TECHNICAL REPORT
NATICK/TR-93/026

AD_____

THE ENVIRONMENTAL SYMPTOMS QUESTIONNAIRE (ESQ): DEVELOPMENT AND APPLICATION

By
James B. Sampson
John L. Kobrick*
Richard F. Johnson*

*U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

March 1993

FINAL REPORT
September 1990 to June 1992

Approved for Public Release; Distribution Unlimited

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

SOLDIER SCIENCE DIRECTORATE

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	MARCH 1993	Final Sep 90 to Jun 92

4. TITLE AND SUBTITLE

The Environmental Symptoms Questionnaire (ESQ): Development and Application

5. FUNDING NUMBERS

AGG CODE
T/81363

WU:1L162786-
AH96AAJ00

6. AUTHOR(S)

James B. Sampson, John L. Kobrick* and Richard F. Johnson*

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

US Army Natick RD&E Center
SATNC-YBH
Natick, MA 01760-5020

8. PERFORMING ORGANIZATION REPORT NUMBER

NATICK/TR-93/026

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

* US Army Research Institute of Environmental Medicine
SGRD-Z
Natick, MA 01760-5007

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Environmental Symptoms Questionnaire (ESQ) was developed to help researchers quantify symptoms experienced by individuals exposed to extreme conditions. The ESQ has evolved into a general symptoms questionnaire from earlier designs for capturing the symptoms of acute mountain sickness. Items have been added, removed and revised, and scale changes were made for greater reliability and ease of administration and completion. Factor analysis revealed significant symptom clusters and weights for scoring the ESQ. Discussion is given to these developments and to the application to a number of environmental studies. Recommendations are offered for its administration and scoring using either factor weights or nonfactored clusters.

14. SUBJECT TERMS

ENVIRONMENTAL SURVEYS	EXTREME ENVIRONMENTAL CONDITIONS	HEAT
EXTREME TEMPERATURES	QUESTIONNAIRES	COLD
ENVIRONMENTAL STUDIES	CLIMATIC CONDITIONS	ALTITUDE

15. NUMBER OF PAGES 27

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

TABLE OF CONTENTS

LIST OF FIGURE AND TABLES

LIST OF ABBREVIATIONS

ALERT	- Alert (Factor Score)
AMS	- Acute Mountain Sickness
AMS-C	- Acute Mountain Sickness, Cerebral (Factor Score)
AMS-R	- Acute Mountain Sickness, Respiratory (Factor Score)
BDU	- Battledress Uniform
CD	- Cold Discomfort Index (Appendix B)
COLD	- Cold (Factor Score)
CPD	- Cardiopulmonary Discomfort Index (Appendix B)
d	- day(s) (Table 2)
DISTRESS	- Distress (Factor Score)
ENT	- Ear, Nose and Throat (Factor Score)
ESQ	- Environmental Symptoms Questionnaire
EXERT	- Exertion (Factor Score)
FATIGUE	- Fatigue (Factor Score)
g	- grams (Table 2)
GHAQ	- General High Altitude Questionnaire
h	- hours (Table 2)
m	- meters altitude (Table 2)
MD	- Muscle Discomfort Index (Appendix B)
MOPP	- Mission-Oriented Protective Posture (0-4)
MUSCLE	- Muscle Discomfort (Factor Score)
^{o}C	- degrees Centigrade temperature (Table 2)
Ps	- Persons (Table 2)
RH	- Relative Humidity (percent) (Table 2)
SHI	- Subjective Heat Illness
T	- Tiredness Index (Appendix B)
USARIEM	- US Army Research Institute of Environmental Medicine
WB	- Well-Being Index (Appendix B)
%CO2	- percent carbon dioxide (Table 2)
%O2	- percent of oxygen (Table 2)

SUMMARY

The Environmental Symptoms Questionnaire (ESQ) was developed to help researchers quantify symptoms experienced by individuals exposed to extreme environmental conditions. The ESQ has evolved from earlier designs into a general symptoms questionnaire for capturing the symptoms of acute mountain sickness. Items have been added, removed and revised, and scale changes were made for greater reliability and ease of administration and completion. Factor analysis revealed significant symptom clusters and weights for scoring the ESQ. Discussion is given to these developments and the application to a number of environmental studies. Recommendations are offered for its administration and scoring using either factor weights or nonfactored clusters.

The Environmental Symptoms Questionnaire (ESQ): Development and Application

INTRODUCTION

Military forces have often suffered more from the extremes of climate than from enemy actions (8,20,21,26,37). Although extreme environmental conditions can have serious medical and psychological effects on military personnel, reliable measures of individual physiological and psychological reactions to climatic conditions have been difficult to obtain. Routine casualty reports and medical treatment records, although valuable sources of such information, are usually unreliable (47). Early studies involving personal records and reports have left us with mixed and sometimes confusing results (2,46). Major problems arise in the use of personal ratings and opinions because of the lack of careful design of subjective scales. Maintaining reliable measurement standards and controlling unwanted variability under field conditions are often very difficult. Consequently, there are few scientific studies of individual symptomatology during exposure to extreme climates. Thus, attempts to quantitatively measure environmentally-induced symptoms have been rare and, until relatively recently, almost nonexistent.

EVOLUTION OF THE ENVIRONMENTAL SYMPTOMS QUESTIONNAIRE

In a classic series of high altitude studies, McFarland (38,39) tried to quantify environmentally induced symptoms by using separate questionnaires for physiological symptoms and behavioral reactions. Unfortunately, the questionnaires were limited in scope and were never standardized for use by others. Since then, other attempts have been made to develop valid and reliable self-report questionnaires for measuring responses to environmental extremes.

A 1965 field study conducted by the US Army Research Institute of Environmental Medicine (USARIEM) attempted to document and quantify reactions to extended exposures to high terrestrial altitude and symptoms of acute mountain sickness (AMS) (19). The General High Altitude Questionnaire (GHAQ), developed and first described by Evans (10), was used in this study to assess altitude symptomatology. The results of the USARIEM study indicated that the GHAQ had been able to identify and quantify some of the commonly reported symptoms of altitude exposure. The GHAQ was used effectively in a number of studies on acute mountain sickness. Eventually, however, it became evident there were several shortcomings in the scale. Each item involved multiple phrases which made the questionnaire more difficult to respond to than necessary. In addition, only 7 of the 26 items dealt with suspected symptoms of altitude, and items relating to fatigue and mood states were over represented. There was also no standardized method for scoring results, leading investigators to score it in a variety of ways. Often they simply summed up all or part of the responses.

The disproportionate number of fatigue and mood items often led to false positive symptom scores at sea level. These characteristics, unfortunately, made it difficult to make comparisons across many of the studies of the same, or different, investigators and, more seriously, created the potential for experimenter bias.

In order to avoid the inherent deficiencies of the GHAQ and to broaden the scope of measured reactions at altitude, Sampson (44) designed the Environmental Symptoms Questionnaire (ESQ) while involved in altitude research at USARIEM. Descriptive phrases of all known symptoms reported at altitude were first collected through an extensive review of studies from high altitude expeditions going as far back as the year 1736 (2). The accumulated symptom phrases were then organized into related generic clusters representing the various dimensions of each symptom (e.g., headache: head pressure, head throbbing, etc.). Questionnaire items were then composed to reflect the derived symptom clusters. The resulting inventory, which shall be referred to as ESQ-I, consisted of 52 symptom phrases, each followed by a 9-point scale for estimating symptom intensity ranging from not-at-all to severe.

ESQ-I was first evaluated in a 4-day high altitude study comparing it to the GHAQ (31). Based on the results, three more items were added, and the response scale was reduced to a 6-point discrete scale (0-5) for easier use. After several studies, redundant items were progressively eliminated, and the inventory was broadened to include responses to heat and cold exposure and to reflect responses to certain military operational conditions (mainly protective clothing and the use of medications).

These changes culminated in the first revision of the questionnaire (ESQ-II), which was then evaluated by Sampson and Kobrick (45) in two separate field studies examining the effects of prolonged overseas flight on health and physical performance (52,55), and the effects of continued load-carrying over several days (56). Based on factor analysis of the data obtained, five principal symptom clusters were derived: 1) exertion, 2) fatigue, 3) headache-nausea, 4) eye, ear, nose, throat symptoms, and 5) wellness. Weighted scoring for symptom clusters was also developed, as well as standardized instructions and procedures for administration. Following the analysis of the ESQ-II, additional items covering altitude reactions and some symptoms of exercise stress were incorporated, and confusing items were re-worded.

These revisions resulted in the version currently in use today, the ESQ-III. It contains 67 items spanning a wider range of environmental reactions, as well as symptoms of heat exhaustion, dehydration, cold exposure, and the common cold. A factor analysis of data obtained using ESQ-III in several altitude studies involving a large test population was subsequently published by Sampson, et al (46), along with

detailed recommendations for administration and scoring. Nine meaningful and reliable factors were identified: 1) acute mountain sickness - cerebral (AMS-C), 2) acute mountain sickness - respiratory (AMS-R), 3) ear, nose, and throat symptoms (ENT), 4) cold stress, 5) distress, 6) alertness, 7) exertion, 8) muscle discomfort, and 9) fatigue. For the first time, acute mountain sickness and other symptom groups had standardized measurement procedures based on experimental data and objective quantitative analysis rather than the intuitively derived clusters of individual experimenters. Of particular interest was the finding of the two sickness clusters showing different temporal sequences at altitude. The factors and their weights are presented in Table 1.

The cerebral and respiratory "sickness" clusters are relatively independent dimensions. Factor ENT refers to ear, nose and throat symptoms, while the cold stress factor involves reactions to being cold. Distress is a complicated combination of both respiratory and psychological mood symptoms. Muscle discomfort reflects symptoms due to exercise, and fatigue includes feelings of weakness and tiredness. Detailed descriptions of the nine factors and criterion values for determining AMS, are presented in Sampson, et al. (46).

The alertness factor involves items both positively-weighted ("Feel good"; "Alert"), and negatively-weighted ("Couldn't sleep"; "Concentration off"; "Feel tired"). The factor weights originally published for alertness were found later to be incorrect; the alertness weights shown in Table 1, however, are the revised values published by Shukitt, Banderet, and Sampson (48) to correct those discrepancies. An alternate version of ESQ-III was developed by Johnson (22) to accommodate certain laboratory requirements by: 1) re-wording the items for the past tense; 2) changing Item 58 (from "I couldn't sleep well" to "I felt wide awake"); and 3) adding Item 68 ("I'm hungry"). This new form, ESQ-IV, has been used successfully in several studies of cold exposure, heat exposure, and the limitations of personal protective clothing and equipment (22,23,24,28,29). A facsimile of this past-tense ESQ is presented in Figure 1.

The ESQ now has been used by numerous investigators to assess symptomatic reactions to high altitude, heat, cold, fatigue, medications, dietary stress, upper respiratory infections, and military operational demands including special equipment and clothing. The questionnaire has been applied effectively in laboratory studies, field exercises, and mountaineering expeditions. The principal findings obtained with the ESQ during exposure to environmental extremes are summarized in Table 2.

TABLE 1

SUMMARY OF ESQ ITEM WEIGHTS AND FACTOR DIVISORS

FOR COMPUTING FACTOR SCORES

Cerebral AMS (AMS-C) [DIVISOR=5.189]		Respiratory AMS (AMS-R) [DIVISOR=7.138]		Ear-Nose-Throat (ENT) [DIVISOR=4.307]	
Feel sick	0.692	Hard to breathe	0.763	Ears ringing	0.784
Hungover	0.584	Short of breath	0.745	Can't hear	0.759
Coord. off	0.519	Stomachache	0.744	Sore throat	0.555
Vision dim	0.501	Hurts to breathe	0.734	Dry mouth	0.470
Lightheaded	0.489	Sick to stomach	0.691	Ears blocked	0.441
Headache	0.465	Backache	0.686	Skin itches/burns	0.367
Dizzy	0.446	Nose bleed	0.578	Nose stuffed up	0.329
Lost appetite	0.413	Nose stuffed	0.534	Sinus pressure	0.302
Feel weak	0.387	Stomach cramps	0.516	Ears ache	0.300
Sick to stomach	0.347	Depressed	0.480		
Feel faint	0.346	Couldn't sleep	0.355		
		Headache	0.312		

Cold stress (COLD) [DIVISOR=4.699]		Distress (DISTRESS) [DIVISOR=5.404]		Alertness (ALERT)* [DIVISOR=3.214]	
Feet cold	0.737	Chest pains	0.566	Feel good	0.787
Feel chilly	0.720	Feel irritable	0.546	Feel alert	0.783
Hands cold	0.642	Chest pressure	0.540	Couldn't sleep (R)*	0.379
Shivering	0.580	Feel restless	0.525	Concentration off(R)	0.351
Feel worried	0.520	Cough	0.523	Feel tired (R)	0.314
Urinate more	0.447	Bored	0.492	Feel sleepy (R)	0.300
Feel feverish	0.364	Depressed	0.479	Depressed (R)	0.300
Hands shaking	0.358	Feel worried	0.379		
Feel weak	0.331	Feel sick	0.373		
		Feel tired	0.348		
		Feel sleepy	0.318		
		Hurts to breathe	0.315		

Exertion (EXERT) [DIVISOR=3.377]		Muscle Discomfort (MUSCLE) [DIVISOR=3.466]		Fatigue (FATIGUE) [DIVISOR=4.958]	
Heart fast	0.573	Muscles tight	0.594	Feel tired	0.665
Heart pounding	0.505	Legs/feet ache	0.492	Feel sleepy	0.579
Chest pains	0.471	Hands/arms ache	0.406	Feel weak	0.492
Hard to breathe	0.419	Muscle cramps	0.402	Feel dizzy	0.418
Lightheaded	0.371	Thirsty	0.330	Feel faint	0.416
Feel weak	0.366	Gas pressure	0.317	Eyes irritated	0.398
Hurts to breathe	0.351	Feel numbness	0.315	Lightheaded	0.384
Short of breath	0.321	Feel weak	0.307	Thirsty	0.371
		Backache	0.303	Runny nose	0.319
				Concentration off	0.312
				Vision Blurry	0.304
				Couldn't Sleep	0.300

* Note: Items marked (R) for the ALERT factor should be reversed scored before multiplying the weight. Thus the S's response of 0 should be changed to 5, 1 to 4, 2 to 3, etc. before multiplication with item weights (see Shukitt, et al 1990 (48) for rationale).

Circle the number of each item to correspond to HOW YOU HAVE BEEN FEELING TODAY. PLEASE ANSWER EVERY ITEM. If you did not have the symptom, circle zero (NOT AT ALL).

	NOT AT ALL	SLIGHT	SOME-WHAT	MODER-ATE	QUITE A BIT	EXTREME
1. I FELT LIGHTHEADED.	0	1	2	3	4	5
2. I HAD A HEADACHE.	0	1	2	3	4	5
3. I FELT SINUS PRESSURE	0	1	2	3	4	5
4. I FELT DIZZY.	0	1	2	3	4	5
5. I FELT FAINT.	0	1	2	3	4	5
6. MY VISION WAS DIM	0	1	2	3	4	5
7. MY COORDINATION WAS OFF	0	1	2	3	4	5
8. I WAS SHORT OF BREATH	0	1	2	3	4	5
9. IT WAS HARD TO BREATHE.	0	1	2	3	4	5
10. IT HURT TO BREATHE.	0	1	2	3	4	5
11. MY HEART WAS BEATING FAST	0	1	2	3	4	5
12. MY HEART WAS POUNDING	0	1	2	3	4	5
13. I HAD A CHEST PAIN.	0	1	2	3	4	5
14. I HAD CHEST PRESSURE.	0	1	2	3	4	5
15. MY HANDS WERE SHAKING/TREMBLING .	0	1	2	3	4	5
16. I HAD A MUSCLE CRAMP.	0	1	2	3	4	5
17. I HAD STOMACH CRAMPS.	0	1	2	3	4	5
18. MY MUSCLES FELT TIGHT OR STIFF. .	0	1	2	3	4	5
19. I FELT WEAK	0	1	2	3	4	5
20. MY LEGS OR FEET ACHED	0	1	2	3	4	5
21. MY HANDS/ARMS/SHOULDERS ACHED . .	0	1	2	3	4	5
22. MY BACK ACHED	0	1	2	3	4	5
23. I HAD A STOMACHACHE	0	1	2	3	4	5
24. I FELT SICK TO MY STOMACH(NAUSEOUS)	0	1	2	3	4	5
25. I HAD GAS PRESSURE.	0	1	2	3	4	5
26. I HAD DIARRHEA.	0	1	2	3	4	5
27. I FELT CONSTIPATED.	0	1	2	3	4	5
28. I HAD TO URINATE MORE THAN USUAL.	0	1	2	3	4	5
29. I HAD TO URINATE LESS THAN USUAL.	0	1	2	3	4	5
30. I FELT WARM	0	1	2	3	4	5
31. I FELT FEVERISH	0	1	2	3	4	5
32. MY FEET WERE SWEATY	0	1	2	3	4	5
33. I WAS SWEATING ALL OVER	0	1	2	3	4	5
34. MY HANDS WERE COLD.	0	1	2	3	4	5
35. MY FEET WERE COLD	0	1	2	3	4	5
36. I FELT CHILLY	0	1	2	3	4	5
37. I WAS SHIVERING	0	1	2	3	4	5
38. PARTS OF MY BODY FELT NUMB. . . .	0	1	2	3	4	5
39. MY SKIN WAS BURNING OR ITCHY. . .	0	1	2	3	4	5
40. MY EYES FELT IRRITATED.	0	1	2	3	4	5
41. MY VISION WAS BLURRY.	0	1	2	3	4	5
42. MY EARS FELT BLOCKED UP	0	1	2	3	4	5
43. MY EARS ACHED	0	1	2	3	4	5

(Cont'd)

Fig. 1. Environmental Symptoms Questionnaire (ESQ-IV) Past Tense

44. I COULDN'T HEAR WELL.	0	1	2	3	4	5
45. MY EARS WERE RINGING.	0	1	2	3	4	5
46. MY NOSE FELT STUFFED UP	0	1	2	3	4	5
47. I HAD A RUNNY NOSE.	0	1	2	3	4	5
48. I HAD A NOSE BLEED.	0	1	2	3	4	5
49. MY MOUTH WAS DRY.	0	1	2	3	4	5
50. MY THROAT WAS SORE.	0	1	2	3	4	5
51. I WAS COUGHING.	0	1	2	3	4	5
52. I LOST MY APPETITE.	0	1	2	3	4	5
53. I FELT SICK	0	1	2	3	4	5
54. I FELT HUNGOVER	0	1	2	3	4	5
55. I WAS THIRSTY	0	1	2	3	4	5
56. I FELT TIRED.	0	1	2	3	4	5
57. I FELT SLEEPY	0	1	2	3	4	5
58. I FELT WIDE AWAKE (COULDN'T SLEEP)	0	1	2	3	4	5
59. MY CONCENTRATION WAS OFF.	0	1	2	3	4	5
60. I WAS MORE FORGETFUL THAN USUAL .	0	1	2	3	4	5
61. I FELT WORRIED OR NERVOUS	0	1	2	3	4	5
62. I FELT IRRITABLE.	0	1	2	3	4	5
63. I FELT RESTLESS	0	1	2	3	4	5
64. I WAS BORED	0	1	2	3	4	5
65. I FELT DEPRESSED.	0	1	2	3	4	5
66. I FELT ALERT.	0	1	2	3	4	5
67. I FELT GOOD	0	1	2	3	4	5
68. I WAS HUNGRY.	0	1	2	3	4	5

Fig. 1. Environmental Symptoms Questionnaire (ESQ-IV) Past Tense (Cont'd)

TABLE 2
Summary of ESQ Findings of Symptomatology
for Varieties of Environmental Exposure

Symptomatic Reactions to Altitude

Author(s)/Date	ESQ Form	Study Conditions	Findings
Banderet & Lieberman (1989) (1)*	III	23 Ps; 4200m and 4700m/15°C/4.5h/ tyrosine/placebo. Hypobaric chamber	Tyrosine reduced headache, coldness, distress, fatigue, muscle discomfort, sleepiness; ESQ factors not used.
Brown (1989) (3)	I	22 Ps; 4800m/5-day shifts. Mountain observatory	Used totaled ratings on ESQ-I items; AMS symptoms infrequent and not severe.
Burse, et al. (1987) (6)	I	12 Ps; 4300m/7d and 18d in 2 studies. Mountain lab.	Higher AMS symptoms in both studies based on selected ESQ-I items;
Burse & Forte (1988) (7)	III	12 Ps; 12.8%O2/8h by respirator; then test at 4500m/2d. Hypobaric chamber	No sig. diff. in AMS-C or AMS-R from placebo at 4500m.
Ellsworth, et al.(1987) (9)	III; GHAQ	47 Ps; 4392m/35h; acetazolamide, dexamethasone and placebo. Mountain climb	Least symptoms with dex; selected ESQ-III items showed AMS, but standard ESQ-III and factor scoring was not used.
Fletcher, et al. (1985) (11)	II	33 Ps; 3 mountain climbs.	Modified ESQ-II; AMS symptoms corresponded to clinical interviews and peer reviews.
Friedl, et al. (1988) (12)	III	9 Ps acetazolamide; 7 Ps placebo;1830m and 3050m/1d each. Mountain climb	No diff. in AMS symptoms between drug and placebo.
Fujimoto, et al.(1989) (13)	III	10 Ps; 2920m/4d. Mountain climb	AMS-C scores higher in AM following irregular sleep patterns.
Fulco, et al. (1989) (15)	III	12 Ps; 4300m/19d; propranolol-placebo. Mountain lab	AMS-C higher for drug & placebo; AMS-R higher only for placebo.
Hackett, et al.(1988) (17)	III	7 Ps dexamethasone, 8 Ps placebo; 4400m/12h. Mountain lab	AMS-C and AMS-R both sig. higher under drug than placebo; corresponded to clinical ratings.
Hamilton, et al. (1991) (18)	III	14 Ps; 4600m/30h. Hypobaric chamber	Impaired motor function; AMS-C increases in 2 hrs exposure.

TABLE 2 (CONT.)
Summary of ESQ Findings of Symptomatology
for Varieties of Environmental Exposure

Symptomatic Reactions to Altitude (cont.)

Author(s)/Date	ESQ Form	Study Conditions	Findings
Johnson, et al. (1984) (25)	III	8 Ps; 4570m/42h; dexamethasone. Hypobaric chamber	AMS-C & AMS-R lower under drug; corresponded to clinical interviews.
Knight, et al. (1990) (27)	III	12 Ps; 13% and 17% O2 with 0.9% CO2; 21% O2/63h each. Hypobaric chamber	AMS-C and AMS-R changes at 17% and 13% O2.
Kobrick & Sampson (1979) (31)	I	12 Ps; 4300m/4d; both ESQ-I & GHAQ used. Mountain lab	First field test of ESQ-1; reflected more AMS symptoms than GHAQ.
Kramar, et al. (1983) (33)	I	7 female Ps; 3050,4250,5000,5500m. Mountain climb	AMS at all test altitudes; headache most prominent.
Larsen, et al. (1986) (34)	III	9 Ps; 4570m/46h; spironolactone and placebo. Hypobaric chamber	AMS-C and AMS-R lower under drug than placebo.
Maresh, et al. (1985) (36)	II	9 high-alt. & 7 low-alt. Ps; 4270m/2d High & low resident altitudes. Hypobaric chamber	More AMS symptoms at 4270m in low-alt. Ps than in high-alt. Ps. Factor scores not used.
Maresh, et al. (1983) (35)	II	6 low-alt. & 8 mod.-alt. Ps; 4270m/2d High & low resident altitudes. Hypobaric chamber	More headache and breathing problems in low-alt. Ps. Factor scores not used.
Meehan, et al. (1986) (40)	III	11 Ps; 4570m/34h; naproxen & placebo. Hypobaric chamber	No diff. in AMS symptoms under drug & placebo; factor scores not used.
Regard, et al. (1991) (41)	III	17 Ps; 4559m/17h. Mountain climb	9 factors compared to clinical interview; low ESQ scores correlated with high interview scores.
Roach, et al. (1983) (42)	I	45 Ps; 3353m, 4392m; antacid-placebo. Mountain climb	Modified ESQ-1; no diff. in AMS symptoms on drug vs. placebo.
Rock, et al. (1989) (43)	III	28 Ps; 4570m/45h; dexamethasone-placebo. Mountain lab	AMS-C and AMS-R lower under drug than placebo.
Sampson, et al. (1983) (46)	III	Review of use of ESQ in studying AMS.	Provides factor weights for AMS-C & AMS-R.

TABLE 2 (CONT.)
Summary of ESQ Findings of Symptomatology
for Varieties of Environmental Exposure

Symptomatic Reactions to Altitude (cont.)

Author(s)/Date	ESQ Form	Study Conditions	Findings
Shukitt-Hale, et al.(1991) (49)	III	20 Ps; 4700m/7h. Hypobaric chamber	Moderate relationship of AMS-C to mood and performance measures.
White (1984) (51)	II	11 Ps; 3600m/36h; acetazolamide. Mountain climb	ESQ reflected AMS; fewer symptoms with acetazolamide.
Wright, et al. (1983) (53)	II	20 Ps; 4985m/3d; methazolamide, acetazolamide. Mountain climb	Modified ESQ showed AMS lower but not different under both drugs.
Wright, et al. (1985) (54)	II	20 Ps; 4980m/5d, 914m/4d; acetazolamide; methazolamide Mountain climb.	ESQ items modified; scoring unexplained; results cannot be interpreted based on published report.
Young, et al. (1980) (56)	II	10 Ps; 4572m/2d, study of muscle strength. Hypobaric chamber	Selected ESQ items; standard scoring not used; headache, nausea, insomnia, weakness most prominent symptoms.
Zell & Goodman (1988) (57)	III	32 Ps; 3650m and 4050m/1d each; acetazolamide, dexamethasone, placebo. Mountain climb	Least AMS for drugs combined; AMS-C and AMS-R both showed high symptom incidence but low severity.
		Symptomatic Reactions to Heat	
Johnson & Merullo (In press) (24)	IV	17 Ps; 10d at 41°C/20%RH for 8h each test; 4g vs. 8g dietary salt intake daily. Chamber study	ESQ-derived index of subjective heat illness (SHI) was higher during initial stages of heat acclimation; SHI showed more heat illness for Ps on 4g dietary salt.
Kobrick, et al. (1990,1989) (29,30)	IV	15 Ps-BDU-21.1°C/30%RH; 35°C/60%RH; 8 Ps-MOPP-IV-V 12.75°C/30%RH; 35°C/60%RH; atropine/2-PAM, placebo/6h each test. Chamber study	ESQ showed more heat than drug reactions; much greater in MOPP-I than in BDU.
Szlyk, et al. (1989) (50)	III	15 Ps; 21.7°C WBGT/6h, walk 4.02km/h; BDU & MOPP-IV. Chamber study	ESQ showed increased heat reactions under MOPP-IV than BDU.

TABLE 2 (CONT.)
Summary of ESQ Findings of Symptomatology
for Varieties of Environmental Exposure

Symptomatic Reactions to Cold

Author(s)/Date	ESQ Form	Study Conditions	Findings
Banderet & Lieberman (1989) (1)	III	23 Ps; 15°C/4200m; 15°C/4700m; tyrosine & placebo. Hypobaric chamber	ESQ reflected fewer and reduced symptoms under drug than placebo.
Johnson, et al. (1989) (23)	IV	59 Ps; -18° to 0°C/3d. Field study	ESQ-derived indices of tiredness, wellness, and discomfort due to cold, and muscle aches correlated with stress and expectations about the exercise; training prevented cold injury.

*Denotes reference numbers

DISCUSSION OF RELEVANT ISSUES

Reliability and Validity

The ESQ has shown remarkable reliability in documenting the salient symptoms of AMS as well as heat and cold reactions, although data for the latter are more limited than for altitude. It has consistently shown the same incidence of symptoms across a variety of altitude exposure situations ranging from mountaineering expeditions to hypobaric chamber studies. It has also delivered consistent results despite variations in form of administration; i.e., page and card format, change of tense of the statements, conversion to computer administration, and modification for language differences. It has even maintained measurement consistency with abbreviated forms using only selected items, rather than the entire inventory. Thus, it would appear that the ESQ robustly measures symptoms most frequently related to a wide variety of environmental conditions.

The ESQ has maintained a consistent logical correspondence to medical and physiological measures, physician ratings, and clinical interview data whenever both types of information were obtained during altitude exposure. Furthermore, factor analysis has demonstrated clear, unambiguous clusterings that reflect the multidimensional aspects of a number of important symptoms. These results suggest that the ESQ reflects true subjective reactions rather than artifacts of measurement or influences of the testing situation.

Administration Procedures

The reliability and validity of the ESQ are largely dependent on the care and attention given to how it is administered. The same time and effort given to measurement of physical or physiological parameters should also be given to administering subjective measures like the ESQ. The volunteer subject should be told of the importance of carefully reading and completing the questionnaire. The investigator should review each questionnaire soon after completion and be prepared to give immediate feedback to each subject. Subjects should be made aware that the questionnaire is carefully reviewed by the research team and that proper completion is very important to the study. Providing routine feedback helps maintain the motivation of volunteers to conscientiously complete the questionnaire repeatedly throughout a study. If some responses seem inconsistent, the subject should be asked to double check their responses for accuracy. This should always be done in a friendly, nonaccusatory manner.

Scoring Procedures

The principal objective for developing the ESQ was to establish standardized measurement and scoring procedures for assessing symptomatology of exposure to high altitude and, later, a number of other environmental conditions. In the process of factor analyzing ESQs administered under a variety of conditions at sea level and altitude, a number of symptom groups, relevant to environmental research, have been indentified. Standard weighted measures are now available for two identified states of "sickness" (cerebral and respiratory), ear-nose-throat discomfort, cold stress, exertion stress, muscle discomfort, fatigue, and states of alertness. Each subject's completed questionnaire (ESQ III or IV) can now be scored on these factors to give a more reliable, independent measure of these subjective states. These scores are computed by multiplying the individual's responses to each item on the questionnaire by the item's factor weight (Table 1), summing the products within the symptom-factor group and dividing by the divisor (also Table 1) for each factor. By computing factor-weighted scores, the researcher has more reliable measures that allow comparison of results across any study using these same measures. Exact computations for each factor are given in Appendix A.

An alternative general method of scoring factor scores without using weights (22,23,24,29) is presented in Appendix B. A factor for Heat Stress, not derived from factor analysis using this method, is also presented in Appendix B.

Although the ESQ has been used in page and card format as well as administered via computer terminals with reasonable success, potential problems of interpretation occur in cases where only subsets of the total available items are used. While meaningful results can be obtained using only selected items, differences in context between being administered a subset

compared to the entire inventory may potentially influence the ratings of respondents. Furthermore, there is added value of having many nonrelated items being surveyed during a study. Many of the "extra" symptoms on the questionnaire, not related to the environmental conditions under study, allow the investigator to identify potentially confounding variables. For example, high scores on the ENT measure might indicate a subject has an upper respiratory infection that might be the source of the symptom scores rather than the environmental conditions. Investigators are, therefore, urged to use the entire inventory whenever possible.

Recommendations for Future Development and Application

A data base of raw scores collected under conditions of heat and a variety of nutritional states are still needed to derive standard factor analytic scores for heat stress and various dietary related symptoms. Until such analyses are conducted, scoring procedures may involve grouping intuitively-relevant symptoms and averaging the scores without weighting individual items, as has been done by Johnson et al. (23). Factor analysis should be applied to new data bases, when sufficiently large, to verify the reliability of factors thus far identified. However, unless dramatic and significant differences in clusters and weights are obtained, there should be no attempt to alter the scoring procedures outlined here. The value of standardized measures used across studies over time will far outweigh any minor improvement in factor structure resulting from new analyses.

The ESQ has been found to be an effective tool for investigating the subjective symptomatology of individuals exposed to a wide variety of extreme conditions. With continued conscientious application, the questionnaire will enable researchers to compile the data necessary to better understand environmental effects on humans under stress. And finally, as the results accumulate, the ESQ should also allow us to more fully explore the multidimensional nature of symptoms in and of themselves.

REFERENCES

1. Banderet LE, Lieberman HR. Treatment with tyrosine, a neurotransmitter precursor, reduces environmental stress in humans. Brain Res. Bull. 1989; 22:759-62.

2. Bert, P. La Pression Barometrique: Recherches de physiologie experimentale. 1878. Translated by M.A. Hitchcock and F.A. Hitchcock. Barometric Pressure. Columbus, OH: College Book Co.; 1943.

3. Brown, D. Acute mountain sickness and physiological stress during intermittent exposure to high altitude. Annals Human Bio. 1989; 16(1):15-23.

4. Bunnell DE, Horvath SM. Interactive effects of physical work and carbon monoxide on cognitive task performance. Aviat. Space Environ. Med. 1988; 59:1133-8.

5. Bunnell DE, Horvath SM. Interactive effects of heat, physical work, and CO exposure on metabolism and cognitive task performance. Aviat. Space Environ. Med. 1989; 60:428-32.

6. Burse RL, Cymerman A, Young AJ. Respiratory response and muscle function during isometric handgrip exercise at altitude. Aviat. Space Environ. Med. 1987; 58:39-46.

7. Burse RL, Forte VA. Acute mountain sickness at 4500m is not altered by repeated eight-hour exposures to 3200-3550m normobaric hypoxic equivalent. Aviat. Space Environ. Med. 1988; 59:942-9.

8. Caulaincourt, A. With Napolean in Russia (Translated by G. Libaire) Wm Morrow and Co., New York, 1955.

9. Ellsworth AJ, Larson EB, and Strickland D. A randomized trial of dexamthasone and acetazolamide for acute mountain sickness prophylaxis. Am. J. Med. 1987; 83:1024-30.

10. Evans WO. Measurements of subjective symptomatology of acute high altitude sickness. Psych. Rep. 1966; 19:815-20.

11. Fletcher RF, Wright AD, Jones GT, Bradwell AR. The clinical assessment of acute mountain sickness. Quart. J. Med. 1985; 54(213):91-100.

12. Friedl KE, Plymate SR, Bernhard WN, Mohr LC. Elevation of plasma estradiol in healthy men during a mountaineering expedition. Horm. Metabol. Res. 1988; 20:239-42.

13. Fujimoto K, Matsuzawa Y, Hirai K, Yagi H, Fukushima M, Shibamoto T, Koyama S, Levine BD, Kobayashi T. Irregular nocturnal breathing patterns at high altitude in subjects susceptable to high-altitude pulmonary edema (HAPE): A preliminary study. Aviat. Space Environ. Med. 1989; 60:786-91.

14. Fulco CS, Cymerman A, Rock PB. A software package for administering and monitoring the Environmental Symptoms Questionnaire (ESQ-III). Aviat. Space Environ. Med. 1985; 56:57-61.

15. Fulco CS, Rock PB, Reeves JT, Trad LA, Young PM, Cymerman A. Effects of propranolol on acute mountain sickness (AMS) and well-being at 4,300 meters of altitude. Aviat. Space Environ. Med. 1989; 60:679-83.

16. Hackett PH, Rennie D. Acute mountain sickness. Seminars in Resp. Med. 1983; 5(2):132-140.

17. Hackett PH, Roach RC, Wood RA, Foutch RG, Meehan RT, Rennie D, Mills WJ. Dexamethasone for prevention and treatment of acute mountain sickness. Aviat. Space Environ. Med. 1988; 59:950-4.

18. Hamilton, AJ, Trad LA, Cymerman A. Alterations in human upper extremity motor function during acute exposure to simulated altitude. Aviat. Space Environ. Med. 1991; 62:759-64.

19. Hansen JE, Harris CW, Evans WO. Influence of elevation of origin, rate of ascent and a physical conditioning program on symptoms of acute mountain sickness. Mil. Med. 1967; 132: 585-92.

20. Holmes, R., Acts of War: The Behavior of Men in Battle. The Free Press, MacMillan, New York, 1985.

21. Ivanichek, F. Prevention and treatment of frostbite in mountain medicine, warfare. In E. Viereck (Ed) Proceedings Symposium on Arctic Medicine and Biology: IV Frostbite. Fort Wainwright, Alaska, Arctic Aeomedical Lab., 1964.

22. Johnson RF. The soldier's subjective response to heat stress while working in microclimate controlled clothing. Paper presented at Human Factors Society Annual Meeting, 1984, San Antonio, Texas.

23. Johnson RF, Branch LG, McMenemy DJ. Influence of attitude and expectation on moods and symptoms during cold weather military training. Aviat. Space Environ. Med. 1989; 60:1157-62.

24. Johnson RF, Merullo DJ. Reevaluation of sodium requirements for work in the heat: subjective reports of heat illness. In Nutrition for Work in Hot Environments. Washington, D.C.: National Academy of Sciences, in press.

25. Johnson TS, Rock PB, Fulco CS, Trad LA, Spark, Maher JT. Prevention of acute mountain sickness by dexamethasone. N. Engl. J. Med. 1984; 310:683-86.

26. Joy RJT., Goldman RE., Microenvironments, modern equipment and the mobility of the soldier. In Symposium and Medical Aspects of Stress in the Military Climate, 22-24 April 1964, Walter Reed Army Institute of Research, Washington DC.

27. Knight DR, Cymerman A, Devine JA, Burse RL, Fulco CS, Rock PB, Tappan DV, Messier AA, Carhart H. Symptomatology during hypoxic exposure to flame-retardant chamber atmospheres. Undersea Biomed. Res. 1990; 17(1):33-44.

28. Kobrick JL. Behavioral responses to altitude stress. Paper presented at Human Factors Society Annual Meeting, 1984, San Antonio, Texas.

29. Kobrick, Johnson and McMenemy, Effects of nerve agent antidote and heat exposure on soldier performance in the BDU and MOPP-IV ensembles. Mil. Med. 1990, 155:159-162.

30. Kobrick J, Johnson RF, McMenemy DJ. Nerve agent antidotes and heat exposure: Summary of effects on task performance of soldiers wearing BDU and MOPP-IV clothing systems. Tech. Rep. No. T1-89. US Army Research Institute of Environmental Medicine, Natick, MA. 1989

31. Kobrick JL, Sampson JB. New inventory for the assessment of symptom occurrence and severity at high altitude. Aviat. Space Environ. Med. 1979; 50:925-9.

32. Knight DR, Cymerman A, Devine JA, Burse RL, Fulco CS, Rock PB, Tappan DV, Messier AA, Carhart H. Symptomatology during hypoxic exposure to flame-retardant chamber atmospheres. Undersea Biomed. Res. 1990; 17(1):33-44.

33. Kramer, PO, Drinkwater, BL, Folonsbee, LJ, Bedi, JF. Ocular functions and incidence of acute mountain sickness in women at altitude. Aviat. Space Environ. Med. 1983; 54(2):116-120.

34. Larsen RF, Rock PB, Fulco CS, Edelman B, Young AJ, Cymerman A. Effect of spironolactone on acute mountain sickness. Aviat. Space Environ. Med. 1986; 57:543-7.

35. Maresh CM, Nobel BJ, Robertson KL, Sime WE. Maximal exercise during hypoxic hypoxia (447 Torr) in moderate-altitude natives. Med. Sci. Sports Exerc. 1983; 15:360-5.

36. Maresh CM, Nobel BJ, Robertson KL, Harvey JS. Aldosterone, cortisol, and electrolyte responses to hypobaric hypoxia in moderate-altitude natives. Aviat. Space Environ. Med. 1985; 56:1078-84.

37. Marshall SLA. Men against fire. New York: William Morrow Press, 1947.

38. McFarland, R.A. Psycho-physiological Studies at High Altitude in the Andes. Part III. Mental and psychosomatic responses during acclimatization. J. Comp. Psychol. 1937a; 23:26-31.

39. McFarland, R.A. Psycho-physiological Studies at High Altitude in the Andes. J. Comp. Psychol. 1937b; 23:191-225.

40. Meehan RT, Cymerman A, Rock P, Fulco CS, Hoffman J, Abernathy C, Needle S, Maher JT. The effect of naproxen on acute mountain sickness and vascular responses to hypoxia. Am. J. Med. Sci. 1986; 292(1):15-20.

41. Regard M, Landis T, Casey J, Maggiorini M, Bartsch P, Oelz O. Cognitive changes at high altitude in healthy climbers and in climbers developing acute mountain sickness. Aviat. Space Environ. Med. 1991; 62:291-5.

42. Roach RC, Larson EB, Hornbein TF, Houston CS, Bartlett S, Hardesty J, Johnson D, Perkins M. Acute mountain sickness, antacids, and ventilation during rapid, active ascent of Mount Rainier. Aviat. Space Environ. Med. 1983; 54(5):397-401.

43. Rock PB, Johnson TS, Larsen RF, Fulco CS, Trad LA, Cymerman A. Dexamethasone as prophylaxis for acute mountain sickness: Effect of dose level. Chest 1989; 95(3):568-73.

44. Sampson JB. Laboratory notebooks nos. 77 and 821. US Army Research Institute of Environmental Medicine, Natick, MA, 1977-1978.

45. Sampson JB, Kobrick JL. The environmental symptoms questionnaire: Revisions and new field data. Aviat. Space Env. Med. 1980: 51:872-7.

46. Sampson JB, Cymerman A, Burse RL, Maher JT, Rock PB. Procedures for the measurement of acute mountain sickness. Aviat. Space Environ. Med. 1983; 148(12):1063-73.

47. Sampson JB, Stokes JW, Barr JG, Jobe JB. Injury and illness during cold weather training, Mil. Med., 1983, 148(4), 324-330.

48. Shukitt BL, Banderet LE, Sampson JB. The Environmental Symptoms Questionnaire: Corrected computational procedures for the alertness factor. Aviat. Space Environ. Med. 1990; 61:77-8.

49. Shukitt-Hale BL, Banderet LE, Lieberman HR. Relationships between symptoms, moods, performance, and acute mountain sickness at 4,700 meters. Aviat. Space Environ. Med. 1991; 62:865-9.

50. Szlyk PC, Francesconi RP, Sils IV, Foutch R, Hubbard RW. Effects of chemical protective clothing and masks, and two drinking water delivery systems on voluntary dehydration. Technical Report T14-89, US Army Research Institute of Environmental Medicine, Natick, MA. May 1989.

51. White AJ. Cognitive impairment of acute mountain sickness and Acetazolamide. Aviat. Space Environ. Med. 1984; 55:598-603.

52. Vogel JA, Sampson JB, Wright JE, Knapik JJ, Patton JF, Daniels WL. Effects of transatlantic troop deployment on physical work capacity and performance. US Army Research Institute of Environmental Medicine, Technical Report T 3/79, Natick, MA. 1979.

53. Wright AD, Bradwell AR, Fletcher RF. Methazolamide and Acetazolamide in acute mountain sickness. Aviat. Space Environ. Med. 1983; 54(7):619-621.

54. Wright AD, Jones GT, Fletcher RF, MacKintosh JH, Bradwell AR. The Environmental Symptoms Questionnaire in acute mountain sickness. Aviat. Space Environ. Med. 1985; 56:572-575.

55. Wright JE, Vogel JA, Sampson JB, Knapik JJ, Patton JF, Daniels WL. Effects of travel across time zones (jet lag) on exercise work capacity and performance. Aviat. Space Environ. Med. 1982, 54(2), 132-137.

56. Young AJ, Wright J, Knapik J, Cymerman A. Skeletal muscle strength during exposure to hypobaric hypoxia. Med. Sci. Sports Exercise, 1980; 12(5):330-335.

57. Zell SC, Goodman PH. Acetazolamide and dexamethasone in the prevention of acute mountain sickness. West. J. Med. 1988; 148:541-5.

APPENDIX A.

SCORING ESQ USING FACTOR WEIGHTS

APPENDIX A

SCORING ESQ USING FACTOR WEIGHTS

Scoring of the ESQ-III or ESQ-IV using factor weights follows the guidance presented in Sampson et al. (46) and in Shukitt, et al (48). However, the formulas for calculating the factor scores have been simplified yielding exactly the same scores as the original formulas. This was made possible by the fact that in the original formulas the numerator and the denominator were each multiplied by the number 5; factoring out the number 5 reduces each formula to its simplest algebraic form. In the following formulas: V1=the subject's reponse (0 to 5) for item 1 Lightheaded; V2=response value 0-5 for item 2, Headache (values 0-5); etc. The complete set of Item Numbers and their descriptors are found in Sampson et al. (46); with the exception of Item 58 ("I couldn't sleep"), these items are reproduced in Figure 1. If for ESQ-IV item 58 is answered by subjects as "Couldn't Sleep" then factor weights for ALERT and FATIGUE apply, but if 58 is answered as "Felt Wide Awake" then the weights for 58 do not apply for these factors. The computational formulas are:

Factor 1: Cerebral Acute Mountain Sickness (AMS-C) = F1/5.189

where: F1=(V1 x .489) + (V2 x .465) + (V4 x .446) + (V5 x .346) + (V6 x .501) + (V7 x .519) + (V19 x .387) + (V24 x .347) + (V52 x .413) + (V53 x .692) + (V54 x .584)

Factor 2: Respiratory Acute Mountain Sickness (AMS-R) = F2/7.138

where: F1=(V2 x .312) + (V8 x .745) + (V9 x .763) + (V10 x .734) + (V17 x .516) + (V22 x .686) + (V23 x .744) + (V24 x .691) + (V46 x .534) + (V48 x .578) + (V58 x .355) + (V65 x .480)

Factor 3: Ear-Nose-Throat = F3/4.307

where: F3=(V3 x .302) + (V39 x .367) + (V42 x .441) + (V43 x .300) + (V44 x .759) + (V45 x .784) + (V46 x .329) + (V49 x .470) + (V50 x .555)

Factor 4: Cold Stress = F4/4.699

where: F4=(V15 x .358) + (V19 x .331) + (V28 x .447) + (V31 x .364) + (V34 x .642) + (V35 x .737) + (V36 x .720) + (V37 x .580) + (V61 x .520)

Factor 5: Distress = F5/5.404

where: F5=(V10 x .315) + (V13 x .566) + (V14 x .540) + (V51 x .523) + (V53 x .373) + (V56 x .348) + (V57 x .318) + (V61 x .379) + (V62 x .546) + (V63 x .525) + (V64 x .492) + (V65 x .479)

***Factor 6: Alertness** = F6/3.214

where: F6=(V56R x .314) + (V57R x .300) + (V58R x .379) + (V59R x .351) + (V65R x .300) + (V66 x .783) + (V67 x .787)

Factor 7: Exertion = F7/3.377

where: F7=(V1 x .371) + (V8 x .321) + (V9 x .419) + (V10 x .351) + (V11 x .573) + (V12 x .505) + (V13 x .471) + (V19 x .366)

Factor 8: Muscle Discomfort = F8/3.466

where: F8=(V16 x .402) + (V18 x .594) + (V19 x .307) + (V20 x .492) + (V21 x .406) + (V22 x .303) + (V25 x .317) + (V38 x .315) + (V55 x .330)

Factor 9: Fatigue = F9/4.958

where: F9=(V1 x .384) + (V4 x .418) + (V5 x .416) + (V19 x .492) + (V40 x .398) + (V41 x .304) + (V47 x .319) + (V55 x .371) + (V56 x .665) + (V57 x .579) + (V58 x .300) + (V59 x .312)

---

*NOTE: Items marked with an R (e.g., "V56R") for the Alertness factor should be reverse scored before multiplying the weight. Thus the S's response of 0 should be changed to 5, 1 to 4, 2 to 3, etc. before multiplication with item weights; see Shukitt, et al (48) for rationale.

APPENDIX B.

SCORING ESQ USING ALTERNATE GENERAL PROCEDURES

APPENDIX B

SCORING ESQ USING ALTERNATE GENERAL PROCEDURES

Presented below are the general procedures that have been be used with the ESQ-IV (Past Tense) (24, 25) but can also be used with ESQ-III (46). The scoring procedures are based on the empirical studies cited and correspond to major environmental conditions. The experimenter can select the index that represents the measure of interest. For example, if the ESQ is administered during hot weather, the researcher should score it for the index of subjective heat illness (SHI). If it is administered during cold weather, it should be scored for indexes of cold discomfort. During studies of physical exertion such as field training exercises (whether in the cold, the heat or under thermally neutral conditions), it should be scored for indexes of tiredness, muscle discomfort, etc. Regardless of environmental condition, it is always valuable to know the incidence of symptoms and symptom predominance.

Symptom Incidence. Symptom Incidence is defined as the frequency of occurrence of a symptom item among subjects for a particular condition. Thus, scoring is accomplished by simply counting the number of subjects who rated the item as "1" or greater for that condition. Chi-square analyses are used to assess whether symptom incidence among conditions varies significantly from chance for that particular item. This procedure is a true measure of incidence without regard to the individual intensity ratings of the items. Symptom Predominance, described below, takes into account intensity of symptom ratings.

Symptom Predominance. Symptom Predominance is defined as the rank ordering of the mean intensities of the symptoms among subjects for a particular condition. Thus, scoring is accomplished by calculating the mean intensity of each item for subjects experiencing a particular condition, and then rank ordering the 68 symptom items from most intense to least intense. Those items with the highest mean scores are considered the predominant symptoms for that environmental condition. This procedure was used successfully by Kobrick et al. (29,30) in a large-scale study of ambient heat, chemical protective clothing and the administration of nerve agent antidote.

Subjective Heat Illness (SHI). The Index of Subjective Heat Illness (SHI) was empirically derived by Johnson and Merullo (24). The SHI is calculated for each subject by summing the intensity ratings (unweighted) of 22 items from the ESQ-General Form. The possible scores for the SHI range from zero (all items scored as "0" or "not present") to 110 (all items scored as "5" or "extreme").

SHI = V1 + V2 + V4 + V5+ + V7 + V8 + V9 + V11 + V16 + V17 + V19 + V27 + V30 + V33 + V38 + V41 + V52 + V53 + V55 + V56 + V62 + V63

where, V1=Item 1, Lightheaded (values 0-5); V2=Item 2, Headache (values 0-5); etc. The complete set of Item Numbers and their descriptors are presented in Table 1.

Cold and Physical Exertion. Four indexes are used to assess symptomatology in physically active subjects exposed to cold weather (23). These indexes reflect feelings of cold discomfort, muscle discomfort, cardiopulmonary discomfort, and tiredness. A fifth index, feelings of well-being, is typically used as an index of recovery. Each index is calculated for each subject by summing the intensity ratings (unweighted) of their respective items from the ESQ-General Form. The items whose intensity ratings are to be summed for calculation of each index are:

Cold Discomfort Index (CD): CD = V34 + V35 + V36 + V37 + V38

Muscle Discomfort Index (MD): MD = V16 + V18 + V20 + V21 + V22

Cardiopulmonary Discomfort Index (CPD): CPD = V8 + V9 + V10 + V11 + V12 + V13 + V14

Tiredness Index (T): T = V19 + V56 + V57

Well-Being Index (WB): WB = V58 + V66 + V67