB.	57.59 +/- 14.19	52.14 +/- 3.67	54.37 +/- 12.73	
FLEXION PEAK/BODY WT. RATIO	%	30.53 +/- 6.32	31.00 +/- 4.51	30.74 +/- 5.63	
FLEXION/EXTENSION PEAK RATIO	%	80.18 +/- 13.23	92.00 +/- 15.91	79.99 +/- 11.69	‡
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	54.35 +/- 12.94	45.57 +/- 9.66	54.09 +/- 13.54	
EXTENSION PEAK/BODY WT. RATIO	%	28.88 +/- 6.01	27.14 +/- 6.47	30.65 +/- 6.91	
PEAK FLEXION	FT. LB.	47.59 +/- 11.28	40.00 +/- 2.24	45.30 +/- 10.78	
FLEXION PEAK/BODY WT. RATIO	%	25.29 +/- 4.69	23.86 +/- 3.02	25.63 +/- 4.91	
FLEXION/EXTENSION PEAK RATIO	%	88.59 +/- 13.62	90.86 +/- 17.53	85.09 +/- 13.25	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.46 +/- 2.84	11.10 +/- 1.04	12.81 +/- 2.81	
TOTAL WORK	FT. LB.	1407.12 +/- 348.62	1226.57 +/- 184.85	1461.90 +/- 335.81	
WORK FIRST 3 REPS	FT. LB.	315.71 +/- 91.17	269.00 +/- 48.39	323.90 +/- 74.39	
WORK LAST 3 REPS	FT. LB.	243.41 +/- 59.42	219.43 +/- 33.82	252.85 +/- 62.91	
ENDURANCE RATIO	%	79.12 +/- 15.86	82.14 +/- 9.37	78.31 +/- 10.51	
WATTS AVERAGE POWER	WATTS	135.18 +/- 33.36	115.86 +/- 18.51	141.00 +/- 33.41	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.94 +/- 2.37	11.92 +/- 0.79	13.06 +/- 2.83	
TOTAL WORK	FT. LB.	1256.71 +/- 268.78	1153.86 +/- 157.45	1237.97 +/- 256.70	
WORK FIRST 3 REPS	FT. LB.	289.53 +/- 71.96	256.14 +/- 24.40	284.45 +/- 55.86	
WORK LAST 3 REPS	FT. LB.	213.94 +/- 43.47	202.14 +/- 40.95	212.15 +/- 49.08	
ENDURANCE RATIO	%	74.94 +/- 8.74	78.71 +/- 12.32	74.52 +/- 8.69	
WATTS AVERAGE POWER	WATTS	119.59 +/- 24.75	108.00 +/- 15.36	118.43 +/- 26.09	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	91.18 +/- 12.97	95.14 +/- 13.16	86.38 +/- 14.92	

‡ - signifies a significant one-way ANOVA across groups

TABLE 8D.

MEANS AND STANDARD DEVIATIONS OF OTHER VARIABLES
FOR ACTIVE SCAPE, CERTIFIED-FOR-SCAPE, AND NON-SCAPE GROUPS

		ACTIVE SCAPE	CERTIFIED-FOR-SCAPE	NON-SCAPE	SIGNIFICANT ANOVA
		n=17	n=7	n=86	
ASTRAND-RHYMING TEST VARIABLES					
VARIABLE	UNITS				
FINAL WORKLOAD SETTING	KPM/MIN.	141.44 +/- 32.06	147.57 +/- 28.73	165.63 +/- 39.02	‡
AVERAGE HEART RATE	BPM	143.00 +/- 9.63	152.14 +/- 8.95	147.73 +/- 8.08	‡
VO2	ML./MIN.	3359.38 +/- 759.87	3150.00 +/- 684.96	3679.65 +/- 907.15	
AGE CORRECTED VO2	ML./MIN.	2799.00 +/- 671.83	2766.43 +/- 638.49	3243.53 +/- 896.29	
VO2 PER KG	ML./KG./MIN	34.15 +/- 9.55	36.87 +/- 10.69	41.17 +/- 11.90	
BLOOD ANALYSIS VARIABLES					
VARIABLE	UNITS				
HEMOGLOBIN	GM./DL.	15.45 +/- 1.15	15.54 +/- 0.80	15.11 +/- 0.96	
HEMATOCRIT	%	45.59 +/- 3.36	45.43 +/- 2.23	44.34 +/- 2.50	
HAPTOGLOBIN	MG./DL.	144.47 +/- 78.86	166.14 +/- 59.14	135.72 +/- 76.43	
TESTOSTERONE	NG./DL.	575.12 +/- 204.73	583.71 +/- 182.21	560.91 +/- 151.18	
ESTROGEN	PG./ML.	63.94 +/- 25.50	63.71 +/- 22.49	62.79 +/- 25.12	
SOMATIC BODY TYPE VARIABLES					
VARIABLE	UNITS				
+ ENDOMORPHY		5.41 +/- 1.48	4.29 +/- 1.15	4.83 +/- 1.55	
+ MESOMORHPY		4.79 +/- 1.30	4.36 +/- 0.85	4.37 +/- 1.26	
+ ECTOMORPHY		1.53 +/- 1.22	2.21 +/- 1.04	1.88 +/- 1.15	
HYDROSTATIC WEIGHING VARIABLES					
VARIABLE	UNITS				
PERCENTAGE BODY FAT	%	23.09 +/- 7.06	18.22 +/- 5.87	20.39 +/- 7.04	
WEIGHT OF BODY FAT	KG.	19.95 +/- 8.00	14.34 +/- 6.28	16.73 +/- 7.53	
FAT-FREE MASS	KG.	64.59 +/- 8.90	62.25 +/- 5.37	63.04 +/- 8.10	
BODY DENSITY	GM./CC.	1.0465 +/- 0.0157	1.0573 +/- 0.0132	1.0525 +/- 0.0157	
RESIDUAL VOLUME	L.	1.47 +/- 0.34	1.46 +/- 0.26	1.34 +/- 0.31	
SIT AND REACH TEST VARIABLES - SPINAL FLEXIBILITY					
VARIABLE	UNITS				
MAXIMUM OF THREE TRIALS	CM.	6.65 +/- 8.31	9.93 +/- 6.38	7.53 +/- 9.53	

‡ - signifies a significant one-way ANOVA across groups
+ - ratings of each somatotype theoretically begin at zero and have no arbitrary endpoint

TABLE 9.

DUNCAN'S MULTIPLE RANGE TEST FOR ACTIVE SCAPE, CERTIFIED-FOR-SCAPE, AND NON-SCAPE GROUPS

	ACTIVE SCAPE	CERTIFIED-FOR-SCAPE	NON-SCAPE
CIRCUMFERENCES			
WAIST	A	B	AB
SKINFOLDS			
SUBSCAPULAR	A	B	B
CHEST	A	B	B
MID-AXILLARY LINE	A	B	AB
CYBEX - KNEE			
TORQUE - 180 DEG./SEC. - 3 REPS			
FLEXION PEAK/BODY WT. RATIO	B	A	AB
CYBEX - SHOULDER			
TORQUE - 60 DEG./SEC. - 3 REPS			
FLEXION/EXTENSION PEAK RATIO	B	A	B
ASTRAND-RHYMING TEST VARIABLES			
FINAL WORKLOAD SETTING	A	A	A
AVERAGE HEART RATE	B	A	AB

-- Groups with different letters for a variable differ significantly for that variable

TABLE 10A.

MEANS AND STANDARD DEVIATIONS OF AGE AND ANTHROPOMETRIC VARIABLES FOR PROPELLANT TRANSFER SCAPE WORKERS, FLIGHT SERVICING SCAPE WORKERS, AND NON-PROPELLANT WORKERS

VARIABLE	UNITS	PROPELLANT TRANSFER SCAPE WORKERS n=10	FLIGHT SERVICING SCAPE WORKERS n=7	NON-PROPELLANT WORKERS n=93	SIGNIFICANT ANOVA
AGE	YEAR	42.70 +/- 11.93	38.57 +/- 7.39	35.89 +/- 9.81	
WEIGHT	KG.	85.80 +/- 13.61	81.79 +/- 12.55	79.72 +/- 12.15	
HEIGHT	CM.	174.95 +/- 9.01	179.16 +/- 10.45	177.80 +/- 6.34	
SITTING HEIGHT	CM.	90.56 +/- 4.89	94.44 +/- 3.93	92.27 +/- 4.34	
ACROMION-DACTYLION LENGTH	CM.	76.70 +/- 4.51	77.29 +/- 4.48	77.77 +/- 3.44	
BREADTHS					
ELBOW	CM.	7.05 +/- 0.34	7.10 +/- 0.39	7.07 +/- 0.37	
KNEE	CM.	9.67 +/- 0.44	9.79 +/- 0.76	9.54 +/- 0.50	
CIRCUMFERENCES					
SHOULDER	CM.	124.51 +/- 8.54	120.31 +/- 10.32	118.30 +/- 7.53	
CHEST	CM.	106.95 +/- 9.98	101.00 +/- 9.63	100.24 +/- 10.88	
WAIST	CM.	96.60 +/- 9.31	88.01 +/- 9.13	87.39 +/- 8.99	‡
BUTTOCKS	CM.	100.87 +/- 6.34	96.94 +/- 6.42	96.85 +/- 6.89	
THIGH	CM.	48.43 +/- 4.74	51.47 +/- 4.29	50.14 +/- 4.37	
CALF	CM.	36.17 +/- 3.25	36.74 +/- 2.35	37.47 +/- 2.97	
BICEPS - RELAXED	CM.	31.26 +/- 2.94	31.60 +/- 4.45	30.57 +/- 3.03	
BICEPS - FLEXED	CM.	35.02 +/- 2.86	35.21 +/- 3.27	33.70 +/- 2.89	
FOREARM	CM.	28.96 +/- 2.18	29.54 +/- 2.21	28.39 +/- 1.87	
SKINFOLDS					
BICEPS	MM.	6.30 +/- 1.69	5.93 +/- 1.72	5.55 +/- 2.09	
TRICEPS	MM.	10.25 +/- 1.99	8.86 +/- 0.85	9.67 +/- 3.19	
SUBSCAPULAR	MM.	20.55 +/- 6.73	16.43 +/- 9.32	14.68 +/- 4.74	‡
CHEST	MM.	23.45 +/- 7.76	16.71 +/- 10.19	14.75 +/- 7.04	‡
MID-AXILLARY LINE	MM.	24.10 +/- 9.45	13.86 +/- 6.57	14.94 +/- 7.27	‡
SUPRA-ILIAC	MM.	30.50 +/- 13.08	24.57 +/- 9.88	24.59 +/- 11.13	
ABDOMINAL	MM.	25.50 +/- 10.82	18.93 +/- 8.99	18.97 +/- 8.54	
THIGH	MM.	14.60 +/- 4.77	14.29 +/- 4.92	13.99 +/- 4.89	
CALF	MM.	11.60 +/- 4.45	9.00 +/- 3.32	10.64 +/- 4.29	

‡ - signifies a significant one-way ANOVA across groups

TABLE 10B.

MEANS AND STANDARD DEVIATIONS OF KNEE CYBEX VARIABLES
FOR PROPELLANT TRANSFER SCAPE WORKERS, FLIGHT SERVICING
SCAPE WORKERS, AND NON-PROPELLANT WORKERS

		PROPELLANT TRANSFER SCAPE WORKERS	FLIGHT SERVICING SCAPE WORKERS	NON-PROPELLANT WORKERS	SIGNIFICANT ANOVA
		n=10	n=7	n=93	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	144.30 +/- 37.87	168.57 +/- 37.69	152.98 +/- 31.92	
EXTENSION PEAK/BODY WT. RATIO	%	74.90 +/- 15.41	92.00 +/- 16.75	86.89 +/- 16.31	
PEAK FLEXION	FT. LB.	83.90 +/- 24.42	92.71 +/- 27.05	88.89 +/- 18.64	
FLEXION PEAK/BODY WT. RATIO	%	43.20 +/- 8.90	50.00 +/- 10.80	50.57 +/- 9.95	
FLEXION/EXTENSION PEAK RATIO	%	58.40 +/- 7.93	54.57 +/- 6.83	59.11 +/- 11.42	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	99.00 +/- 23.72	105.29 +/- 26.42	103.32 +/- 22.68	
EXTENSION PEAK/BODY WT. RATIO	%	51.40 +/- 8.10	57.14 +/- 10.02	58.46 +/- 10.60	
PEAK FLEXION	FT. LB.	66.33 +/- 14.44	69.43 +/- 17.43	67.67 +/- 13.75	
FLEXION PEAK/BODY WT. RATIO	%	30.40 +/- 10.39	37.57 +/- 7.39	38.54 +/- 7.63	*
FLEXION/EXTENSION PEAK RATIO	%	63.78 +/- 7.85	66.00 +/- 3.74	66.67 +/- 10.92	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	18.31 +/- 4.70	20.08 +/- 5.92	18.73 +/- 4.09	
TOTAL WORK	FT. LB.	1385.30 +/- 460.25	1577.71 +/- 379.34	1538.75 +/- 348.95	
WORK FIRST 3 REPS	FT. LB.	317.50 +/- 98.16	359.00 +/- 83.42	340.02 +/- 80.85	
WORK LAST 3 REPS	FT. LB.	234.30 +/- 79.74	269.00 +/- 64.97	266.08 +/- 65.09	
ENDURANCE RATIO	%	74.10 +/- 11.37	75.29 +/- 8.42	79.18 +/- 14.68	
WATTS AVERAGE POWER	WATTS	209.20 +/- 58.51	229.00 +/- 62.19	231.54 +/- 53.89	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	7.07 +/- 3.42	10.43 +/- 2.49	9.76 +/- 3.31	*
TOTAL WORK	FT. LB.	1033.89 +/- 313.25	1175.71 +/- 282.59	1098.17 +/- 249.44	
WORK FIRST 3 REPS	FT. LB.	214.20 +/- 109.45	278.14 +/- 67.99	248.97 +/- 61.33	
WORK LAST 3 REPS	FT. LB.	151.20 +/- 70.32	189.57 +/- 43.49	184.28 +/- 45.99	
ENDURANCE RATIO	%	66.20 +/- 31.09	69.00 +/- 8.87	75.34 +/- 15.70	
WATTS AVERAGE POWER	WATTS	137.80 +/- 61.97	168.71 +/- 44.50	163.84 +/- 39.20	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	69.44 +/- 10.43	75.00 +/- 6.30	72.62 +/- 14.20	

* - signifies a significant one-way ANOVA across groups

TABLE 10C.

MEANS AND STANDARD DEVIATIONS OF SHOULDER CYBEX VARIABLES
FOR PROPELLANT TRANSFER SCAPE WORKERS, FLIGHT SERVICING
SCAPE WORKERS, AND NON-PROPELLANT WORKERS

		PROPELLANT TRANSFER SCAPE WORKERS	FLIGHT SERVICING SCAPE WORKERS	NON-PROPELLANT WORKERS	SIGNIFICANT ANOVA
		n=10	n=7	n=93	
TORQUE - 60 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	69.30 +/- 12.60	74.86 +/- 13.26	68.43 +/- 18.61	
EXTENSION PEAK/BODY WT. RATIO	%	36.50 +/- 6.02	40.71 +/- 4.57	38.77 +/- 8.75	
PEAK FLEXION	FT. LB.	55.70 +/- 14.99	60.29 +/- 13.61	54.20 +/- 12.29	
FLEXION PEAK/BODY WT. RATIO	%	28.80 +/- 6.03	33.00 +/- 6.30	30.76 +/- 5.53	
FLEXION/EXTENSION PEAK RATIO	%	79.50 +/- 12.77	81.14 +/- 14.84	80.89 +/- 12.36	
TORQUE - 180 DEG./SEC. - 3 REPS					
VARIABLE	UNITS				
PEAK EXTENSION	FT. LB.	49.80 +/- 11.65	60.86 +/- 12.60	53.45 +/- 13.44	
EXTENSION PEAK/BODY WT. RATIO	%	25.90 +/- 4.70	33.14 +/- 5.21	30.39 +/- 6.91	
PEAK FLEXION	FT. LB.	44.60 +/- 11.10	51.86 +/- 10.87	44.90 +/- 10.47	
FLEXION PEAK/BODY WT. RATIO	%	23.30 +/- 4.03	28.14 +/- 4.26	25.49 +/- 4.81	
FLEXION/EXTENSION PEAK RATIO	%	89.80 +/- 10.00	86.86 +/- 18.40	85.53 +/- 13.59	
WORK AND ENDURANCE - EXTENSION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	11.43 +/- 2.53	13.92 +/- 2.78	12.68 +/- 2.75	
TOTAL WORK	FT. LB.	1314.00 +/- 355.87	1540.14 +/- 314.71	1444.18 +/- 332.13	
WORK FIRST 3 REPS	FT. LB.	284.90 +/- 87.34	359.71 +/- 82.97	319.76 +/- 74.01	
WORK LAST 3 REPS	FT. LB.	227.60 +/- 62.22	266.00 +/- 50.95	250.33 +/- 61.72	
ENDURANCE RATIO	%	82.00 +/- 19.80	75.00 +/- 6.98	78.60 +/- 10.43	
WATTS AVERAGE POWER	WATTS	126.40 +/- 34.36	147.71 +/- 29.74	139.11 +/- 33.13	
WORK AND ENDURANCE - FLEXION - 15 REPS					
VARIABLE	UNITS				
PEAK TOTAL ACCELERATED ENERGY	FT. LB.	12.40 +/- 2.67	13.72 +/- 1.79	12.97 +/- 2.74	
TOTAL WORK	FT. LB.	1195.20 +/- 260.36	1344.57 +/- 275.07	1231.63 +/- 250.99	
WORK FIRST 3 REPS	FT. LB.	272.50 +/- 68.63	313.86 +/- 74.63	282.32 +/- 54.57	
WORK LAST 3 REPS	FT. LB.	203.50 +/- 42.17	228.86 +/- 43.93	211.40 +/- 48.39	
ENDURANCE RATIO	%	75.80 +/- 10.35	73.71 +/- 6.34	74.84 +/- 9.00	
WATTS AVERAGE POWER	WATTS	113.90 +/- 24.86	127.71 +/- 23.99	117.65 +/- 25.53	
VARIABLE	UNITS				
FLEXION/EXTENSION WORK RATIO	%	93.20 +/- 12.84	88.29 +/- 13.60	87.04 +/- 14.91	

‡ - signifies a significant one-way ANOVA across groups

TABLE 10D.

MEANS AND STANDARD DEVIATIONS OF OTHER VARIABLES
FOR PROPELLANT TRANSFER SCAPE WORKERS, FLIGHT SERVICING
SCAPE WORKERS, AND NON-PROPELLANT WORKERS

		PROPELLANT TRANSFER SCAPE WORKERS	FLIGHT SERVICING SCAPE WORKERS	NON-PROPELLANT WORKERS	SIGNIFICANT ANOVA
		n=10	n=7	n=93	
ASTRAND-RHYMING TEST VARIABLES					
VARIABLE	UNITS				
FINAL WORKLOAD SETTING	KPM/MIN.	131.00 +/- 21.22	154.86 +/- 39.94	164.27 +/- 38.52	‡
AVERAGE HEART RATE	BPM	144.00 +/- 11.66	141.71 +/- 6.87	148.06 +/- 8.18	
VO2	ML./MIN.	3150.00 +/- 600.00	3628.57 +/- 901.78	3639.78 +/- 900.36	
AGE CORRECTED VO2	ML./MIN.	2597.00 +/- 589.77	3058.71 +/- 724.37	3207.62 +/- 885.89	
VO2 PER KG	ML./KG./MIN	30.86 +/- 7.53	38.38 +/- 10.73	40.85 +/- 11.81	‡
BLOOD ANALYSIS VARIABLES					
VARIABLE	UNITS				
HEMOGLOBIN	GM./DL.	15.38 +/- 1.28	15.56 +/- 1.04	15.14 +/- 0.95	
HEMATOCRIT	%	45.60 +/- 3.98	45.57 +/- 2.51	44.42 +/- 2.48	
HAPTOGLOBIN	MG./DL.	175.50 +/- 78.97	100.14 +/- 57.72	138.01 +/- 75.44	
TESTOSTERONE	NG./DL.	550.30 +/- 217.88	610.57 +/- 195.11	562.62 +/- 152.71	
ESTROGEN	PG./ML.	64.00 +/- 30.14	63.86 +/- 19.28	62.86 +/- 24.82	
SOMATIC BODY TYPE VARIABLES					
VARIABLE	UNITS				
+ ENDOMORPHY		5.80 +/- 1.34	4.86 +/- 1.60	4.78 +/- 1.52	
+ MESOMORHPY		4.95 +/- 0.98	4.57 +/- 1.72	4.37 +/- 1.23	
+ ECTOMORPHY		1.05 +/- 0.93	2.21 +/- 1.32	1.90 +/- 1.14	
HYDROSTATIC WEIGHING VARIABLES					
VARIABLE	UNITS				
PERCENTAGE BODY FAT	%	26.09 +/- 6.35	19.24 +/- 6.33	20.23 +/- 6.95	‡
WEIGHT OF BODY FAT	KG.	23.04 +/- 7.83	15.98 +/- 6.75	16.55 +/- 7.44	‡
FAT-FREE MASS	KG.	63.54 +/- 8.88	65.94 +/- 9.45	62.98 +/- 7.91	
BODY DENSITY	GM./CC.	1.0399 +/- 0.0140	1.0551 +/- 0.0143	1.0529 +/- 0.0156	‡
RESIDUAL VOLUME	L.	1.47 +/- 0.41	1.47 +/- 0.27	1.35 +/- 0.30	
SIT AND REACH TEST VARIABLES - SPINAL FLEXIBILITY					
VARIABLE	UNITS				
MAXIMUM OF THREE TRIALS	CM.	7.40 +/- 8.31	5.57 +/- 8.85	7.71 +/- 9.33	

‡ - signifies a significant one-way ANOVA across groups
+ - ratings of each somatotype theoretically begin at zero and have no arbitrary endpoint

TABLE 11.

DUNCAN'S MULTIPLE RANGE TEST FOR PROPELLANT TRANSFER SCAPE WORKERS, FLIGHT SERVICING SCAPE WORKERS, AND NON-PROPELLANT WORKERS

	PROPELLANT TRANSFER SCAPE WORKERS	FLIGHT SERVICING SCAPE WORKERS	NON-PROPELLANT WORKERS
CIRCUMFERENCES			
WAIST	A	B	B
SKINFOLDS			
SUBSCAPULAR	A	AB	B
CHEST	A	B	B
MID-AXILLARY LINE	A	B	B
CYBEX - KNEE			
TORQUE - 180 DEG./SEC. - 3 REPS			
FLEXION PEAK/BODY WT. RATIO	B	A	A
WORK AND ENDURANCE - FLEXION - 15 REPS			
PEAK TOTAL ACCELERATED ENERGY	B	A	A
ASTRAND-RHYMING TEST VARIABLES			
FINAL WORKLOAD SETTING	B	AB	A
VO2 PER KG	A	A	A
HYDROSTATIC WEIGHING VARIABLES			
PERCENTAGE BODY FAT	A	B	B
WEIGHT OF BODY FAT	A	B	B
BODY DENSITY	B	A	A

-- Groups with different letters for a variable differ significantly for that variable.

FIGURE 1. PHOTOGRAPH OF SELF-CONTAINED ATMOSPHERIC PROTECTIVE ENSEMBLE (SCAPE); FRONT VIEW

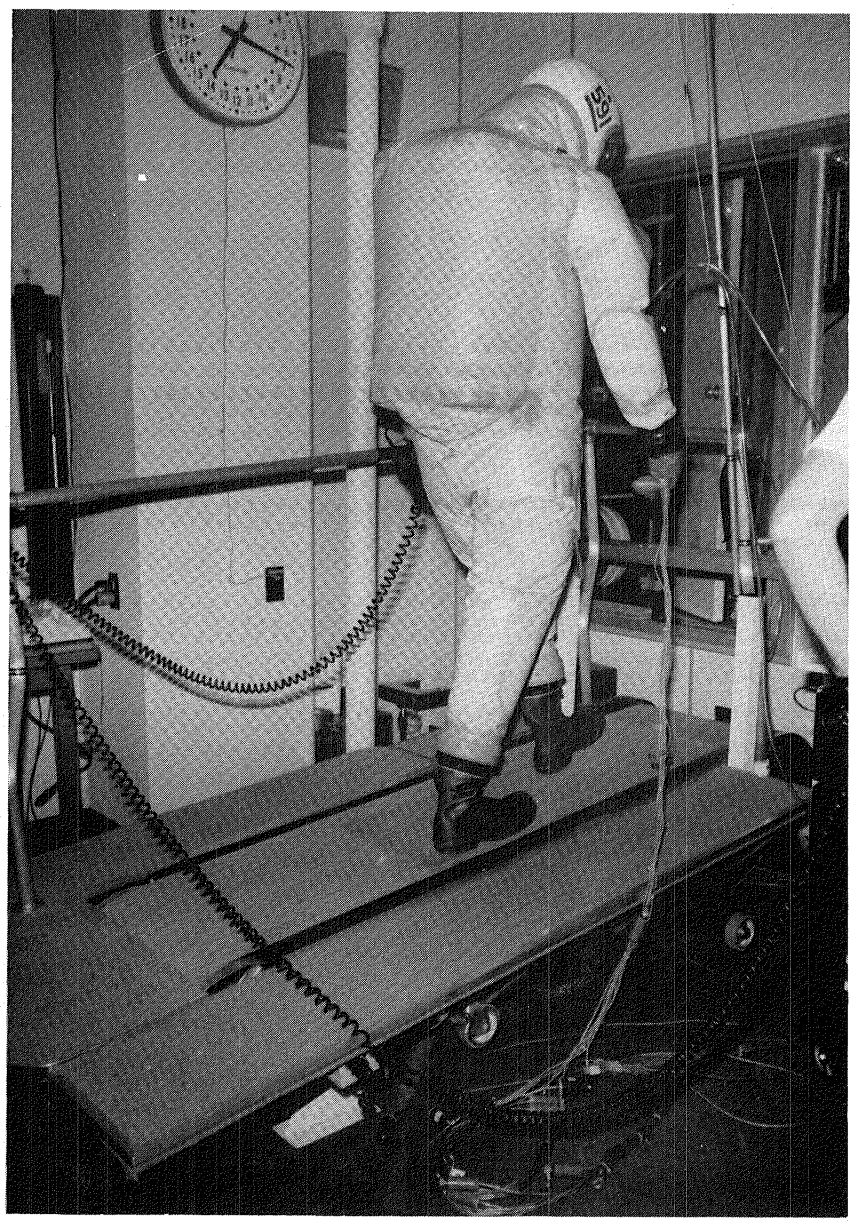

FIGURE 2. PHOTOGRAPH OF SELF-CONTAINED ATMOSPHERIC PROTECTIVE ENSEMBLE (SCAPE) SHOWING AIR PACK ON BACK

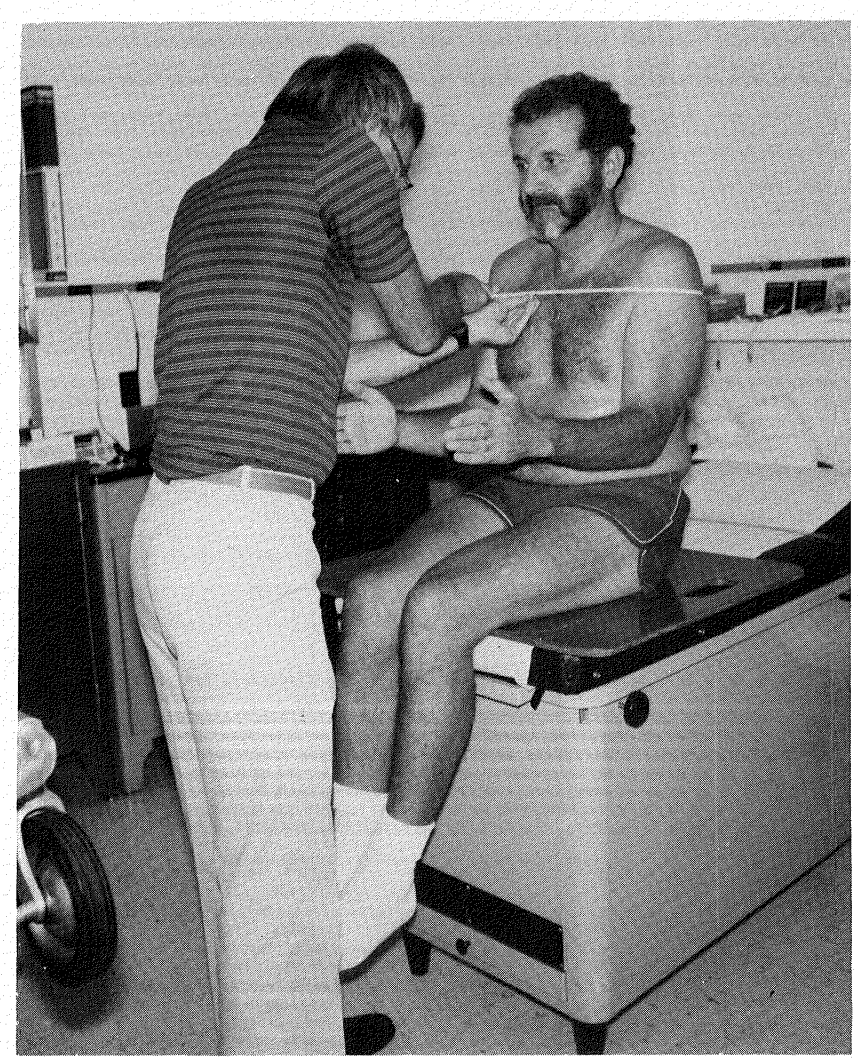

FIGURE 3. PHOTOGRAPH OF
ANTHROPOMETICAL MEASUREMENT;
SHOULDER CIRCUMFERENCE

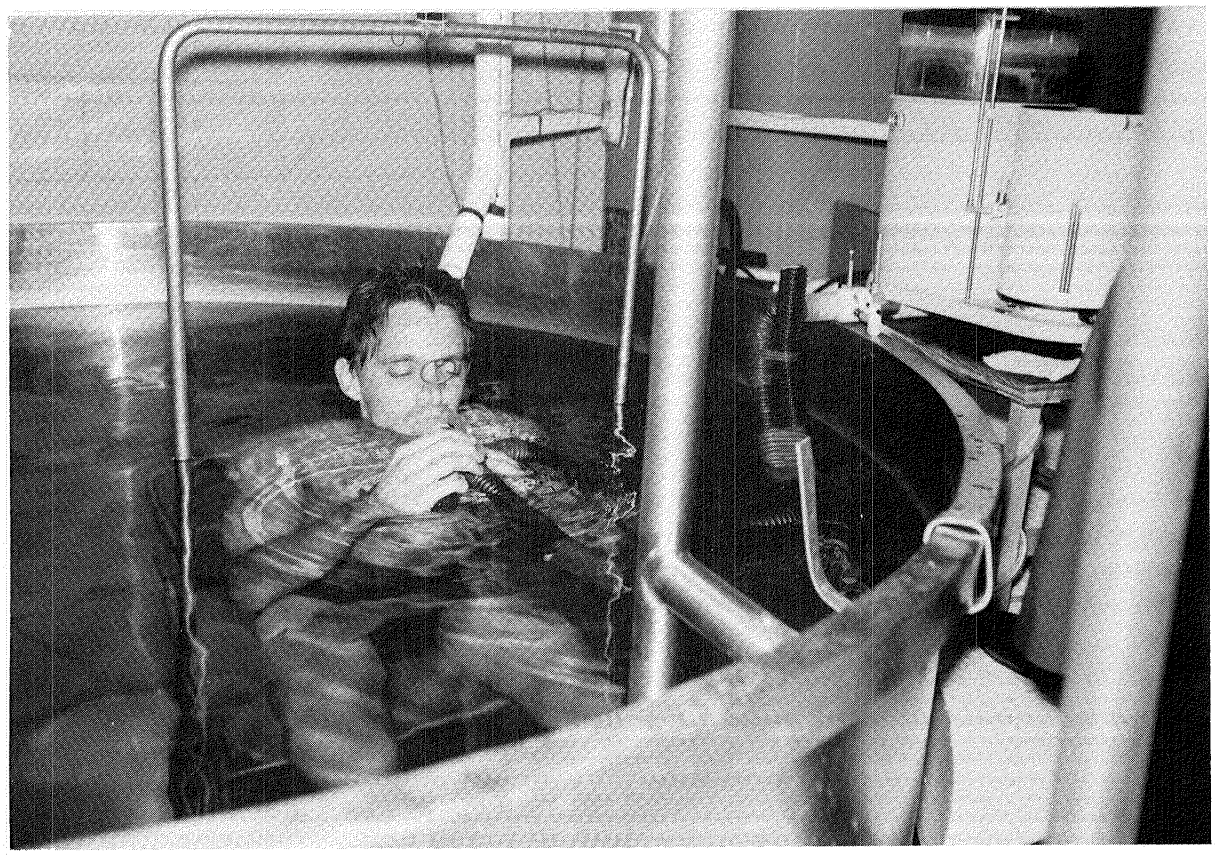

FIGURE 4. PHOTOGRAPH OF
HYDROSTATIC WEIGHING FOR
DETERMINING PERCENT BODY FAT

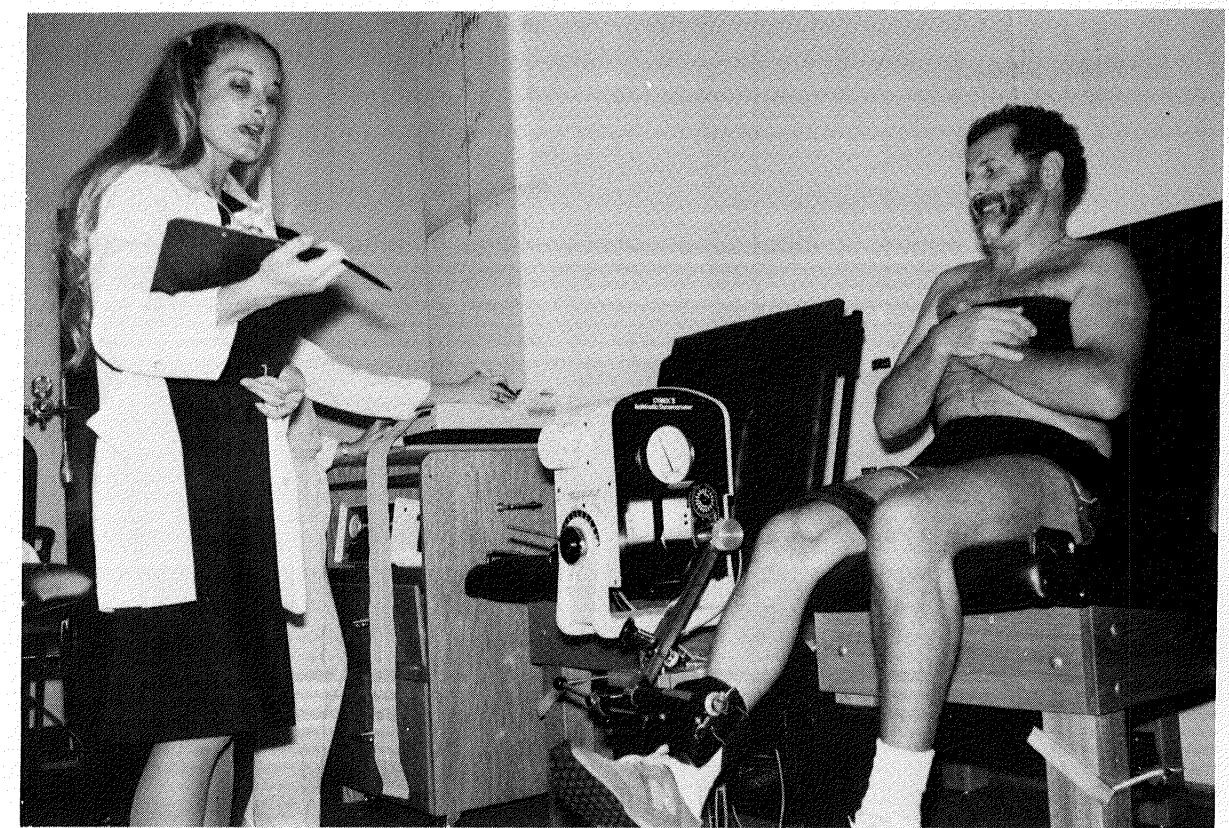

FIGURE 5. PHOTOGRAPH OF KNEE STRENGTH, POWER AND ENDURANCE TESTING USING THE CYBEX II ISOKINETIC SYSTEM

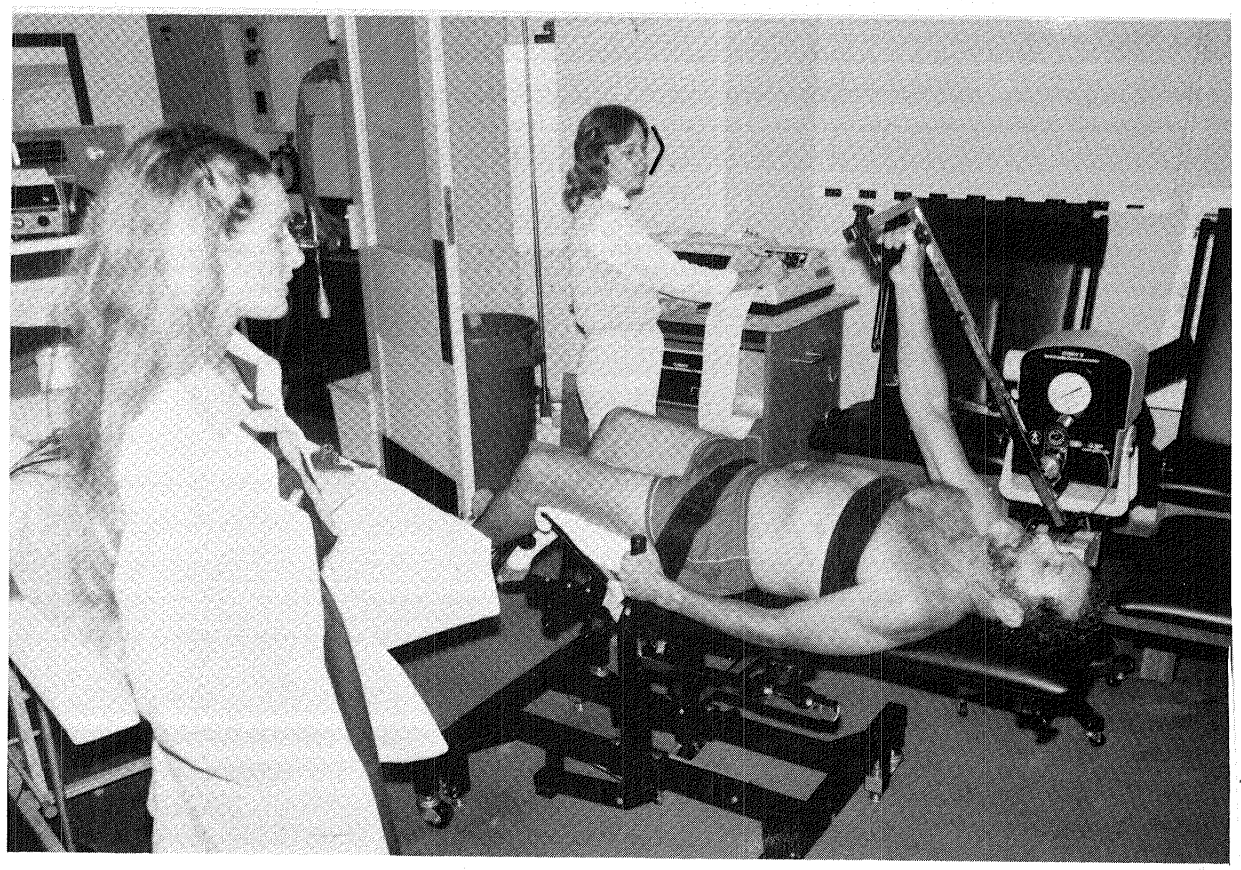

FIGURE 6. PHOTOGRAPH OF SHOULDER STRENGTH, POWER AND ENDURANCE TESTING USING THE CYBEX II ISOKINETIC UPPER BODY EXERCISE TESTING TABLE

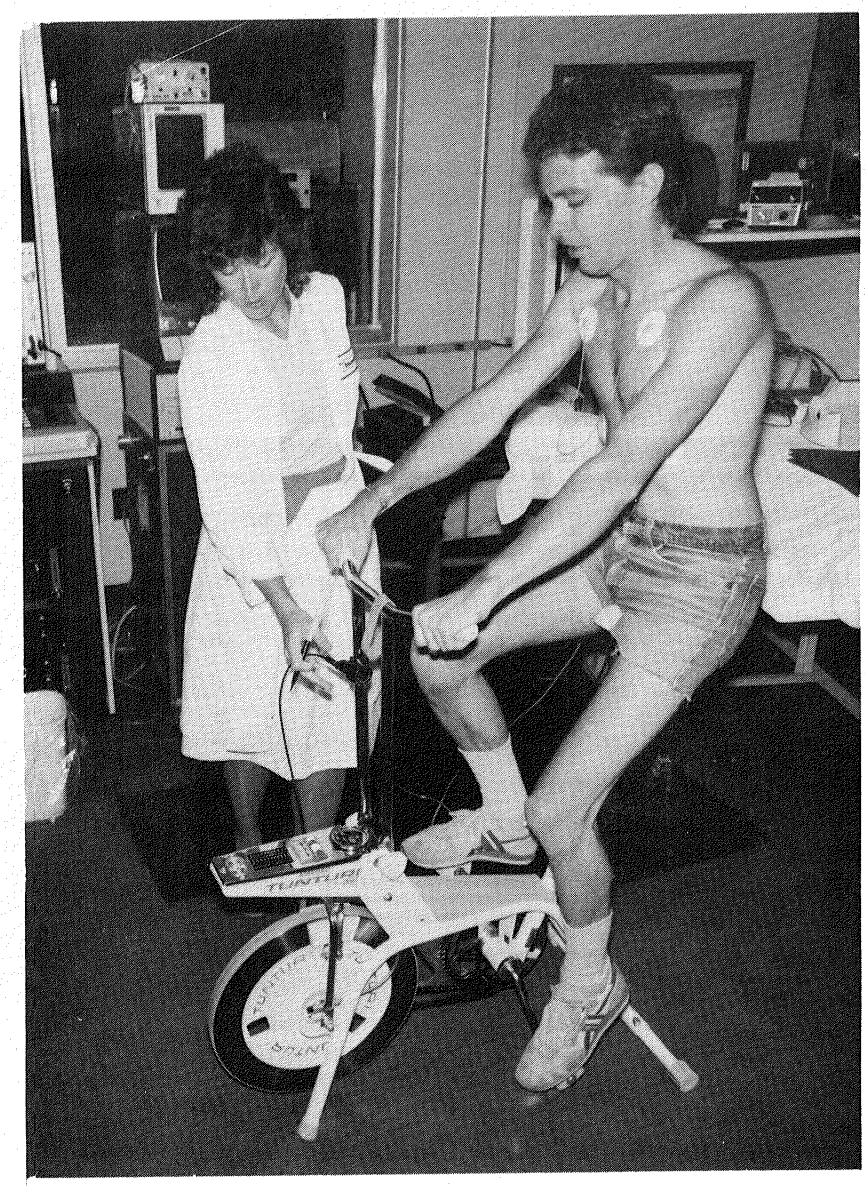

FIGURE 7. PHOTOGRAPH OF THE ASTRAND-RHYMING BICYCLE ERGOMETER SUBMAXIMAL WORK TEST

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15. Abstract INTRODUCTION. Employees working in Self-Contained Atmospheric Protective Ensembles (SCAPE) are exposed to physical hazards such as thermal stress, suit weight, and limited mobility. The purpose of this study was to compare physical traits of different types of SCAPE workers to each other and to other occupational groups at Kennedy Space Center. METHODS. Male workers (N=110), 22-58 yr, were evaluated for body composition using hydrostatic weighing, anthropometry, and somatotyping; maximal oxygen uptake ($\dot{V}O_2max$) predicted by the Astrand-Rhyming cycle ergometer submaximal work test; flexibility measured with the Sit and Reach test; muscular strength, power, and endurance about the knee and shoulder with a Cybex II system. Three different comparisons using ANOVA (α=.05) were made: 1) six different occupational groups; 2) Active SCAPE, Certified-for-SCAPE, and Non-SCAPE workers; and 3) Propellant Transfer SCAPE Workers, Flight Servicing SCAPE Workers, and other workers. RESULTS. 1) Few significant differences were found among the six occupational groups. 2) Active SCAPE, Certified-for-SCAPE and Non-SCAPE workers had few statistically significant differences; however, the data suggest a trend that Active SCAPE workers may be less physically fit than Certified-for-SCAPE or Non-SCAPE. 3) Propellant Transfer SCAPE Workers had significantly higher percent body fat and lower predicted $\dot{V}O_2max$ than Flight Servicing SCAPE Workers. CONCLUSION. These data provide a database for selection criteria of SCAPE workers. The current group of Propellant Transfer SCAPE Workers may be less capable than Flight Servicing SCAPE Workers of performing tasks that require high aerobic capacity.

16. Key Words Self Contained Atmospheric Protective Ensemble (SCAPE), Propellant Transfer SCAPE Workers, Flight Servicing SCAPE Workers, skinfold thickness, circumferences, breadth, age, height, weight, somatotype, percent body fat, lean body mass, body density, strength, power, endurance, flexibility, aerobic capacity.

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