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SUMMARY PAGE

THE PROBLEM

A new multi-dimensional quantitative ataxia test battery employing the "rail method" of testing was developed to assess more precisely than heretofore postural equilibrium-disequilibrium under unusual conditions and stresses such as rotating environments.

FINDINGS

High reliability, including test-retest reliability, was demonstrated for each of two versions: a Long Version employing six rails of varying widths, and a Short Version employing two of these rails. Normative standards covering a wide age range, and age, height, and weight influences upon performance, tentative sex differences in performance, practice effects, and Test Battery relationships with several clinical-type ataxia tests were determined. Validity of the standardized test procedures in the laboratory, in the field, and in clinical situations was demonstrated, present and future uses of the Test Battery in normals and auricular-involved individuals in vestibular research as well as in related research-clinical areas were outlined, and several methodological limitations were were indicated.

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INTRODUCTION

The disturbances of equilibrium while standing or walking are diagnostic signs with a long tradition of usefulness in clinical medicine. Many procedures have been proposed to quantify these disturbances (2-5, 8,9,11,16-20, 22,27,31-35, 37,39,41,42,44,45, 48-62, 65,66) but almost as many have not stood the test of time. The procedures commonly used today, subjective estimates of disequilibrium, are valued mainly as rough screening tests to indicate lines of direction for more precise diagnostic study and, judging from the small investigative interest expressed in such tests, it must be assumed that they are adequate for all except special purposes.

Our interest in ataxia tests grew out of the fact that subjects exposed to the unusual inertial forces in a rotating environment initially experience ataxia, then gradually adapt, and a quantitative measure of the time-course of this adaption was needed. The requirements were stringent inasmuch as it was necessary to measure small differences in postural equilibrium over the normal and abnormal range. It is the purpose of this report to describe a new ataxia test battery with numerical scores, demonstrate its reliability and validity, and point out some of its uses in laboratory and clinic.

GENERAL CONSIDERATIONS

The reader is referred elsewhere for a review of the numerous physiological mechanisms and psychological factors which govern postural equilibrium and the various pathological alterations which may affect it. Here it is important only to set forth the guide lines which were followed in devising the test battery, namely 1) selection and categorization of subjects, 2) medical evaluation, 3) standardizing the test procedure, 4) objectivity in scoring, and 5) choice of "long" or "short" version of the Test Battery.

Healthy subjects were selected to provide normative data and were categorized on the basis of age, sex, height, weight, occupation, et cetera. All had had a recent medical examination and none complained of postural difficulties. A more comprehensive examination including tests of vestibular function was carried out in the case of groups used in validation studies. Some of the subjects were selected on the basis of labyrinthine defects, and, hence, manifested vestibular ataxia.

All of the tests were carried out using "rails" (5,7,8,10,12,13-15, 17-19, 21,23, 25,28-30, 39,43,46,47,52,59,64) with their advantages of flexibility in width and objectivity in scoring; i.e., the subject either remained "on" or "fell off." The subject was required to remain upright with arms folded and stand or walk heel-to-toe as the case might be. Well-fitting shoes with nonflexible soles and low heels were required. Inasmuch as the test was interesting, good motivation was the rule.

Only two measurements were made: 1) the number of seconds the subject could "stand" and 2) the number of "steps" he could take without "falling." No attempt was made to grade variations in the amount of body sway. A number of trials were given to increase reliability. The test procedures described in APPENDIX A represent the end product of evolutionary development during which many variations of tests were tried and the various items subjected to statistical analysis. Two versions of the test evolved: a Long Version which utilized six rails of varying widths, and a Short Version which utilizes only two of these rails.

The Long Version was designed to test individual performance differences over an extremely wide age range in both normal and clinical populations. Although somewhat time-consuming to administer (about forty-five minutes), the Long Version proved ideal for testing the postural equilibrium performances of the group of labyrinthine defective subjects (L.D.'s), who participate regularly in the vestibular research program of this laboratory, inasmuch as individual differences within this group were apparent for each of the six rails. As our samples of the higher scoring normal subjects increased, however, it became increasingly clear that a briefer version of the Test Battery was needed since about one half of the rails afforded no performance discrimination whatsoever.

The Long Version serves the original purpose of assessing the performance capabilities of extreme age groups (children and senior citizens) and certain clinical patients. It offers the major advantage of establishing subtle individual differences in such samples.

The Short Version, as will be seen from our results, serves ideally the purpose of assessing individual differences in normal subjects and fulfills the premium time-saving requirement imposed by much repeated pre-, per-, and post-testing of subjects with no vestibular dysfunctioning, or with varying amounts of vestibular losses, who are exposed to unusual experimental situations.

TEST BATTERY (LONG VERSION)*

A total of 550 normal males, 11 labyrinthine defective males (L.D.'s),# and 158 females widely varying in age and occupational status comprise the samples tested with the Long Version of the Test Battery. The samples include highly experienced Naval and Marine Corps test pilots, aviators, (Project Gemini applicants)**; military flight surgeons; Naval and Marine Corps student aviators and "Project Astronaut Candidates" (1); military officers and enlisted personnel; firemen; college professors; college students; senior citizens; clerical and technical medical staff; physicians; medical students; nurses; scientists; and high school students.

The Test Battery, the Classical Romberg Test (50), and the Sharpened Romberg Test (SR)(4) which were undertaken by these subjects are described fully in terms of materials, administration, and scoring procedures in APPENDIX A.

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*Test Battery refers only to the three tests undertaken on the rails, viz., Walk H/T (walking heel-to-toe with eyes open), Stand E/O (standing heel-to-toe with eyes open), and Stand E/C (standing heel-to-toe with eyes closed).

#College professors, graduates, or near college graduates.

**One is now a Gemini Astronaut.

NORMATIVE DATA

Test Battery means and standard deviations by age classification in the samples of male and female populations are shown in Table I. The ranges of scores observed in each sample and the percentile rankings are contained in APPENDIX B. There were marked individual differences in performance. The two standing tests appear to be more sensitive to age increase than is the Walk H/T test. In males, standing test performances appear to decline significantly as early as age 43, and Walk H/T performance appears to decline significantly at the later age of 54. A strict assessment of sex differences was not considered practical because of great variability in the footwear of our female subjects as opposed to great uniformity of footwear in the males. In our opinion, however, sex differences will still be apparent when tests of this variable are carried out.

RELIABILITY

Intra-test correlations (r's between best trial and second best trial) of Walk H/T ranged from 0.75 to 0.92; intra-test correlations of Stand E/O and Stand E/C ranged from 0.83 to 0.96. Test-retest reliabilities ranged from moderate to high (r's of 0.57 to 0.96) over a period of seven successive test sessions in a group of twelve normal subjects.

PRACTICE EFFECTS

Walk H/T performance plateaued at 9 per cent improvement on the fourth day; Stand E/O performance plateaued at 29 per cent improvement on the fourth day; Stand E/C performance plateaued at 9 per cent improvement on the fifth day.

INTER-TEST RELATIONSHIPS

Correlations between Walk H/T and Stand E/O ranged from 0.37 to 0.69; correlations between Walk H/T and Stand E/C ranged from 0.13 to 0.48; correlations between Stand E/O and Stand E/C ranged from 0.41 to 0.61. It is apparent from these results that each test comprising the Test Battery relates only moderately to each other test and thereby suggest a nearly ideal distinctness desired in a battery of tests designed to measure complex performances referred to singularly as ataxia, or postural equilibrium.

HEIGHT AND WEIGHT INFLUENCES

All correlations with height and weight (except in highly heterogeneous subjects) were very low or zero order, and had negligible influences upon performance.

Table I

Test Battery (Long Version) Means and Standard Deviations by Age Classification in Samples of Male* and Female Populations

N	Age Range	Walk H/T Test Mean	Walk H/T Test S.D.	Stand E/O Test Mean	Stand E/O Test S.D.	Stand E/C Test Mean	Stand E/C Test S.D.
				MALES			
32	13-16	51.3	5.36	469.2	64.09	196.0	89.45
424	17-42	54.8	4.53	483.1	59.15	203.7	98.61
9	43-50	56.7	4.08	457.4	88.78	150.4	98.01
4	51-53	54.5	5.50	416.3	92.19	120.8	70.97
7	54-66	45.3	9.11	322.1	139.01	101.7	67.88
				FEMALES			
28	14-16	51.5	4.26	489.6	41.71	225.8	69.08
112	17-42	51.3	4.66	486.2	54.49	232.3	99.52
7	43-50	46.6	6.64	475.6	33.95	196.1	107.24
2	51-53	43.0	1.00	320.0	32.00	49.5	1.50
9	54-67	41.0	10.34	296.8	140.73	90.7	77.78

*The samples here represented do not include 74 student military aviators and "Project Astronaut Candidates."

VALIDITY

LABYRINTHINE DEFECTIVE GROUP

The majority of this group scored at the 1st percentile on each of the tests. In this group virtually no improvement with extended practice was shown in their Stand E/C performances (only 3 per cent), whereas Walk H/T and Stand E/O performances typically improved rather markedly-- 70 per cent and 60 per cent, respectively, over seven daily retest periods.

PREDICTION OF MOTION SICKNESS SUSCEPTIBILITY

In a small group of male subjects (N = 15) who were evaluated with regard to susceptibility to motion sickness by means of a motion sickness questionnaire, a boat ride, an exhaustive motion sickness-arousing air ride, and rotations on the Pensacola Slow Rotation Room (SRR) and on the Toronto Counter-Rotating Platform (24), susceptibility to motion sickness was predicted to a moderate extent; correlations with the Test Battery ranged from 0.50 to 0.75.

DISCRIMINATORY POWER AND LIMITATIONS OF THE LONG VERSION

Inter-correlations of performances by normals on each of the six rails disclosed that Rail 5 (3/4" wide) showed highest communality with the remaining rails in the case of Walk H/T and Stand E/O, and Rail 2 (2-1/4" wide) showed highest communality in the case of the Stand E/C test. Consequently, in the interest of economy we pilot-tested a large number of randomly selected miscellaneous normal subjects, with the modified procedure of scoring the best three out of five trials. The Short Version of our Test Battery was derived utilizing these two rails.

TEST BATTERY (SHORT VERSION)

A total of 828 normal males, 10 of the L. D.'s tested previously on the Long Version, 17 male otoneurological patients, 99 normal females, and 15 female otoneurological patients comprise the samples tested. These normals included experienced military aviators; Naval and Marine Corps student aviators and "Project Astronaut Candidates"; flight surgeons; military officers; enlisted personnel; and military and civilian scientific, clerical, and technical personnel.

The Test Battery (Short Version) and the Sharpened Romberg Test were undertaken by all subjects, and, in addition, many of the subjects undertook the Stand One Leg Eyes Closed test (SOLEC) (5,8,65), and the Walk Line Eyes Closed test (WALEC) (42,58). These are described fully in terms of materials, administration, and scoring procedures in APPENDIX A. Score sheet is shown in APPENDIX C.

NORMATIVE DATA

Subjects tested to date ranged 17-59 years in age. As with the Long Version, there were marked individual differences in the capabilities tapped by the Short Version, and there was considerable overlap in the performances of older and younger individuals (Table II). The ranges of scores observed and the percentile equivalents are shown in APPENDIX D. In the males tested, performance declined significantly in about the age range of 43 to 53 years. Analysis of possible sex differences in performances again was not considered practical in view of marked variability of footwear of the females as opposed to virtual uniformity of footwear in the males.

Table II

Test Battery (Short Version): Means and Standard Deviations by Age Classification in Samples of Male and Female Populations

N	Age Range	Walk H/T Test Mean	Walk H/T Test S.D.	Stand E/O Test Mean	Stand E/O Test S.D.	Stand E/C Test Mean	Stand E/C Test S.D.
				MALES			
340	17-42	12.5	2.62	37.6	31.98	103.8	58.37
471	43-50	10.4	3.10	19.1	13.47	52.0	45.90
17	51-53	9.2	3.99	13.2	5.87	24.2	14.09
				FEMALES			
41	18-29	11.5	2.66	26.7	14.05	84.6	60.92
47	30-49	9.9	2.95	18.8	10.65	49.1	43.33
11	50-59	8.8	4.00	13.5	5.90	42.6	37.61

INTRA-TEST RELIABILITY

Intra-test correlations (best trial with second best, best trial with third best, and second best with third best) of Walk H/T scores ranged from 0.71 to 0.90, of Stand E/O scores from 0.89 to 0.96, and of Stand E/C scores from 0.82 to 0.96. Thus, performance on a given test utilizing a single rail, as opposed to utilizing six rails, duplicated the high reliability established for the Long Version.

TEST-RETEST RELIABILITY

In a group of twelve normal male subjects in the age range 18-49 who undertook ten successive daily performances* on the Test Battery, test-retest reliabilities, computed by correlations of Day 1 performance with mean performances on Days 2 through 10, were 0.40, 0.86, and 0.91 for Walk H/T, Stand E/O,and Stand E/C, respectively. Other combinations of initial and early performances when correlated with later, practiced performances yielded virtually identical coefficients. Substantial repeatability of standing test performances was apparent. The lower reliability of Walk H/T performance reflects the more rapid rate of learning afforded both by the locomotor aspect of this test, and in turn, a more easily attained perfect score than was found on the standing tests.

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*Two additional daily re-tests were administered while subjects wore basketball shoes.

Comparisons of Days 1 and 2 (combined) with Days 9 and 10 (combined) performances revealed 26 per cent improvement on Walk H/T, 77 per cent on Stand E/O, and 82 per cent on the Stand E/C test.

PRACTICE EFFECTS AND EFFECTS OF FOOTWEAR UPON HIGHLY PRACTICED PERFORMANCE

These results are summarized in Figure 1. In the group of twelve normal male subjects, performances improved in almost linear fashion throughout the ten-day period, although the improvements were relatively slight following the plateau points on the learning curve. Plateaus in Walk H/T, Stand E/O, and Stand E/C performances were realized on the third, fourth, and fifth day, respectively. The detrimental effects of wearing basketball shoes upon highly practiced standing test performances (obtained while the subjects wore street shoes) reached the extent of a 44 per cent decrease in Stand E/O performance and a 47 per cent decrease in Stand E/C performance. In marked contrast, Walk H/T performance decreased a mere 6 per cent, indicating that the loss of stability due to basketball shoes was almost completely compensated for on Walk H/T and very poorly compensated for on the two standing tests.

INTER-TEST RELATIONSHIPS

Correlations among the three distinct tests comprising the Short Version corresponded very nearly to those reported for the Long Version. The correlations ranged from 0.19 to 0.51.

HEIGHT AND WEIGHT INFLUENCES

The correlations with the Test Battery were very low, or zero order, and negligible for differentation and prediction purposes--a finding in keeping with results on the Long Version.

VALIDITY

The Identification of Individuals with Auricular Defects

The mean performance scores of L. D.'s, streptomycin-treated Menière's patients, and clinical patients which include those showing postural vertigo, positional nystagmus, Menière's, pseudo-Menière's, and labyrinthitis were compared with the mean performance scores of an equivalent number of randomly sampled, age-matched normal, symptom-free, individuals. In all instances, the performances of individuals with auricular involvement were significantly poorer than the performances of the normals.

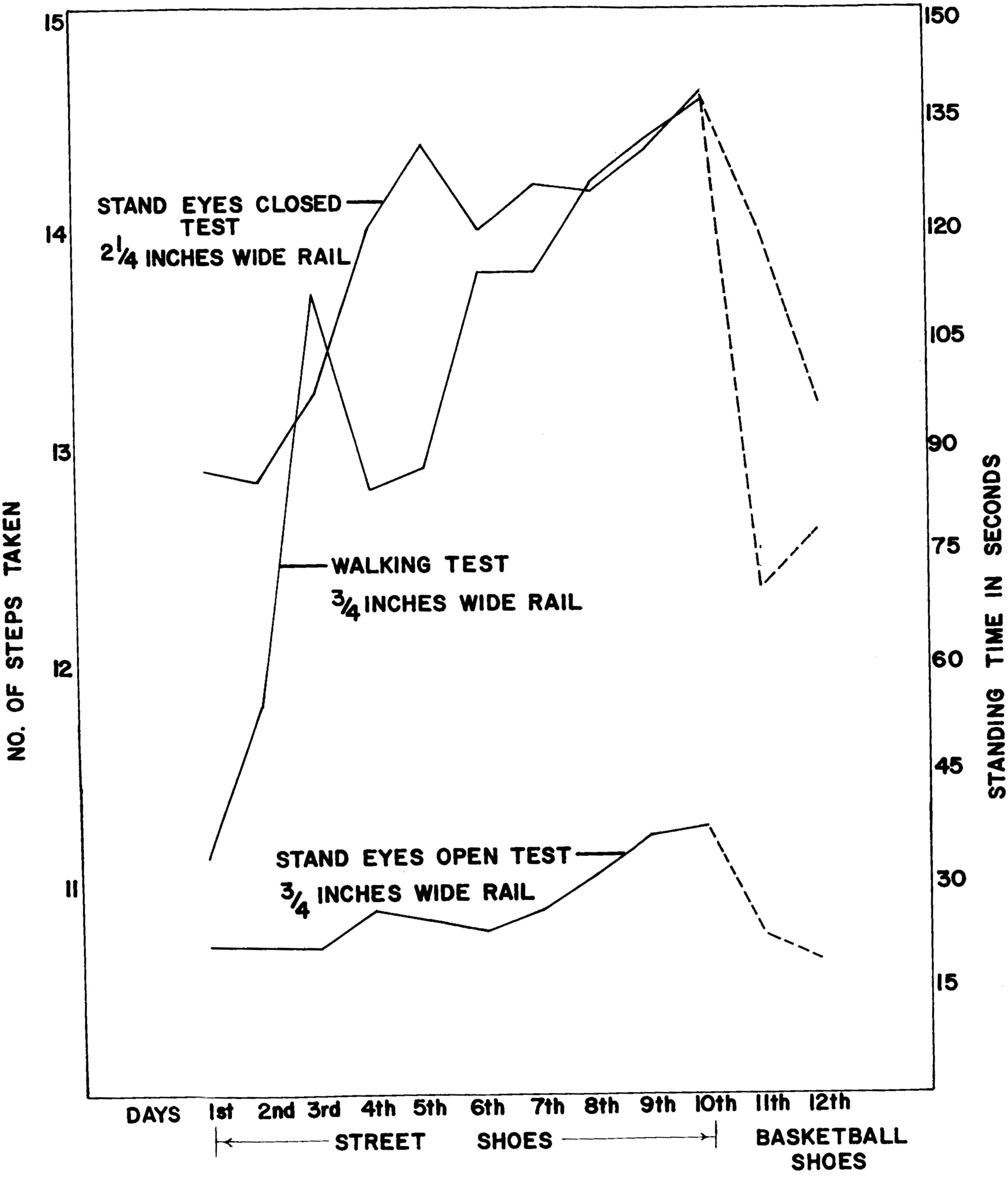

Figure 1
Influence of Practice and of Type of Footwear on Test Battery (Short Version)
Performance in a Group of Normal Male Subjects (N=12)

RELATIONSHIPS WITH THRESHOLD CALORIC RESPONSES

The performances of eleven symptom-free male individuals with below normal threshold caloric responses ($\geqq$35.0°C) were compared with the performances of eleven randomly selected normal male individuals with normal threshold caloric responses (36.0° to 36.6° C). Both Stand E/O and Stand E/C performances were identified with depressed semi-circular canal sensitivity insofar as such sensitivity is reflected by caloric responses in the range of 35.0°C and below (.02 level of confidence). Mean Walk H/T performances in the two groups were virtually identical.

IDENTIFICATION OF CANAL SICKNESS SUSCEPTIBILITY

In a sample of twenty normal male subjects the test performances of the ten most susceptible to canal sickness on the SRR were compared with the test performances of the ten remaining, i.e., least susceptible subjects. Susceptibility in this instance was defined as a rank ordering of the twenty subjects in terms of the number of dial sequences completed during rotation and qualitative ratings by an observer (38). Generally, on all three tests the ten most susceptible subjects as a group attained higher performance scores than those attained by the least susceptible subjects. To this extent, the Test Battery would appear to reflect sensitivity to canal sickness, which is a finding in parallel with predictability of motion sickness from Long Version performance.

EFFECTS OF PROLONGED ROTATION IN THE PENSACOLA SLOW ROTATION ROOM

Prerotation Test Battery performances were compared with postrotation performances in several groups of normal subjects who were rotated at 10 RPM for 12 days in the SRR(25). Post-testing occurred immediately upon cessation of rotation, and in all instances severe declines in test performances were evidenced. Daily retesting during the postrotation periods revealed complete recovery, within 24-72 hours, of all Test Battery performances except Stand E/C performances. The visually-influenced performances on the Walk H/T and Stand E/O tests had not only recovered but had improved, whereas the nonvisually-influenced Stand E/C performances proved more sensitive to the influences of prolonged rotation.

INFLUENCES OF MODERATE AND SEVERE SEA CONDITIONS UPON PERFORMANCE

In the Nova Scotia Experiment* twenty normal male subjects withstood a twenty-five-hour ride on an ocean-going tug in mid-winter during moderate and severe sea conditions between Nova Scotia and Newfoundland. Baseline Test Battery performances, which were obtained prior to the experiment, were compared with performances obtained within 30 minutes to 4 hours, within 16-21 hours, and at 36 hours following the sea experience. Comparisons were made by the split-half method; i.e., the ten subjects with the highest baseline performance scores on each test of the Test Battery were compared with the remaining ten subjects having the lowest baseline performance scores. It was

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*In preparation for publication.

revealed (Figure 2) that the performances of the lowest scoring subjects were hardly affected by the sea experience; indeed, those who did not at least maintain their baseline performance levels showed significant improvements in performance. The ten initially highest scoring subjects, in marked contrast, showed significant decreases in performances. Both the Walk H/T and Stand E/O performances of these sensitive subjects recovered to baseline level within 16-21 hours, but Stand E/C performances had only partially recovered within 36 hours of the sea experience. This Stand E/C result is reminiscent of the delayed recovery of Stand E/C performances of the several groups of subjects exposed to prolonged rotation in the SRR.

Ten L.D. male subjects acted as the control group in the Nova Scotia Experiment. As expected, the Test Battery performances of the L. D. group were not at all affected by the sea experience. Indeed, as was the case with the low scoring (relatively insusceptible) normals, performances during the post-testing periods were either maintained or improved.

RELATIONSHIPS WITH TRAMPOLINE PERFORMANCE

From each of several successive classes of student aviators undertaking physical training in the U. S. Naval School, Pre-Flight, two to four men at the very top in terms of proficiency on the trampoline and two to four men at the very bottom in trampoline proficiency were selected for performance testing.* It was found that the top group on the trampoline scored higher on Walk H/T (.01 confidence level) and Stand E/O (.10 confidence level) than did the bottom group. The means of the two groups on Stand E/C were virtually identical. Inasmuch as the group mean differences observed were limited to the two visually-enhanced postural equilibrium performances, it is suggested that visual-motor, primarily locomotor, factors (versus vestibulo-motor factors) underlie the relationships found between Test Battery and trampoline performance.

SOME RELATIONSHIPS WITH SEVERAL CLINICAL-TYPE ATAXIA TESTS

Several individuals who undertook the Test Battery also took the following tests:# Sharpened Romberg (SR), Stand One Leg Eyes Closed, and Walk Line Eyes Closed. The Test Battery performances of normal male subjects who scored perfectly on these clinical-type tests were compared with the Test Battery performances of age-matched normal male subjects who had scored less than perfect on the clinical-type ataxia tests. Generally, results were in the direction of positive relationships between Test Battery scores and scores obtained on the ataxia tests. Notably, individuals with "perfect" ataxia test scores generally scored higher (better) on the Stand E/O and Stand E/C tests than did those individuals with less than perfect ataxia test scores. There were no significant differences, however, in Walk H/T performances between the two groups, and, understandably, none of the correlations between Walk H/T and the ataxia tests were statistically significant.

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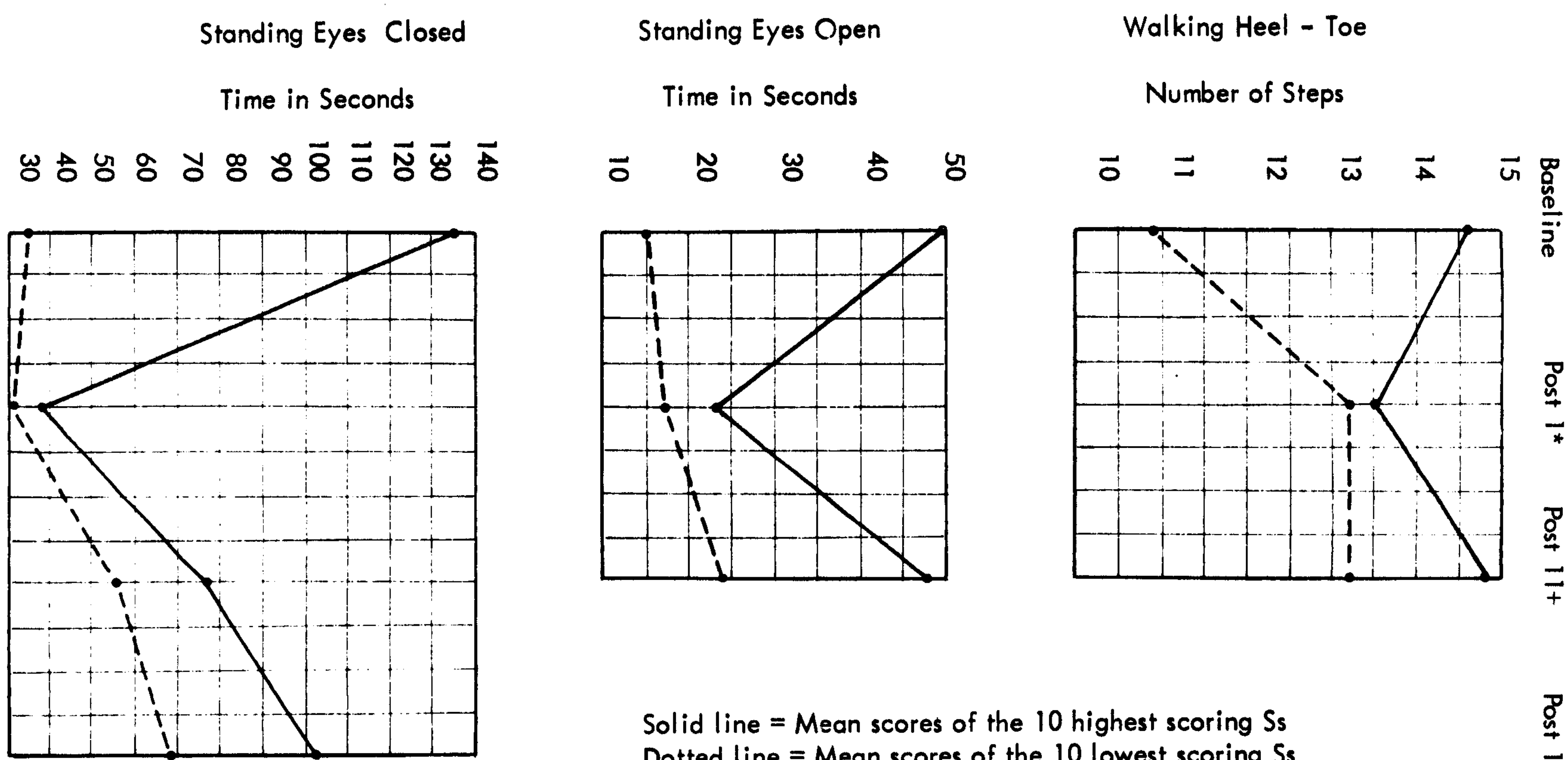
*Subjects were very carefully selected by Mr. Joseph F. Lowder, Physical Education Instructor, Naval School of Pre-Flight, and Coach, Navy "Starflights" trampoline demonstration team.

#Described fully in APPENDIX A.



Solid line = Mean scores of the 10 highest scoring Ss
Dotted line = Mean scores of the 10 lowest scoring Ss
*1/2 -4 hours following boat ride
+16-21 hours following boat ride
**36 hours following boat ride

Figure 2

Recoverability from Moderate to Severe Sea Conditions, Reflected by Test Battery (Short Version) Performance, As a Function of Baseline Performance of Normal Males

COMPARATIVE DIFFICULTY IN PERFORMING THE STAND E/C TEST AND THE SHARPENED ROMBERG TEST IN RELATION TO AGE

The only procedural difference between the SR test and the Stand E/C test is that the SR was performed while subjects stood on the floor, whereas the Stand E/C was performed while subjects stood on a 2-1/4 inch wide rail. Standing for a period of sixty seconds in position with eyes closed constituted a perfect score on each of the two tests. The two tests appeared to most subjects, deceptively, to be of equivalent difficulty. Consequently, most of our subjects expressed surprise, if not chagrin, at their considerably greater difficulty in performing on the rail than on the floor. Quantitative comparisons of the two tests in terms of difficulty in samples of male subjects (N = 530) and female subjects (N = 211) in various age ranges revealed remarkable differences between the two tests. Some 24 per cent to 92 per cent of the subjects scored perfectly on the first trial of the SR test, but only 3 per cent to 23.5 per cent of the subjects scored perfectly on the first trial of the Stand E/C test. Eighty-seven per cent of the younger subjects (ages 19-26) scored perfect first trials on the SR, and only 56 per cent of the older subjects (ages 43-53) did so. But greater still was the percentage differences in Stand E/C performance between the younger group and the older group--18 per cent perfect first trial scores in the younger group versus only 3.5 per cent perfect first trial scores in the older group. These findings reflect a mean age difference between the two groups of twenty-three years.

INFLUENCE OF ALCOHOL UPON TEST BATTERY AND CLINICAL-TYPE ATAXIA TEST PERFORMANCES

As part of a larger study* which included positional alcohol nystagmus measurements and blood alcohol measurements, thirteen subjects were posture-tested 30 minutes, 1 hour, 2 hours, 3 hours, 4-1/2 hours, 6 hours, and 7 hours after consuming 80-proof vodka on an empty stomach in the amount of 1 cc per pound body weight in the following sequence: 1) SR; 2) Walk H/T; 3) Stand E/O; 4) Stand E/C; 5-6) SOLEC L & R: 7) WALEC (each of these seven tests was administered repeatedly at the intervals indicated). The entire experiment was duplicated two days later with the same subjects but with 100-proof vodka as the stimulus. The alcohol had the immediate effect of producing a marked decrement in performance by all subjects on all seven tests. Peak decrements in performance were evidenced one hour after alcohol intake, and performances did not recover to baseline level until 3-7 hours after alcohol intake. Generally, the 100-proof vodka provided greater performance decrement than did the 80-proof, and the recovery period with the 100-proof was somewhat longer than with the 80-proof. The SR test proved least sensitive to alcohol both in terms of decrement and recovery time, whereas the Test Battery proved most sensitive in terms of recovery time although it tended to equal the SOLEC and WALEC in terms of the extent of performance decrement.

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*In preparation for publication in collaboration with Dr. Martin Bergstedt

Several L.D. subjects undertook, identically, this alcohol experiment with the interesting result that, unlike normal subjects, they did not suffer performance decrements despite the adequate stimuli, suggesting that the vestibular apparatus is an essential component of ataxia due to alcohol stimulation.

DISCUSSION

The normal standards set forth must be regarded as tentative. The most reliable figures are those for males in the 17 to 53 age range. These values are representative of the scores obtained on subjects who not only had passed the flight medical examination on more than one occasion but also had demonstrated, in the performance of their professional and recreational activities, freedom from significant disturbances of psychophysiological mechanisms governing postural equilibrium. In the great majority the functional status of the semicircular canals and otolith organs was not determined specifically and, had this been done, some would have been eliminated from the "normal" group. It is worth noting, however, that when comprehensive evaluations were carried out in the case of aviators with low scores, the findings usually revealed no definite abnormality. In some instances, even after practice the scores remained low, suggesting either an inherited lack of skill or some cryptic disorder.

In the female populations the normative values are faulted partly on the basis of a limited medical examination and partly by the fact that in some instances the fitting of the shoes was less than ideal. Nevertheless, the values are probably not far from "normal" and are included as a guide, indicating that significant sex differences exist.

While the usefulness of any ataxia test is dependent on the establishment of normal values, this dependence is lessened when serial measurements are made on a single person. In the experimental situation each subject serves as his own control; in clinical evaluations, the improvements in score or lack of it in one or more test items constitutes an additional "lead."

Our experience with the Test Battery has centered mainly around its use in measuring vestibular ataxia. It was found to be a reliable indicator both of loss of vestibular function and disturbed function. With regard to the former, our findings suggest that small loss (or suppression) of semicircular canal function in the presence of normal otolith function, as revealed by the counterrolling test, is sufficient to cause slight ataxia. This is supported by the results of Igarashi, et al. (36), who produced ataxia in squirrel monkeys by the administration of streptomycin sulfate. Subsequent pathological studies revealed a significant loss of sensory epithelium of the cristae with little or no pathological changes in the maculae. The significance of these findings should be limited only to the probability that loss of semicircular canal function alone may lead to ataxia; the data are insufficient to evaluate fully the relative roles of both vestibular organs.

It was found that the ataxia in subjects with bilateral loss of labyrinthine function could be reduced with practice. This reduction was slight in the absence of visual cues, moderate in standing with eyes open, and substantial when walking with eyes open. In addition to demonstrating the role of vision and the advantage of better cues in the more dynamic test, walking, compared with standing, this practice effect pointed out the desirability of training such subjects to improve their postural equilibrium. The experience with L. D. subjects raises the question whether such training should be given to all persons with abnormally low performance scores. Old persons, for example, who have become "unsteady" might improve their postural equilibrium with appropriate training. Their performance level and improvement with practice could be determined easily. Such improvement might represent the loss in skill imposed by avoiding all circumstances where a test of skill is involved. That even L. D. subjects can improve their Test Battery performance with practice (Stand E/C performance excepted) underscores the necessity of practice (in auricular-involved individuals and normal individuals alike) to reach performance plateaus before undertaking validation studies if maximum results are to be realized.

Further experience with the Test Battery is needed to determine its limitations and exploit its usefulness. Its adaptability readily can be made for either general or specific purposes.

In the laboratory, it would appear to have great value in measuring adaptation in dynamic force environments, as our experiences with the Slow Rotation Room have shown (6,23,25). The time-courses of adaptation and rates of recovery may be studied multidimensionally in a minimum of time with the expectation of reasonable returns for the effort. Hoepfully, this, or extensions of this, approach will throw more light on the problem of understanding differential effects within the vestibular apparatus in its varied responses to differential force environments.

In the clinic, particularly otolaryngology, neurology, and geriatrics, greater attention to finer, differential details of postural equilibrium functioning may facilitate diagnostic and treatment formulations. The time-course of a disturbance or recovery of a disorder may be assessed as easily as induced disorders in the laboratory. Moreover, in the process of such continued observations additional clues to novel as well as conventional methods of rehabilitation may evolve. As reservoirs of information so obtained more or less routinely build up, unique patterns of functioning peculiar to given diagnostic categories might well become revealed and perforce aid expedition of medical situations in which ataxia is part of the problem.

Awaiting all researchers who seek a fuller understanding of postural equilibrium functioning are such problems as elaborating the practical as well as theoretical significance of appreciable differences between a given individual's visual and nonvisual performance capabilities, of differentiating more carefully locomotor and other types of ataxia from vestibular ataxia, of clarifying the notion of an "otolithic ataxia" versus a "semicircular canal ataxia," of definitively measuring differences between "dynamic" and "static" equilibrium, and of delineating apparent differences between nature- and nurture-influences upon equilibration generally.

Available vehicles for such research include the systematic study of such unusual individuals as congenitally and adventiously blind persons with and without vestibular dysfunctioning; persons with unilateral and bilateral vestibular dysfunctioning, ranging from "minimal" to "complete"; persons with circumscribed neurological handicaps and disorders involving the vestibular pathways; and apparently normal individuals with extraordinarily good postural equilibrium functioning. Most desirable are longitudinal studies which systematically include vestibular evaluations as part of the complete medical evaluation (26,40), and, ideally, the cross-sectional and longitudinal vestibular functional testing of large numbers of individuals at all ages whose temporal bones will, eventually, be made available for structural-functional correlational analysis. If in such studies the postural equilibrium evaluations are quantified, then data processing would be facilitated considerably by modern computers.

The high reliability, in our experiences, of both versions of the Test Battery, and their demonstrated validity in terms of reflecting auricular involvement and related sensory-motor functioning in widely varied situations suggest their usefulness generally as a tool for enhancing vestibular test batteries designed for more than cursory assessment of postural equilibrium functioning. In addition to high reliability and evidence of validity, each version combines uniquely the advantages of the rail method of testing, stringent body position, high ego-involving task interest and novelty, objectivity of scoring, uniformity and ease of administration (particularly the Short Version), and multi-dimensional sensitivity--locomotor versus static, visual versus nonvisual, sensory versus motor, and especially visual-motor versus vestibular-motor functioning. Moreover, there is an abundance of normative data.

Methodological limitations of the Test Battery* include the following: 1)differential test sensitivity, e.g., Walking versus Standing, or Stand Eyes Open versus Stand Eyes Closed performances, even where subjects serve as their own controls, cannot be strictly assessed inasmuch as the rails are not equated as to difficulty, and, accordingly; 2) comparative performance effects, such as exposure to prolonged rotation, between groups unmatched in performance skills, e.g., vestibular defective individuals versus vestibular normal individuals, cannot be strictly assessed; and 3) performances on any or all of the tests comprising the Test Battery do not portend definition nor even representation necessarily of postural equilibrium (or ataxia) however it may be defined, subjectively or objectively, by any other test or battery of tests.

In conclusion, the Test Battery (Short Version) has been found useful as a tool for the study of: 1) the influences, generally, of various types and degrees of clinically- or experimentally-induced vestibular disturbances; 2) adaptation and habituation to unusual force environments; 3) the nature of rotation and post-rotation effects (6,23-25, 47); 4) the effectiveness of antimotion sickness drugs and other pharmacological agents (63), and 5) relationships between postural equilibrium functioning and such conventional

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*The limitations are equally applicable to other equilibrium tests including the clinical-type ataxia tests and, generally, to other types of multi-dimensional performance tests.

vestibular functional tests as responses to caloric irrigation, cupulometry, counterrolling responses, et cetera. The Test Battery may prove useful in the study of: 1) the influences of sensory and sensory-motor alterations or stresses (isolation, deprivation, fatigue, boredom, suggestibility, et cetera, 59); 2) short- and long-term neuromuscular effects (including muscle atrophy) of zero G and sub-G environments, including water immersion and rotating space vehicles; 3) the influences of physiological aging and of physical fitness. In the clinic one or the other version of the Test Battery may prove invaluable for the study of problems in otolaryngology, neurology, and geriatrics.

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APPENDIX A

APPENDIX A

Postural Equilibrium Tests and Clinical-Type Ataxia Tests: Apparatus, Administration, and Scoring Procedures

APPARATUS *

Test Battery (Long Version)

Six rails of pine wood construction, each 8 feet long and each superimposed on its 5-1/2 inch wide plywood base, and each with width and height dimensions as follows: Rail 1:2-3/4" wide and 1" high (above base); Rail 2: 2-1/4" wide and 1" high; Rail 3: 1-3/4" wide and 1" high; Rail 4: 1-1/4" wide and 1" high; Rail 5: 3/4" wide and 1-1/2" high; Rail 6: 1/2" wide and 1-1/2" high. The four widest rails are attached to the top of the base, whereas the two narrowest rails are inserted within the base and held there by screws underneath to provide adequate support. Rails 5 and 6 are 1/2" higher from the base than Rails 1-4 to prevent subjects from obtaining support from the base by means of over-riding the feet. Also, to prevent splintering, primarily of Rails 5 and 6, the top of each rail is covered by 1/16" thick Fiberglas attached by means of ordinary glue. However, any wear-resistant, nonslip surface material equivalent to Fiberglas would prove satisfactory. To prevent warping, each rail is secured to the floor with screws through the base. The rails are situated in parallel position at 22-inch intervals (Figure 1A).

A more durable version of the apparatus consists of a singular metal base (with the same dimensions as each wooden base) within which each of six metal rails (with sand-blasted top surfaces and with dimensions identical with the wooden version) may be inserted readily by simple turning of two rigid-securing hand screws. Four pairs of set screws within the base permit leveling on uneven floors.

Test Battery (Short Version)

Rail No. 2 (2-1/4" wide, 30" long) and Rail No. 5 (3/4" wide, 8' long) of the Long Version (wood version or metal version) (Figure 2A) or a portable, foldable metal unit specific to the Short Version (Figure 3A).

METHOD

Test Battery (Long Version)

The tests were performed with shoes on. Most male subjects wore a military or military-type shoe with relatively thick soles, whereas most female subjects wore relatively thin-soled flats. Prior to testing, all subjects read the following instructions:

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* Utmost safety precaution is necessary on the part of the examiner to prevent possible injury of subjects from inadvertent falling.

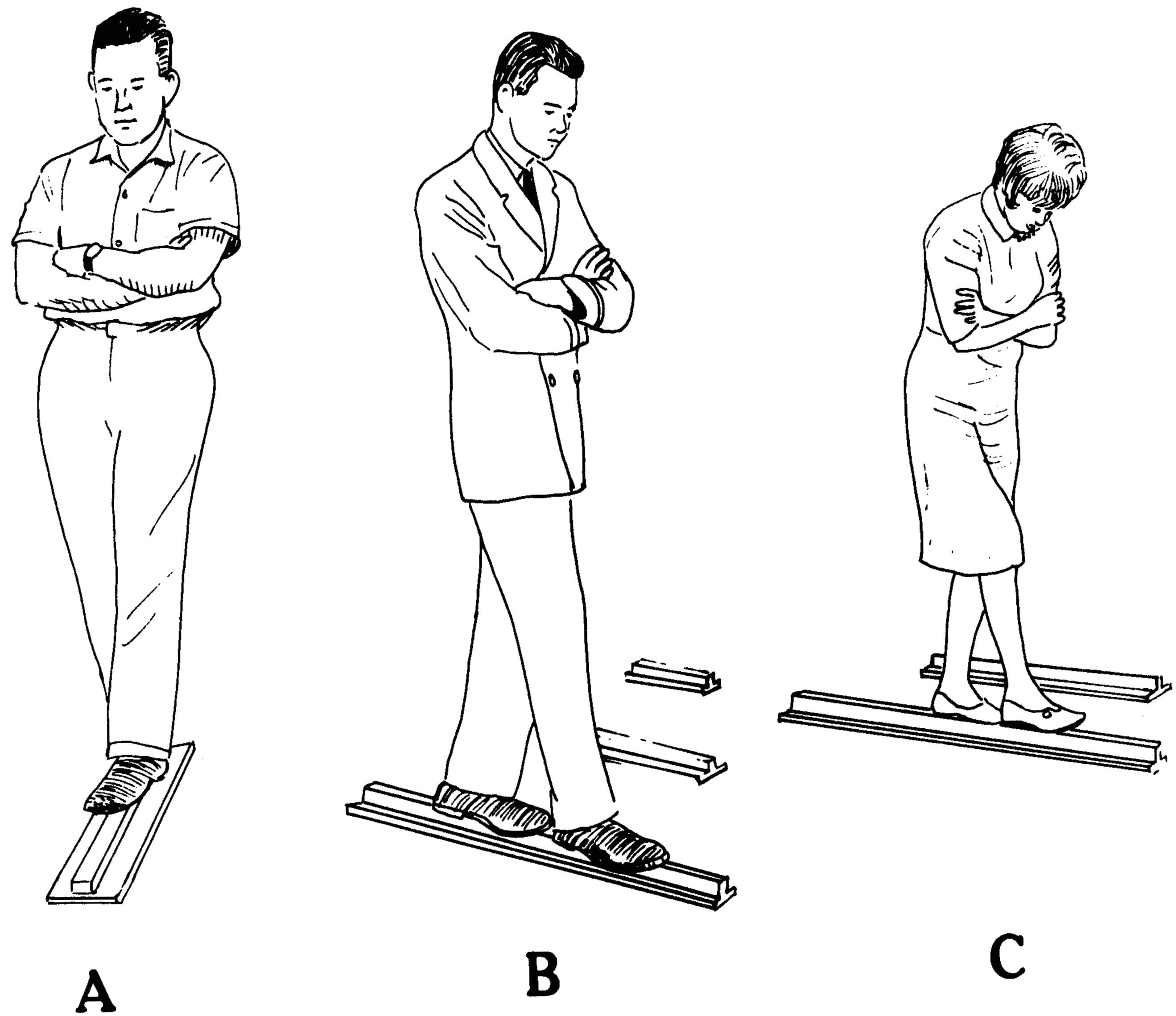


Figure 1 A
Test Battery (Long Version): A) Walk H/T Test (Walking with eyes open), B)Stand E/O Test (Standing with eyes open), and C) Stand E/C Test (Standing with eyes closed)

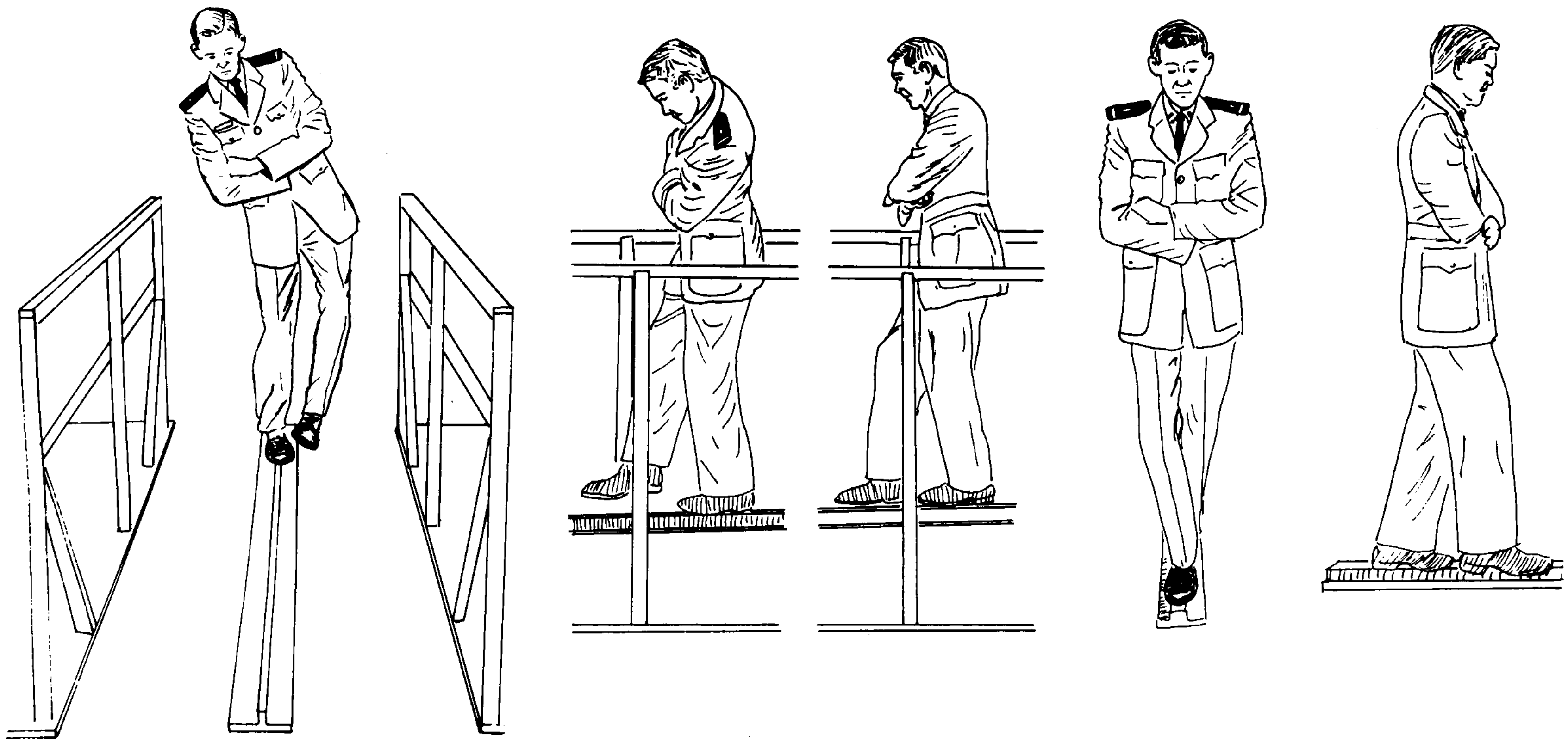
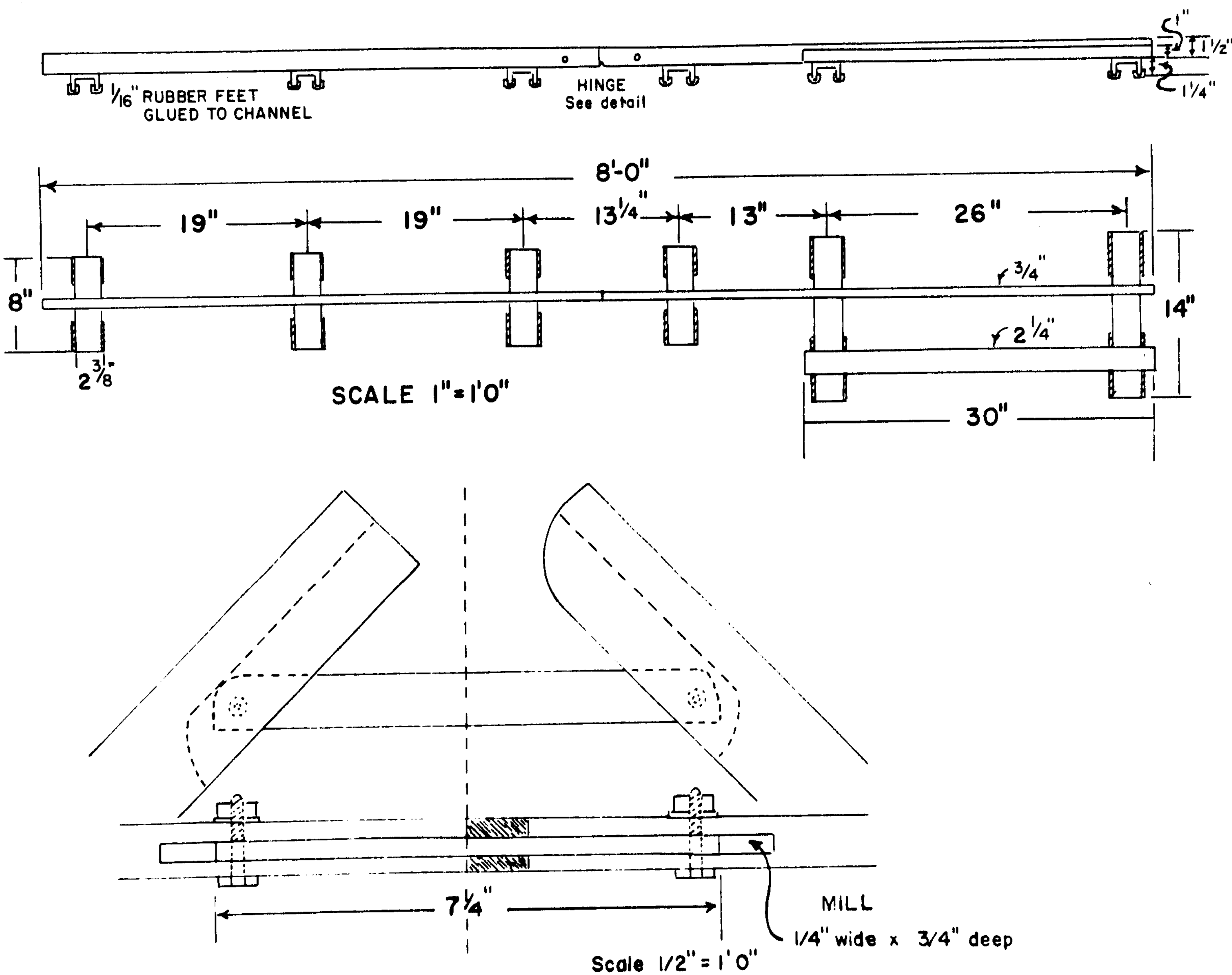


Figure 2 A
Test Battery (Short Version): A–B) Walk H/T Test (on 3/4" wide rail), C) Stand E/O Test (on 3/4" wide rail), and D–E) Stand E/C Test (on 2-1/4" wide rail)



HINGE DETAIL

Figure 3 A
Portable Metal Rail Unit, Specific to the Test Battery (Short Version)

TEST BATTERY (Long Version)
Instructions

Test Sequence:

a. Walking with eyes open on each of six rails of varying width
b. Standing with eyes open on each of the six rails*
c. Standing with eyes closed on each of the six rails

Body Position for All Tests:

a. Body erect or nearly erect
b. Arms folded against chest
c. Feet in heel-to-toe position
d. Feet tandemly aligned

Scoring: The best two out of three trials constitutes the scoring of each test.

a. Walk H/T Test - The first two steps, which are necessary for positioning on the rail, are not scored. A trial begins when the third step is taken.
b. Stand E/O Test - Timing begins as soon as correct position on the rail is assumed.
c. Stand E/C Test - You may take unlimited time for positioning yourself on the rail first with your eyes open. Timing will begin as soon as you close your eyes. Examiner will observe your eyes carefully, so that signalling the examiner is unnecessary.

General:

As there does not appear to be any single "best method," you must develop (rapidly) your own techniques. You may position your head up or down and/or forward or backward; you may lean forward or backward slightly if you do not prefer a perfectly erect position; between trials, alternation of the feet is permissible; you may place more weight on your front foot than on your rear foot or vice versa, or you may distribute your weight equally. However, a stooping position should be avoided.

After subjects read the instructions the examiner demonstrated all procedures and attempted to answer all questions raised about the manner of performing. The brief demonstration included illustrations of correct versus incorrect body and foot positions,

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*Normal subjects began on Rail 3, and if a perfect score was attained, subject was credited with perfect performances on Rails 1 and 2. If score on Rail 3 was less than perfect, testing was undertaken on Rail 2 (and Rail 1 if necessary) and upon completion subjects proceeded to Rail 4.

two or three demonstrations of walking one or more rails with emphasis that speed of walking should be considered secondary to negotiating the rails, and one or more demonstrations of appropriate positions for standing with eyes open and closed. The importance of maintaining the tandem, heel-to-toe position was reemphasized as often as necessary. Subjects were requested to avoid signalling the examiner upon closing the eyes to minimize losses of assumed position(s) on the rail(s).

Not included on the score sheet were the "false starts," defined as inadequate initial positioning on the rail leading to immediate loss of equilibrium on any trial, or a low time score (usually two or three seconds) not in keeping with a given subject's generally higher level of performance.* The scoring procedures were as follows:

Scoring Procedures

Walk H/T Test

a. Each correct step is scored as one (step)
b. Maximum trial score equals five (steps)
c. Maximum rail score equals ten (steps), or total of the two best trials
d. Total score equals 60 (steps), the sum of all six rail scores.

Stand E/O Test

a. Timing, to the nearest second, begins when subject assumes correct and balanced position on the rail, and timing ends at 60 seconds, or when subject violates his position or falls off the rail
b. Maximum trial score equals 60 (seconds)
c. Maximum rail score equals 120 (seconds), the sum of the two best trials
d. Total score equals 720 (seconds), the sum of all six rail scores.

Stand E/C Test

a. Timing begins as soon as positioned subject closes his eyes, and timing ends at 60 seconds or when subject violates his position, or opens his eyes, or falls off the rail
b. Maximum trial score equals 60 (seconds)
c. Maximum rail score equals 120 (seconds), the sum of the two best trials
d. Total score equals 720 (seconds), the sum of all six rail scores.

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*Faulty techniques may be distinguished from inability even by inexperienced examiners.

Classical and Sharpened Romberg Procedures

Prior to undertaking the Test Battery, subjects were administered one trial of the Classical Romberg test with eyes closed. Subjects who failed to stand the required 60 seconds were then administered one trial of the Classical Romberg Test with eyes open. These subjects then were administered one trial in the Sharpened Romberg position* with eyes closed. Subjects who failed to stand the required 60 seconds then attempted to stand in the Sharpened Romberg position for a period of 60 seconds with eyes open.

Test Battery (Short Version)

As with the Long Version, the tests were performed with shoes on. Again, most of the males wore a military or military-type shoe, whereas most female subjects wore relatively thin-soled flats. Prior to testing, all subjects read the following instruction sheet:

TEST BATTERY (Short Version)
Instructions

Test Sequence:

a. Walking with eyes open on a 3/4" wide rail
b. Standing with eyes open on a 3/4" wide rail
c. Standing with eyes closed on a 2-1/4" wide rail

Body Position for All Tests:

a. Body erect or nearly erect
b. Arms folded against chest
c. Feet in heel-to-toe position
d. Feet tandemly aligned

Scoring: The best three out of five trials constitutes the scoring procedure.

a. Walk H/T Test - The first two steps, which are necessary for positioning on the rail, are not scored. A trial begins when the third step is taken.
b. Stand E/O Test - Timing begins as soon as correct position on the rail is assumed.
c. Stand E/C Test - You may take unlimited time for positioning yourself on the rail first with your eyes open. Timing will begin as soon as you close your eyes. Examiner will observe your eyes carefully, so that signalling the examiner is unnecessary.

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*The Sharpened Romberg position refers to the following: Subject attempts standing on floor for 60 seconds in arms-folded-against-chest, feet tandemly aligned and heel-to-toe.

General:

As there does not appear to be any single "best method," you must develop (rapidly) your own techniques. You may position your head up or down and/or forward or backward; you may lean forward or backward slightly if you do not prefer a perfectly erect position; between trials, alternation of the feet is permissible; you may place more weight on your front foot than on your rear foot or vice versa, or you may distribute your weight equally. However, a stooping position should be avoided.

As with the Long Version, after subjects read instructions the examiner demonstrated all procedures and answered all questions raised about the performance procedures. Examiner gave two or three demonstrations of walking the 3/4" wide rail and one or two demonstrations of standing on each of the two rails. The scoring procedures were as follows:

Scoring Procedures

Walk H/T Test

a. Each correct step is scored as one (step)
b. Maximum trial score equals five (steps)
c. Maximum test score equals fifteen (steps), the sum of the three best trials.

Stand E/O Test

a. Timing, to the nearest second, begins when subject assumes correct and balanced position on the rail, and timing ends at 60 seconds, or when subject violates his position or falls off the rail
b. Maximum trial score equals 60 (seconds)
c. Maximum test score equals 180 (seconds), the sum of the three best trials.

Stand E/C Test

a. Timing begins as soon as positioned subject closes his eyes, and timing ends at 60 seconds or when subject violates his position, or opens his eyes, or falls off the rail
b. Maximum trial score equals 60 (seconds)
c. Maximum test score equals 180 (seconds), the sum of the three best trials.

Sharpened Romberg Test (SR)*

All subjects prior to undertaking the Test Battery undertook the SR test. Subjects who failed to stand for the required period of 60 seconds on the first trial were administered a second trial. Subjects who failed to stand 60 seconds on the second trial were administered a third trial before proceeding with the Walk H/T test. Subjects who failed to stand 60 seconds on the third trial were administered an additional (fourth) trial upon their completion of their Stand E/C test.

SR performance was scored as follows: a perfect score of 60 seconds on the first trial was weighted 4, and a score of 240 (60 x 4) was assigned; a perfect score on the second trial was weighted 3, and 180 (60 x 3) plus the number of seconds stood on the first trial became the assigned test score; a perfect score on the third trial was weighted 2, and 120 (60 x 2) plus the number of seconds stood on the first two trials became the assigned test score; with subjects requiring a fourth trial, the total number of seconds stood on the four trials became the assigned test score.

In addition to undertaking the SR test, a clinical-type ataxia test, on the occasion of undertaking the Test Battery our most recently tested subjects undertook two additional clinical-type tests: 1) Stand One Leg Eyes Closed Test (SOLEC), and 2) Walk Line Eyes Closed Test (WALEC).

SOLEC

Subjects undertook this test upon completion of the Test Battery. The task as a static test consists of standing on each leg (SOLEC-R and SOLEC-L) with arms folded against chest and with eyes closed for a period of 30 seconds. Subjects were not permitted to make this a dynamic test by virtue of moving the standing foot in any way. Rather, it was required that the standing foot remain stationary. However, any amount of movement of the opposite leg or of the body was permitted so long as the body was maintained in an erect or near erect position. Subjects were permitted to close their eyes at any time after assuming a correct standing position. Subjects who violated the static foot requirement were stopped immediately, and the number of seconds stood prior to violation constituted the trial score. Subjects began the test on the leg of their choice. Subjects who required more than one trial on each leg (for the perfect score criterion of 30 seconds) were requested to alternate legs on additional trials in the interest of reducing fatigue.

SOLEC performance was scores as follows: A perfect score on the first trial was weighted 5, and a score of 150 (30 x 5) was assigned; a perfect score on the second trial was weighted 4, and a score of 120 (30 x 4) plus the number of seconds stood on the first trial was assigned; a perfect score on the third trial was weighted 3, and a score of 90

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*Indicates standing in the Sharpened Romberg position with eyes closed for a maximum of four trials.

(30 x 3) plus the number of seconds stood on the two previous trials was assigned; a perfect score on the fourth trial was weighted 2, and a score of 60 (30 x 2) plus the number of seconds stood on the three previous trials was assigned; with subjects requiring a fifth trial, the total number of seconds stood on the five trials became the assigned test score.

WALEC

Subjects undertook this test upon completion of the SOLEC. The test consists of walking as straight as possible a 12-foot long line on the floor at a typical (to the subject) speed with eyes closed, arms folded against chest, and feet heel-to-toe. Subjects alternated their starting positions from trial to trial. Each scorable trial required that subject walk the entire length of the line. The number of inches of deviation from the line at the end of its 12-foot length constituted a trial score, and the total of the <u>two best trials out of three</u> (best equaled least deviant from the line) constituted the test score.*

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*A major limitation of the WALEC procedure is that in notably ataxic individuals the qualitative performance is often more deviant than the individual's score would indicate. Accordingly, the WALEC would appear to be more of a test of spatial orientation than of ataxia or of postural equilibrium.

APPENDIX B

APPENDIX B

Test Battery (Long Version) Raw Scores and Their Percentile Equivalents

	MALES									FEMALES								
	Ages 13 - 16 N = 32			Ages 17 - 42 N = 424			Ages 43 - 50 N = 9			Ages 14 - 16 N = 28			Ages 17 - 42 N = 112			Ages 43 - 50 N = 7		
% tile	W*	S/O#	S/C**	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C
99th	60	555	350	60	640	420	60	566	367	60	552	342	60	605	430	60	515	373
98th	59	550	347	59	595	402	59	559	340	59	549	340	59	601	422	59	514	362
97th	59	545	345	59	585	385	59	553	314	59	547	337	58	580	415	59	513	354
96th	58	542	342	59	575	370	59	549	287	58	545	334	57	570	395	59	512	343
95th	58	539	339	59	565	355	59	544	261	57	540	325	57	560	385	58	511	331
90th	58	525	325	59	530	320	59	539	235	57	534	321	57	530	365	58	509	318
80th	56	510	285	58	519	295	59	509	230	55	521	284	55	520	300	52	508	306
70th	54	505	244	57	510	270	59	504	192	53	514	276	54	510	280	46	507	256
60th	53	495	220	57	501	240	58	503	177	52	507	244	52	500	270	45	498	254
50th	51	485	174	55	495	200	58	500	116	51	504	233	51	498	230	44	496	144
40th	50	460	150	54	480	165	56	499	79	49	501	205	50	485	210	43	442	142
30th	48	435	140	52	460	130	55	402	77	48	478	187	48	468	169	42	438	119
25th	47	425	125	51	445	115	52	396	75	47	461	179	47	460	145	41	437	92
20th	46	410	104	50	430	90	50	361	70	47	450	166	46	450	130	40	435	75
15th	45	401	84	49	409	79	49	312	56	47	441	157	46	430	115	39	434	60
10th	43	392	80	48	402	65	48	270	41	46	420	122	45	410	80	39	434	60
9th	42	385	75	47	395	62	48	270	41	46	415	121	45	405	78	39	434	60
8th	41	370	70	47	390	58	48	270	41	45	411	121	45	400	77	39	434	60
7th	40	359	65	46	385	55	48	270	41	45	407	120	44	395	76	39	434	60
6th	39	349	55	46	380	53	48	270	41	44	405	110	44	390	75	39	434	60
5th	38	330	51	46	375	51	48	270	41	43	403	100	42	368	70	39	434	60
4th	37	315	48	45	365	49	48	270	41	43	401	90	41	345	65	39	434	60
3rd	35	305	44	44	354	47	48	270	41	43	401	90	41	320	55	39	434	60
2nd	35	305	44	43	330	45	48	270	41	43	401	90	40	305	47	39	434	60
1st	35	305	44	42	291	45	48	270	41	43	401	90	38	299	39	39	434	60

*Walk H/T (Six rails) #Stand E/O (Six rails) ** Stand E/C (Six rails)

APPENDIX C

APPENDIX C

Score Sheet

Name (Last)			Date	
Date of Birth (Mo.) (Day) (Yr.)			Age	Sex
Height	Weight	Occupation		

Trial	Walk	Stand Open	Stand Closed	SR	Stand One Leg Closed RT	LT
1						
2						
3						
4						
5						
TOTALS						

Postural Equilibrium Test Series NavScolAvnMed 3930/1 (7-63)

APPENDIX D

APPENDIX D

Test Battery (Short Version) Raw Scores and Their Percentile Equivalents

	MALES									FEMALES								
	Ages 17 – 42 N = 235			Ages 43 – 50 N = 360			Ages 51 – 53 N = 14			Ages 18 – 29 N = 41			Ages 30 – 49 N = 47			Ages 50 – 59 N = 11		
% tile	W*	S/O#	S/C**	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C	W	S/O	S/C
99th	15	163	180	15	125	180	15	41	42	15	61	180	15	48	180	15	27	121
98th	15	146	179	15	66	177	15	39	41	15	58	175	15	44	174	15	25	118
97th	15	137	177	15	56	175	15	37	40	15	56	170	15	40	169	15	24	115
96th	15	128	176	15	46	172	15	35	39	15	54	165	14	36	163	15	23	111
95th	15	122	174	15	42	170	15	33	38	15	52	160	14	34	141	15	22	107
90th	15	74	173	14	30	136	14	32	35	15	50	153	13	32	120	14	19	103
80th	15	50	172	13	24	81	13	16	27	14	44	150	12	24	80	13	18	89
70th	14	39	154	12	20	54	12	14	23	13	32	107	11	20	60	10	17	58
60th	13	30	123	11	17	43	11	12	21	12	25	90	10	17	39	9	15	33
50th	13	25	92	10	15	33	10	11	20	11	21	64	10	16	31	8	13	30
40th	12	22	68	9	14	28	9	10	18	11	18	51	9	14	24	7	11	25
30th	11	19	47	8	12	23	7	9	16	10	16	33	8	12	20	6	9	19
25th	10	17	39	8	11	21	6	9	16	10	15	28	7	11	18	5	8	19
20th	10	16	35	7	10	19	4	8	15	9	14	26	7	10	15	4	7	18
15th	9	15	26	7	10	15	2	8	14	8	12	22	6	9	12	3	7	15
10th	8	13	20	6	9	14	1	7	13	7	12	18	6	8	11	3	7	12
9th	8	13	19	6	9	14	1	7	13	7	12	18	5	7	11	2	6	9
8th	8	13	18	6	8	13	1	7	12	6	12	18	5	7	11	2	6	6
7th	7	12	17	5	8	13	1	6	11	6	12	17	5	6	11	2	6	6
6th	7	11	16	5	8	12	1	6	11	6	12	17	5	6	10	2	6	6
5th	6	11	15	5	7	12	0	6	11	5	11	16	4	6	10	2	5	6
4th	5	10	15	5	7	11	0	6	11	5	11	15	4	6	10	1	5	5
3rd	5	9	14	5	7	10	0	5	11	5	11	14	4	5	9	1	5	5
2nd	4	9	13	4	6	9	0	5	11	4	10	13	3	5	8	1	5	5
1st	4	8	12	3	5	8	0	5	11	3	9	8	2	5	6	1	5	5

*Walk H/T (3/4" wide rail) #Stand E/O (3/4" wide rail) **Stand E/C (2-1/4" wide rail)

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A new multi-dimensional quantitative ataxia test battery employing the "rail method" of testing was developed to assess more precisely than heretofore postural equilibrium-disequilibrium under unusual conditions and stresses such as rotating environments.

High reliability, including test-retest reliability, was demonstrated for each of two versions: a Long Version employing six rails of varying widths, and a Short Version employing two of these rails. Normative standards covering a wide age range, and age, height, and weight influences upon performance, tentative sex differences in performance, practice effects, and Test Battery relationships with several clinical-type ataxia tests were determined. Validity of the standardized test procedures in the laboratory, in the field, and in clinical situations was demonstrated, and present and future uses of the Test Battery in normals and auricular-involved individuals in vestibular research as well as in related research-clinical areas were outlined, and several methodological limitations were indicated.

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Postural equilibrium functioning Ataxia tests Vestibular functional tests Psychomotor skills Otoneurological tests						

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