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VALIDITY OF AN OCCUPATIONAL STRENGTH TEST BATTERY (STB) FOR EARLY IDENTIFICATION OF POTENTIAL UNDERWATER DEMOLITION TEAM AND SEA/AIR/LAND TEAM TRAINEES

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An experimental strength test battery (STB) including 11 tests measuring 4 strength factors (static, dynamic, power, and anthropometric) was administered to underwater demolition team (UDT) and sea/air/land (SEAL) trainees, and results were validated against attrition. Tests that were predictive were anthropometric (weight and weight/height squared), dynamic (sit-ups, push-ups, pull-ups), and power (ergometer).

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Results indicated that an STB for occupational classification should include dynamic types of strength tests to predict performance in Navy jobs requiring rapid, extensive body movement. Also, the STB could be used to identify larger numbers of highly qualified potential UDT/SEAL trainees and thus reduce historically high levels of training attrition.

FOREWORD

This project was initiated in response to a request from Commander, Naval Military Personnel Command (NMPC-5) (Occupational Systems Department) to develop occupational strength standards "to allow the Navy the best choice of personnel assignment in a time of access to a decreasing manpower pool." The objectives of the project are to (1) develop a strength test battery (STB) to predict how well personnel will perform muscularly-demanding job tasks, (2) identify the most muscularly-demanding tasks of Navy jobs and shipboard duties, and (3) determine the percentages of men and women capable of performing those tasks. The project is in support of work unit N6298083-WRW5072 (Occupational Physical Requirements).

A previous report (NPRDC Tech. Rep. 82-42) described the development of the STB (objective 1). It is important that the tests in the STB be versatile enough to predict performance in a variety of Navy activities with substantial muscular demands. The present effort was conducted to evaluate the STB's usefulness in predicting trainee success at the Basic Underwater Demolition/Sea/Air/Land (SEAL) School (BUDS), Naval Amphibious Base, Coronado, California, and to identify potential applicants for this training. The work is related to previous research (NPRDC Spec. Rep. 81-13) conducted to determine how student selection, student motivation, and administrative policies affect BUDS attrition. Subsequent efforts will evaluate the STB's usefulness in predicting performance on other Navy job tasks.

The assistance of the following persons is gratefully acknowledged: FTCM G. L. Hamm and RMC R. E. Hayden of the BUDS staff, for scheduling trainees to take the STB, and LT E. J. Marcinik of the Naval Health Research Center, for STB administration. Also, discussions with CAPT J. T. Williams, former Commanding Officer, Naval Amphibious Schools (NAVPHIBSCOL), Coronado; CDR J. J. Couture, former Executive Officer, NAVPHIBSCOL (and former Director, BUDS School); and CDR T. S. Nelson, former Director, BUDS School, provided valuable insights during the analysis phase of this report.

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SUMMARY

Problem

The Naval Military Personnel Command (NMPC-5) has identified a requirement to develop physical standards, where needed, for Navy job specialties and shipboard duties with substantial muscular demands. Some of these work activities include handling heavy components of machinery or weapons systems with relatively little body movement. Others involve rapid movement in extreme environments of soft sand and water.

The work of the underwater demolition team (UDT) and sea/air/land (SEAL) team involves the latter kind of activities. The physical demands of the job and training rank with the most rigorous of military activities. Attrition in training tends to be very high, especially during indoctrination and Phase I training, and sufficient numbers of graduates are not always available to staff the special warfare units in the fleet.

Objectives

The objectives of this effort were to determine (1) the validity and versatility of a basic strength test battery (STB) in predicting training performance at the Basic UDT/SEAL (BUDS) School, and (2) whether more effective selection procedures are needed to increase the number of BUDS graduates.

Approach

Attrition data for 20 BUDS classes over a 4-year period were analyzed. The STB was administered to two of these classes immediately prior to the beginning of Phase I training. The following measures were evaluated to determine whether they could be used to predict attrition during Phase I training: weight, height, weight/height squared, percent fat, sit-ups, push-ups, pull-ups, bent-arm hang, hand-grip, arm-pull, arm-lift, ergometer, 4-mile run, and obstacle course.

Predictor scores of successful and nonsuccessful BUDS trainees were compared, correlational and multiple regression analysis were performed to determine the validities of individual and composite predictors of attrition, and composite scores of successful BUDS trainees and Navy recruits were compared.

Findings

1. During a 4-year period, the average attrition rate was 61 percent of those starting the indoctrination phase of training.

2. Attrition decreased briefly when some intervention strategies for instructor techniques were applied but then returned to historical levels.

3. The individual tests found to be related to attrition were (a) anthropometric (weight and weight/height^2), (b) dynamic (sit-ups, push-ups, pull-ups), and (c) power (ergometer). The composite tests found to be related to attrition were (a) two multiple-regression analyses, which yielded cross validities of .34 and .49, and (b) unit-weighted tests in a field composite, which yielded a validity of .42.

4. BUDS trainees performed at considerably higher levels on the STB than did Navy recruits. Nonetheless, a comparison between the two performance distributions revealed that a sizeable number of Navy recruits are physically qualified for BUDS recruitment.

Conclusions

1. STB dynamic strength measures (sit-ups, push-ups, and pull-ups) and relative body weight (weight-to-height^2) are valid predictors of success in BUDS Phase I training. This finding is consistent with other investigations that have reported a strong relationship between BUDS attrition and dynamic physical tests such as calisthenics, swimming, and running.

2. Present minimum performance requirements on physical selection tests, particularly sit-ups, push-ups, and pull-ups, are substantially below the average of BUDS fail groups, and are therefore inadequate for final screening of applicants.

3. Applicant screening procedures could be substantially improved, and attrition rates reduced, by decreasing selection ratios. This could be accomplished by increasing the size of the applicant pool and applying a selection cut-score to a composite of maximum effort performance tests, instead of the present procedure of requiring minimum performance on a series of individual tests.

4. The size of the applicant pool might be increased, thereby providing more favorable selection ratios, by identifying potential BUDS trainees from recruit populations.

Recommendations

It is recommended that OP-13 (Special Warfare):

1. Initiate further research to develop and validate potentially useful tests identified by this effort and other research (e.g., run and swim tests).

2. Specify selection procedures that require applicants to perform to their maximum ability on each test rather than those that require applicants to achieve only a minimum score.

3. Select applicants with the highest scores on a composite.

4. Increase the size of the BUDS applicant pool by early identification of high-potential applicants, particularly at recruit training centers.

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INTRODUCTION

Problem

The Naval Military Personnel Command, Occupational Systems Department (NMPC-5), has identified a requirement to develop physical standards, where needed, for Navy job specialties and shipboard duties with substantial muscular demands. Some of these work activities include handling heavy components of machinery or weapons systems with relatively little body movement. Others involve rapid body movement in extreme environments of soft sand and water.

The work of the underwater demolition team (UDT) and sea/air/land (SEAL) team involves the latter kind of activities. The physical demands of the job and training rank with the most rigorous of military activities. Attrition in training tends to be very high, and sufficient numbers of graduates are not always available to staff the special warfare units in the fleet (Doherty, Trent, & Bretton, 1981).

Objectives

The objectives of this effort were to determine (1) the validity and versatility of a basic strength test battery (STB) (Robertson, 1982) in predicting training at the Basic UDT/SEAL (BUDS) School, and (2) whether more effective selection procedures are needed to increase the number of BUDS graduates.

Background

Selection Requirements

To be admitted to BUDS School, applicants must be between the ages of 18 and 31 years, score a total of 105 on two Armed Services Vocational Aptitude Battery (ASVAB) subtests (word knowledge and arithmetic reasoning--WK + AR), and pass a physical screening test.[1] In the physical screening test, the applicant must (1) swim 300 yards within 7-1/2 minutes, (2) run 1 mile within 7-1/2 minutes, and (3) perform certain calisthenics--30 push-ups, 30 sit-ups, and 6 pull-ups--each within 2 minutes.

Under current selection procedures, the physical performance tests for BUDS applicants are administered at various special warfare activities or by BUDS staff members who travel to other Navy installations. The tests are performed in the following sequence: 300-yard swim, 30 push-ups, 30 sit-ups, 6 pull-ups, and a 1-mile run (in boots). Rest periods range from 2 to 10 minutes between tests.

BUDS School Training

BUDS School training includes a 2-week indoctrination period (Indoc) followed by three training phases. Phase I (6 weeks), in which most attrition occurs (64 percent of all post-Indoc attrition (Doherty et al., 1981), requires extremely rigorous physical conditioning under highly stressful conditions, especially during the fourth week--called

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[1]Chief of Naval Operations OPNAV NOTICE Ser 132C10/375336; Subj: Enlisted entry to the Navy Diving, Special Warfare (UDT/SEAL), and Explosive Ordnance Disposal (EOD) Programs; procedures concerning, 21 May 1981.

"Hellweek." Phase II (7 weeks) and Phase III (10 weeks) emphasize the technical and combat requirements of UDT/SEAL Teams; attrition during these final 17 weeks includes considerable academic as well as physical failure.

Previous Research

Several investigations have explored a number of physiological and psychological measures to determine how they relate to BUDS training performance. Hertzka and Anderson (1956), who analyzed four BUDS classes with a combined attrition rate of 43 percent, found high correlations between graduation and swimming and physical fitness tests: Backstroke, .45; breaststroke, .52; sidestroke, .50; underwater swim, .44; 1-mile run, .44; push-ups, .26; and sit-ups, .30. Multiple regression analysis with several of these measures yielded a multiple R of .64, although no cross-validation was performed. Correlations were low for the Navy Basic Test Battery (BTB) of technical aptitude and for a battery of personality characteristics. Biersner, Gunderson, Ryman, and Rahe (1972) reported correlations between success in a pre-UDT training program and sit-ups (.24), pull-ups (.31), and squat-jumps (.28).

Doherty et al. (1981) evaluated psychological, technical, and attitudinal measures for four entering BUDS classes with an attrition rate of 44 percent. The measures that correlated highest with a criterion of BUDS graduation included: the 300-yard swim, .31; the 1-mile run, .28; an ASVAB composite (WK + AR), .29; the mathematics inventory (a basic mathematics test administered during Phase I), .44; and a battery of personality/attitude tests, .52. A multiple regression analysis (using the 300-yard swim, prior scuba qualification, the mathematics inventory, the 1-mile run, and the WK + AR composite) yielded a multiple R of .48 and a cross-validity of .35. Personality measures were not included in this analysis because of vulnerability to faking. A curvilinear relationship of age with graduation was observed, with lower rates of success for trainees younger than 19 or older than 29. This finding was similar to one reported by Hertzka and Anderson (1956).

Doherty et al. (1981) also monitored training practices and attrition during the extreme rigors of Hellweek for 12 BUDS classes. Changes in instructor techniques were recommended and applied as intervention strategies. Hellweek attrition dropped substantially for five of six post-intervention training classes.

Strength Test Battery (STB)

The STB (Robertson, 1982) evaluated in this research contained 11 tests measuring 4 strength factors:

1. Static strength--Handgrip, arm-pull, and arm-lift, all measured by dynamometers.

2. Dynamic strength--Sit-ups, push-ups, pull-ups, and bent-arm hang.

3. Power--A measure of upper-torso strength using a hand-cranked ergometer to simulate job tasks that involve a turning or pumping activity.

4. Anthropometric--Measures of height, weight, and skinfold at the abdominal site.

Additional scores derived from the anthropometric measures included lean body weight, fat body weight, and percent body fat.[2] Robertson (1982) described STB administration and scoring procedures, distribution statistics and intercorrelations for Navy recruit populations of men and women, and several strength and body weight tests that predicted simulated job tasks of cranking or pumping activities, using the ergometer as the criterion. The best predictor for men was lean body weight ($r = .45$); and for women, arm-pull ($r = .36$).

METHOD

Predictor Variables

Strength Test Battery (STB)

The STB was administered by the procedures described by Robertson (1982), except for three modifications. Because BUDS trainees are much more capable than are male recruits in performing the sit-up and ergometer tests, the maximum allowable performance times for these two measures were increased: (1) from 30 to 120 seconds for sit-ups, and (2) from 30 to 60 seconds for the ergometer test. Also, BUDS trainees wore field clothing (including boots) while performing pull-ups, which increased body weight by 6 pounds for each trainee.

In addition to recording scores for height, weight, body fat, and the eight strength tests, height and weight were used to calculate weight-to-height squared.[3] A field composite was developed using tests that had been shown to be predictive of BUDS attrition and did not require measurement apparatus to be transported to field locations. The field composite score was calculated by the following formula: sit-up + 32 (weight-to-height^2 x 100) + .4 push-up + pull-up. The weights were approximated after individual variables in other studies had been examined. Greater weights were applied to variables demonstrating higher validities, and then were adjusted for the relative size (to sit-up) of each variable's standard deviation in the present data set.

To summarize, the following 13 scores were produced: weight, height, weight-to-height^2, percent body fat, sit-ups, push-ups, pull-ups, bent-arm hang, handgrip, arm-pull, arm-lift, ergometer, and field composite.

BUDS First Week Training Performance

Additional data were extracted from school records. Trainee performance times were recorded for one 4-mile run and one obstacle course run during the first week of Phase I training (the research staff was not present to observe testing conditions). Scores for these two tests were also analyzed for their validity in predicting completion of Phase I training.

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[2]Percent body fat was estimated from the skinfold measures and weight, using the Wilmore and Behnke (1969) formula.

[3]Weight-to-height^2 was evaluated because it is a better measure of relative body weight than is weight-to-height (Keys, 1980).

Sample

During the second week of Indoc, the STB was administered to a total of 69 BUDS trainees who were members of two successive classes (101 and 102). To evaluate the STB's validity, formal testing was suspended with class 103 when program interventions recommended by Doherty et al. (1981) were implemented. Because the STB's usefulness in predicting success in physical training activities was of primary interest, administrative and medical attritees were excluded from the sample. Of the resulting trainees, 27 (39%) completed Phase I training, and 42 (61%) attrited.

Criterion

The criterion variable analyzed was the successful completion of BUDS Phase I training, the period of extremely strenuous physical and mental conditioning in which much of the school's attrition occurs. A dichotomous criterion was used, with trainees who completed Phase I (pass group) coded 2 and attriters (fail group) coded 1.

The data used in the analysis were extracted from school records for 20 successive training classes: from Class 94 entering May 1977, through Class 113 entering February 1981.

Analyses

Overall graduation (Phase I-III) and attrition for trainees in Classes 94 through 113 were tracked over a 4-year period. The numbers of trainees reporting to Indoc, starting Phase I, and graduating from Phase III were tallied, and attrition percentages (1) during Indoc, (2) from Indoc through Phase III, and (3) from Phase I through Phase III were calculated. Data for trainees from seven classes (Classes 94-100) conducted before STB was administered (to Classes 101 and 102) were analyzed to establish an attrition baseline. In addition, five classes (109-113) were tracked after Doherty et al.'s (1981) post-intervention period had been completed.

The mean scores of the pass and fail groups were compared for the STB tests, field composite, 4-mile run, and obstacle course. Significant differences were determined, using the two-tailed t-test.

The validities of predictor variables were calculated by the point-biserial correlation formula and tested for statistical significance. Given the pass:fail ratio of 39:61, the maximum point-biserial r was .79 (Guilford & Fruchter, 1973).

Two-thirds of the sample (N = 46) was randomly assigned to a multiple regression analysis group; and the other third (N = 22), to a cross-validation group. Because of the relatively small sample sizes, a second random two-thirds/one-third sort was performed and a second multiple regression and cross-validation analysis were conducted to test the stability of the results. In each analysis (Sorts 1 and 2), the cross-validity was evaluated from b weights of the first four STB variables to enter the stepwise regression program.

An empirical demonstration of the effects of screening, using rank-ordered field composite scores, was performed for three selection ratios--100, 70, and 50 percent selection from the applicant pool. The size of the applicant pool was varied to maintain a constant number of selectees (N = 69) by weighting the Ns of the 70 percent selection situation by 1.43 and the 50 percent situation by a weight of 2. Thus, in the 70 percent situation, 69 applicants were selected from a simulated pool of 99; and in the 50 percent situation, 69 applicants were selected from a pool of 138. For each situation, the numbers and percentages of correct and incorrect selectees and Phase I graduates were tallied.

A theoretical expectancy chart was constructed, applying the Lawshe, Boldo, Brune, and Auclair (1958) tabular data, to display the probabilities of passing BUDS for five intervals of field composite scores (from the top through the bottom quintiles). The percentage completing Phase I (39%) was used for base rate data, and the result of the validation of the field composite (r = .48) was used for the value of the validity coefficient in computing the results.

For the purpose of early identification of potential BUDS applicants in a recruit population, the field composite was also calculated from a sample of male recruits (RTC). Mean scores on all STB tests were compared between the RTC and BUDS samples. In addition, the approximate percentages and annual numbers of recruits with field composite scores within the range of performance of the BUDS pass group were determined.

RESULTS

Historical Attrition Analysis

Table 1 presents the numbers and percentages of BUDS trainees, graduates, and attrites for 20 successive classes (94-113) over a 4-year period (May 1977-February 1981). Although a total of 1532 applicants reported to Indoc, only 1173 started Phase I training, representing a pretraining loss of 23 percent. (A detailed analysis of BUDS pretraining attrition was reported by Doherty et al. (1981). A total of 599 trainees graduated from Phase III, which represents an overall attrition rate of 61 percent of the 1532 Indoc trainees and 49 percent of the 1173 trainees who started Phase I training.

The Phase I through Phase III attrition rates of the two classes that had been administered the STB (101 and 102) were 67 and 54 percent respectively. These rates are similar to those of the preceding seven classes (94-100), which had a combined Phase I-III attrition of 59 percent.

Table 1 also reflects the substantial drop in attrition experienced by the post-intervention classes (103-108) (Doherty et al., 1981). These classes experienced a combined Phase I-III attrition of only 36 percent. However, Table 1 also shows a significant rise in attrition after the post-intervention period. In fact, for Classes 109-113, the combined Phase I-III attrition is 49 percent, which is identical to the 4-year historical average.

Predictor Scores of Pass and Fail Groups

Table 2 presents the average scores and standard deviations of the pass and fail groups for all predictor variables. As shown, the pass group scored significantly higher than did the fail group on 4 of the 12 STB measures--sit-ups, push-ups, pull-ups, and ergometer--and higher but not significantly higher, on all other STB tests except height and arm-lift. The pass group also scored significantly higher than did the fail group on the field composite but not on the 4-mile run and the obstacle course.

Table 1

Class Size and Attrition Percentages for 20 BUDS Classes

Class[a] ID No.	Number of Trainees: Reported Indoc[b]	Started Phase I	Graduated	Percent Attrition: Indoc	From Reporting to Indoc. Through Phase III	From Start of Phase I Through Phase III
94	87	54	21	38	76	61
95	105	66	38	37	64	42
96	79	48	23	39	71	52
97	94	67	12	29	87	82
98	103	70	37	32	64	47
99	97	78	35	20	64	55
100	86	69	18	20	79	74
101	75	54	18	28	76	67
102	40	24	11	40	72	54
103	70	55	39	21	44	29
104	90	82	56	9	38	32
105	88	85	60	3	32	29
106	95	84	54	12	43	36
107	77	69	43	10	44	38
108	87	82	40	6	54	51
109	83	54	30	35	64	44
110	66	41	19	38	71	54
111	41	34	21	17	49	38
112	25	22	11	12	56	50
113	44	35	13	20	70	63
Total	1532	1173	599	23	61	49

[a]Range of starting dates: May 1977 (Class 94) through February 1981 (Class 113).

[b]Indoc is a 2-week indoctrination period immediately preceding Phase I.

Table 2

Means, Standard Deviations, and Validity Coefficients

Test	Total (N=69)		Pass (N=27)		Fail (N=42)		Validity Coefficient[b]
	$\bar{X}$	SD	$\bar{X}$[a]	SD	$\bar{X}$	SD	
STB							
Weight (lbs.)	160.6	18.14	165.5	17.94	157.5	17.77	.22*
Height (in.)	69.4	2.27	69.2	2.61	69.6	2.04	-.06
Wt/Ht^2 (x100)	3.3	.29	3.4	.27	3.3	.28	.33**
Percent fat	11.2	1.82	11.6	1.91	10.9	1.74	.18
Sit-ups (no.)	56.6	9.48	61.3**	8.55	53.6	8.87	.40**
Push-ups (no.)	52.2	13.68	56.8*	12.02	49.3	14.00	.27*
Pull-ups (no.)	12.5	3.72	13.7*	3.11	11.7	3.91	.26*
Bent-arm hang (sec.)	39.9	11.85	42.0	10.70	38.6	12.47	.14
Hand-grip (km)	52.2	8.32	52.5	7.48	52.0	8.91	.03
Arm-pull (lbs.)	153.9	28.93	157.1	27.39	151.9	30.02	.09
Arm-lift (lbs.)	119.8	24.66	117.4	22.23	121.3	26.26	-.08
Ergometer (revs.)	119.5	14.41	124.1*	13.94	116.5	14.07	.26*
Field Composite[c]	196.4	19.64	208.0**	14.96	188.8	18.71	.48***
BUDS First Week							
4-mile run (min.)	30.6	2.22	30.5	1.52	30.8	2.71	-.07
Obstacle course (min.)	11.9	2.15	11.5	1.95	12.2	2.28	-.17

[a] Significance level for differences between pass and fail groups is displayed on the higher value.

[b] Point-biserial r. Criterion (Phase I attrition) coded: fail = 1 (61%); pass = 2 (39%). Maximum point-biserial r_{pbi} = .79 for 61%:39%, fail:pass group (Guilford & Fruchter, 1973).

[c] Composite = sit-up + (32 x (weight/height^2) x 100) + (.4 x push-up) + pull-up.

*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

Test Validity

Individual Tests

Table 2 also presents the validity coefficients between attrition and predictor variables. Except for the 4-mile run and the obstacle course, a positive correlation indicates that higher scores are associated with completing Phase I training. Thus, 6 of the 12 STB measures were found to be significant predictors of Phase I attrition: weight, weight-to-height^2, sit-ups, push-ups, pull-ups, and ergometer.[4] The static measures of upper-torso strength (hand-grip, arm-pull, and arm-lift) showed little relationship with the criterion. Percent fat and bent-arm hang were positively but not significantly related to attrition, and height was slightly negative. Although the correlations for the 4-mile run and the obstacle course were in the expected direction, these measures were not significantly related to attrition.

Composite Tests

Table 2 shows that the field composite was found to be highly predictive of Phase I attrition. Table 3, which presents the results of the two multiple regression and cross-validation analyses of STB variables, shows that, in both cases, the cross-validation r's were statistically significant.

Table 3

Results of Multiple Regression Analyses and Cross-validation

Variable (in order entered)	Regression Analysis R	Regression Analysis b Weight	Cross-validation r	Cross-validation $p \leq$
First Two Thirds/One Third (46/22) Sort				
Sit-ups	.40	.017		
Arm-pull	.43	-.005		
Weight/Height^2	.47	.580		
Pull-ups	.51	.028		
Constant		-1.113		
Composite (of above four)			.49	.010
Second Two Thirds/One Third (46/22) Sort				
Sit-ups	.42	.007		
Weight/Height^2	.52	.985		
Pull-ups	.59	.042		
Hand-grip	.61	-.011		
Constant		-2.200		
Composite (of above four)			.34	.058

[4] The maximum possible r equals .79 (see page 4).

DISCUSSION

Dynamic vs. Static Strength Tests

The results of this research suggest that dynamic strength tests (sit-ups, push-ups, and pull-ups) are better predictors of BUDS Phase I training performance than are static strength tests (hand-grip, arm-pull, and arm-lift). Further, the kinds of training and operational tasks performed by UDT/SEAL team personnel provide considerable face validity for including dynamic strength measures in a selection test battery. This view is supported by previous research results (Hertzka & Anderson, 1956; Biersner et al., 1972; Doherty et al., 1981). However, it contrasts with that of other on-going validation investigations of the STB, in which static strength measures have been found to be better predictors of tasks involving lifting, pulling, or pushing heavy objects when little rapid or prolonged movement of the body is involved (Robertson & Trent, 1983). These contrasting findings suggest that it is necessary to include both dynamic and static measures in the STB to maximize its usefulness in predicting performance in a wide variety of Navy job tasks.

The utility of the dynamic strength tests (especially sit-ups) was further demonstrated when comparing the similar validities of the STB composite (produced by multiple regression analysis) and the field composite. As a practical selection device, the field composite is more advantageous because it is simpler to compute and does not require testing instrumentation (e.g., dynamometers, ergometers, or skinfold calipers).

Alternative Approaches to Reduce Attrition

As evidenced by historically high attrition rates, Indoc and Phase I training (especially "Hellweek") both tend to operate as additional screening methods. However, when applicants fail during such training, sizeable costs result in terms of lost work time, travel, and training. Improved field screening procedures that would identify those who are unlikely to complete BUDS School before they commence training may be substantially more cost effective than using the high BUDS attrition rate as a screening device.

The findings in the present report are consistent with those of other investigations regarding the predictability of dynamic tests such as calisthenics, running, and swimming activities. Efforts to reduce BUDS attrition require better selection tests, using predictors presently and previously identified.

Because the BUDS School requirements for individual performance tests are substantially lower than the average scores of the fail group (see Table 2), such scores would be ineffective as screening devices (but they could be used for preliminary screening). To reduce attrition by better use of known predictors, the selection ratio must be decreased by increasing the number of applicants and selecting only those scoring highest on a composite battery. This would require a change in test administration procedures; that is, applicants would perform to their maximum on each test in the composite, rather than just satisfying minimum standards.

Table 4 shows the effects of selecting only those applicants scoring highest on a composite battery for three alternative selection ratio situations. The 100 percent situation describes the present empirical sample: all 69 applicants were selected, 27 (39%) passed and 42 (61%) failed. However, if only the top 70 or 50 percent of the applicants had been selected, the number passing from a controlled input class size of 69 would have increased to 34 (49%) or 45 (65%) respectively. In terms of savings in training costs, decreasing the selection ratio (from 100 to 70 or 50) would mean that the percentage of selected candidates who failed would decrease from 61 percent to 51 or 35 percent. These increases in correctly selected trainees and decreases in incorrectly selected trainees would, of course, require larger numbers in the applicant pool.

Table 4

Effects of Using STB Field Composite for Screening

Selection Ratio (%)	Applicant Pool[a] (N)	STB Screening: Select (N)	STB Screening: Non-select (N)	Phase I Results Selectees: Fail (N)	Fail (%)	Pass (N)	Pass (%)
100	69	69	0	42	61	27	39
70	99	69	30	35	51	34	49
50	138	69	69	24	35	45	65

[a]Analysis based on preselected BUDS trainees; thus, "Applicant Pool" is defined as BUDS applicants who satisfy existing selection standards. The two larger applicant pools were simulated by weighting the 70 percent Ns by 1.43 and the 50 percent Ns by 2 to standardize the number of selected trainees.

In Figure 1, which presents the probability of individuals with various field composite scores completing Phase I, the base rate of 39 percent passing and the field composite validity of .48 were applied to the Lawshe et al. (1958) tabular data. An applicant with a score in the top quintile would have a 69 percent chance of completing Phase I training, compared to 50, 28, or 14 percent for applicants in the second, fourth, or bottom quintiles.

Increasing BUDS Applicant Pool

The size of the BUDS applicant pool could be increased by identifying those persons in recruit training who have the exceptional physical capabilities that are required for BUDS training. Once identified, those persons could be counseled and encouraged to apply. Table 5, which compares the STB scores of BUDS trainees and recruits, shows that BUDS trainees have about the same body weight but proportionally less body fat. Also, as expected, BUDS trainees performed substantially better on most strength measures, especially the dynamic tests.

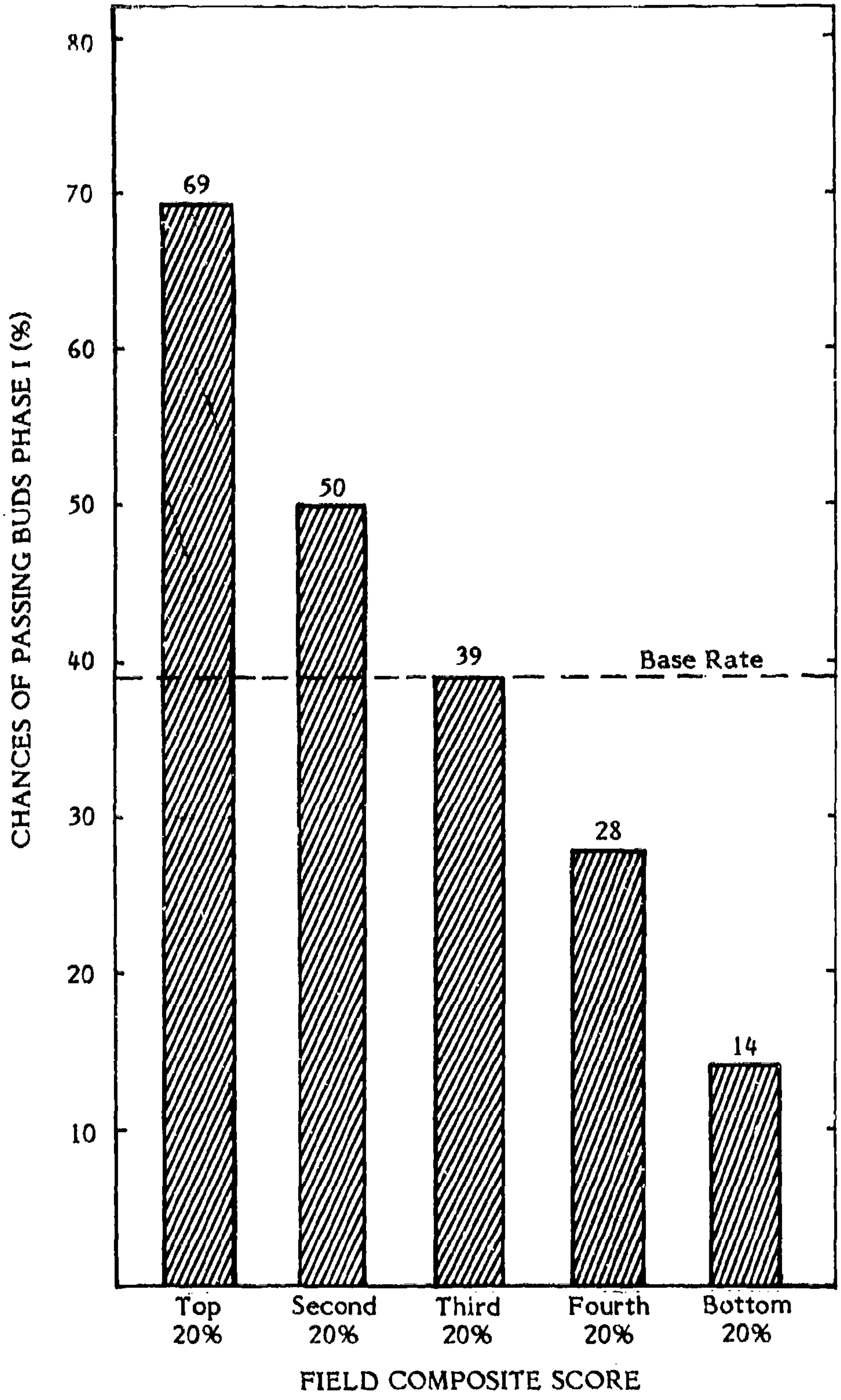

Figure 1. Individual expectancy chart derived from field composite scores, applying Lawshe et al. (1958) tables.

Table 5

STB Scores Obtained by BUDS Trainees and Male Recruits

STB Test	Mean Score: BUDS Trainees (N = 69)	Mean Score: Male Recruits[a] (N = 493)
Weight	164.6	157.3
Height	69.4	68.9
Weight/Height^2	3.3	3.3
Percent fat	11.4	12.5
Sit-ups[b]	55.7	20.2
Push-ups	50.5	25.5
Pull-ups[c]	10.8	6.1
Bent-arm hang	44.6	35.0
Hand-grip	50.4	46.6
Arm-pull	160.1	157.0
Arm-lift	118.4	98.9
Ergometer[b]	106.1	68.4

[a]Recruit posttest data (Robertson, 1982).

[b]Scores for the two groups differ, since tests were administered under different conditions. For sit-ups, BUDS trainees were allowed 120 seconds; and recruits, 30 seconds. For the ergometer, BUDS were allowed 60 seconds; and recruits, 30 seconds.

[c]BUDS trainees performed pull-ups wearing field clothing and boots, which increased their body weight by 6 pounds.

Table 6 shows the percentages of BUDS Phase I graduates and recruits who would score at or above various field composite cut-scores. For example, 92.6 percent of the BUDS group and 4.8 percent (N = 3,153) of the men recruited annually could meet the cut-score of 182. These persons could be encouraged to apply for BUDS training.

Table 6

BUDS Phase I Graduates and Navy Recruits Scoring at Selected Field Composite Cut-scores

Field[a] Composite Cut-scores	Sample of BUDS Phase I Graduates (N = 27) %	N	Sample of Navy Recruits (Estimated) %	N[b]
204	59.3	16	0.2	131
198	74.1	20	1.3	854
188	88.9	24	3.2	2102
182	92.6	25	4.8	3153
178	96.3	26	9.6	6306
172	100.0	27	15.6	10247
167	100.0	27	22.2	14582

[a]BUDS field composite = sit-up + 32 ((weight/height^2) x 100) + .4 (push-up) + pull-up. Because test administration time differed (30 seconds for recruits and 120 seconds for BUDS trainees), an estimate of equivalency was applied by increasing the recruit sit-up score 2X for the 78th to 99th percentile scores and 1.5X for the 50th to 77th percentile scores. For recruits, the scores were calculated from recruit posttest data (administered at the end of 7 weeks of recruit training). Recruits: N = 485, $\bar{X}$ = 162.5, S.D. = 13.9, range = 123-205.

[b]Based on estimated annual N of 65,585 first-term male enlistments--1 October 1979 through 30 September 1980.

There are two limitations to the procedure for identifying potential BUDS trainees shown in Table 6. First, because the sit-up tests were administered under different maximum time conditions (see footnote a in Table 6), the equivalency estimate for recruits may not be correct. Second, the most critical screening factor in the field may be the swim test (for which no data were available for this analysis). Nonetheless, this procedure appears to have merit, if all physical screening tests were included in the field composite distribution.

To benefit from applying cut-offs on rank-ordered composite scores, an alternate testing procedure would have to be applied. The following sequence is recommended:

Sequence	Max. Effort	Duration (Minutes)
Test 1	Push-ups	1.5
Rest	---	10.0
Test 2	Sit-ups	1.5
Rest	---	10.0
Test 3	Pull-ups	1.5
Rest	---	10.0
Test 4	1-mile run	--
Rest	---	10.0
Test 5	300-yard swim	--

Although the minimum scores presently specified for BUDS training could be retained, applicants achieving minimum requirements would be further screened on the field composite battery. After adequate data are compiled for maximum effort scores on the swim and run tests, they should also be analyzed for appropriate weighting and added to the field composite equation.

CONCLUSIONS

1. STB dynamic strength measures (sit-ups, push-ups, and pull-ups) and relative body weight (weight-to-height^2) are valid predictors of success in BUDS Phase I training. This finding is consistent with other investigations that have reported a strong relationship between BUDS attrition and dynamic physical tests such as calisthenics, swimming, and running.

2. Present minimum performance requirements on physical selection tests, particularly sit-ups, push-ups, and pull-ups, are substantially below the average of BUDS fail groups, and are therefore inadequate for final screening of applicants.

3. Applicant screening procedures could be substantially improved and attrition rates reduced by decreasing selection ratios. This could be accomplished by increasing the size of the applicant pool and applying a selection cut-score to a composite of maximum effort performance tests, instead of the present procedure of requiring minimum performance on a series of individual tests.

4. The size of the applicant pool might be increased, thereby providing more favorable selection ratios, by identifying potential BUDS trainees during recruit training.

RECOMMENDATIONS

It is recommended that OP-13 (Special Warfare):

1. Initiate further research to develop and validate potentially useful tests identified by this effort and other research (e.g., run and swim tests).

2. Specify selection procedures that require applicants to perform to their maximum ability on each test rather than those that require applicants to achieve only a minimum score.

3. Select applicants with the highest scores on a composite.

4. Increase the size of the BUDS applicant pool by early identification of high-potential applicants, particularly at recruit training centers.

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