Success in the TACP Training Program
An Objective Method for Selecting Battlefield Airmen

FINAL REPORT

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Covering the Period: June 16, 2008 - October 15, 2009

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Abstract: *Purpose*: Develop a statisitcal model that predicts the likelihood of success or failure of a TACP candidate using results from testing. *Scope:* Data were acquired from candidates prior to start of indoctrination training. Data comprised demographic, physical activity history, psychological, physical performance and salivary fatigue biomarker index. Fifty-five variables were evaluated for significance as inputs creation of a predictive model. A total of 126 candidates were tracked until they either passed or failed training. *Results/Conclusions:* Four of the fifty-five variables were useful for predicting success or failure. The predictive quality of the model can likely be improved by increasing the size of the test population.

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14. ABSTRACT
Purpose: Develop a statistical model that predicts the likelihood of success or failure of a TACP candidate using results from testing.

Scope: Data were acquired from candidates prior to start of indoctrination training. Data comprised demographic characteristics, physical activity history, psychological profile, physical performance and values for salivary fatigue biomarker index. Fifty-five variables were evaluated for significance as inputs for creation of a predictive model. A total of one hundred twenty six candidates were tracked until they either passed or failed training.

Results/Conclusions: Four of the fifty five variables were useful for predicting success or failure. The predictive quality of the model can likely be improved by increasing the size the test population.

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SUCCESS IN THE TACP TRAINING PROGRAM

AN OBJECTIVE METHOD FOR SELECTING BATTLEFIELD AIRMEN

FINAL REPORT

I. Introduction

The goal of this program is the development of an effective and objective means to select candidates for battlefield airmen. Battlefield airmen comprise four groups of elite Air Force personnel who are responsible for specialized ground-support duties ranging from rescue and extraction of personnel from threatening environments to coordinating Special Operations and air strikes. One such group, Tactical Air Command and Control Specialists consists of two-member teams (Tactical Air Control Party –TACP) assigned to Army combat units around the world. These teams direct close air support firepower toward enemy targets on the ground and advise Army combat commanders on the use of Air Force air power. Training of TACP specialists requires approximately 1 year and an investment of $30,000 per airman. Unfortunately, the Air Force has not been able to meet its goals in producing TACP specialists in recent years and the problem has intensified during the last two years. For the TACP training pipeline 3593 training days are wasted each year because of failure to perform on the part of the trainee. In the four TACP classes comprising the present study approximately 50% of the trainees failed to complete the training successfully. Improved methods for selection of candidates are essential to the improvement in the number of trainees completing the training and becoming deployable members of a TACP team.

We have developed a mathematical relationship, based on data collected during the study, that predicts who will succeed and who will fail training. Virtually all of the data, including human performance biomarker data is collected at the outset of the training cycle, thus it is conceivable that candidates at high risk of failure can be identified and corrective measures brought to bear leading ultimately to training success. Alternatively, assessment could be made prior to arriving for TACP training to either positively select basic trainee for TACP or other career fields or negatively select candidates that have a low probability of success during the initial training cycle. Ultimately, the approach could prove useful at improving pass rates through undermanned career fields without compromising the quality of entrants.

II. Research Methodology and Accomplishments

Methodology

Data were collected and analyzed from four TACP training classes. At the beginning of training, each potential subject was given a brief explanation of the testing and a signed informed consent document (Appendix A7) was obtained. A demographic questionnaire (Appendix A8) was administered by project investigators to the trainees upon enrollment. Over the course of the 13.5 week training, psychological and aptitude data were collected using the Bar-On Emotional Quotient Inventory (EQi) testing instrument (below) and the Armed Services Aptitude Battery (ASVAB) (below). Physical test (PT) scores were collected for the entire course using the routine training information supplied by the TACP instructors. If, for any reason, a trainee was eliminated from the course, an elimination questionnaire (Appendix A9) was administered by project investigators. Weekly saliva samples were collected for biomarker analysis. Demographic data, EQi, ASVAB, PT scores, and biomarkers were analyzed for predictive value in determining successful completion of the TACP training program.

<u>The Bar-On Emotional Quotient Inventory</u> is a self-report measure of emotionally and socially intelligent behavior that provides an estimate of emotional-social intelligence (Bar-On, 2006). Consisting of 133 questions, it is the most widely used measure of emotional social intelligence to date (Bar-On, 2004). The test gives an overall EQ score as well as scores for the following 5 composite scales and 15 subscales. *Intrapersonal Scales:* Self-Regard, Emotional Self-Awareness, Assertiveness, Independence, Self-Actualization. *Interpersonal Scales:* Empathy, Social Responsibility, Interpersonal Relationship. *Adaptability Scales:* Reality Testing, Flexibility, Problem Solving. *Stress Management Scales:* Stress Tolerance, Impulse Control. *General Mood Scales:* Optimism, Happiness

<u>Armed Services Vocational Aptitude Battery (ASVAB)</u> is the most widely used multiple-aptitude test battery in the world. It is a required entrance test for every enlisted combat controller. It is a 200 question test completed in 134 minutes. The ASVAB measures strengths, weaknesses, and potential for future success by testing the following areas: general science, arithmetic reasoning, word knowledge, paragraph comprehension, auto and shop information, mathematics knowledge, mechanical comprehension, and electronics. The results of the test are shown as composite scores in the following areas; verbal ability, mathematical ability, and academic ability.

<u>Physical Test (PT)</u> administered as part of the TACP training consists of a two-mile run, push-ups, sit-ups, and pull-ups. Training candidates need to pass the minimum standards to enter TACP training.

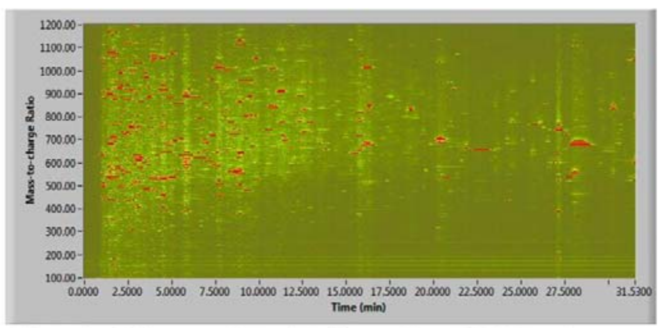
<u>Saliva sample collection and analysis by LCMS.</u> *Sample Collection and Protein Quantification*. Samples were collected from study participants at the beginning of the training class and at “stressor” events during training. The stressor events comprised so-called “rucks” consisting of timed runs for defined distances (usually four to six miles) with defined additional pack weight. Ruck conditions were specified by the TACP instructors independent of the study investigators. Approximately 5 ml of saliva were collected by expectoration into a 15 ml conical tube prior to the ruck and an additional 5 ml collected as soon as practical after the ruck. Samples were immediately placed on ice and then transferred to -80°C for temporary storage before shipment to Hyperion Biotechnology. Following receipt by Hyperion, samples were stored at -80^{o} until processed for LCMS analysis. Protein concentration in each sample was determined using the colorimetric bicinchoninic assay (BCA). Absorbance measurements (562nm) and standard

solutions were used to construct a calibration curve and linear regression was used to determine the final protein concentration for the sample.

Sample Fractionation and Concentration. Samples were fractionated through two different size-based centrifugal filters (Microcon, Millipore) with nominal sieve sizes of 50 kDa and 10 kDa. The 50 kDa filter was centrifuged at 4,000 x g at 4°C for approximately 2.5 hours. The filtrate was then transferred to the 10 kDa filter and centrifuged at 10,000 x g at room temperature for approximately 45 minutes. The filtrates from the 10 kDa filter were loaded onto a peptide trap column (C8, Michrom) and eluted in approximately 200 µL of elution buffer. The eluted sample was then dried using a heated vacuum chamber (Centrivap, Labconco).

Mass-specific Labeling of Primary Amines. The dried sample was resuspended in a mixture of triethylammonium bicarbonate/ethanol (50 mM TEAB, final concentration) and acetic anhydride/ethanol (1:250 dilution). The TEAB/EtOH and acetic anhydride/EtOH solutions were then be mixed (200 µl + 20 µl, respectively). For the acetic anhydride, both 'light' (methyl protons) and 'heavy' (methyl deuterons) forms were used to allow mass-specific labeling of samples. The samples were incubated on a rotating platform for one hour at 37°C, after which they were dried (Centrivap) and resuspended in LC-MS grade water containing 0.1% acetic acid.

Liquid Chromatography. Small molecular weight components in saliva were separated using a liquid chromatography system (Waters ACQUITY) equipped with a C18 column (Acquity UPLC, BEH300 C18, 1.7 µm particle, 2.1 x 100 mm, Waters). Proteins and peptides were eluted using a linear gradient of water and methanol (90%- 65% H2O), containing 0.1% acetic acid to aid ionization during the subsequent analysis by mass spectrometry



Chemical Fingerprint of Saliva. About 5,000 unique peptides less than 2,000 molecular weight in saliva. Visualized with PeakQuest™ software.

Mass Spectrometry. The LC eluent was injected into the electrospray ionization chamber of an ion-trap mass spectrometer (Esquire 3000+, Bruker, Billerica, MA). To optimize detection and identification of small molecular weight peptides, the mass spectrometer was configured for detection of cations in the "Standard Detection" mode. A method of visualizing and comparing the very complex spectra generated was developed by Hyperion during the period of performance of this contract. The software enables the visualization of these very large (>100MB) files and also comparison of groups of files (failure, success) to enable biomarker discovery. The software also measures the amount of known biomarkers present in samples.

<u>Data Analysis</u>. A classification tree approach was used to develop a predictive model. This method looks at each variable and finds a value such that the separation between the two groups is as great as possible. It does this iteratively for each variable until a set of rules is found which minimizes the misclassification of observations. A total of 126 candidates were tracked until they either passed or failed training. In some instances, data was missing. In these instances, data was imputed by generating values for the missing data using Monte Carlo simulation based on probability distribution determined in the remaining classes. All statistical

analysis was done using R 2.9.0 with mice package for the imputation of missing data and the tree package for the classification tree. Briefly, classification trees are created by application of the following steps in the statistical language R 2.9.2 (http://cran.r-project.org/): 1) from a single set of observations (the node) estimate error of a predictive model, 2) search over the set of all possible partitions of the current node, choosing the partitions for which the model's error is reduced as much as possible. If partitioning creates nodes with less than a predetermined number of observations or if the error was reduced by less than a certain amount the partitioning is stopped, and 3) for each new node created, return to step one and repeat until no more new nodes can be created using limitations set forth in step 2. The model is validated, and sensitivity and specificity calculated using the Leave-One-Out (LOO) method. The method involves taking one observation out of the dataset, fitting the model and predicting the category the observation left out falls into, either success or failure.

The classification of was done using classification trees. Analysis revealed only 4 of 55 variables evaluated were useful for predicting success or failure. In descending order of effect these were: time to complete require training run, recent (1 year) history of run training, value of fatigue biomarker index, trainee height. This analysis allowed the construction of classification trees for the predictive value of specific variables.

Classification trees provide a method of predicting (or classifying) observations into one of two or more categories. Predicting the category to which each observation belongs is inherently a nonlinear regression problem. To solve this problem, there are two approaches. The first approach is to develop a model, say by logistic regression that will predict the category using a set of covariates. Inherent in this approach is the assumption that the data behaves in a similar manner across the entire population from which the observations were sampled. This may cause problems when the data has features that interact in complex ways. Classifications trees, on the other hand, deal with this issue by recursively partitioning the data space into regions in which the observations have similar values for the covariates. Just as important, and in contrast to some other recursive classifications methods such as *k*-means clustering, in each partition, the algorithm to create the tree partitions the data such that observations mostly belong to the same category.

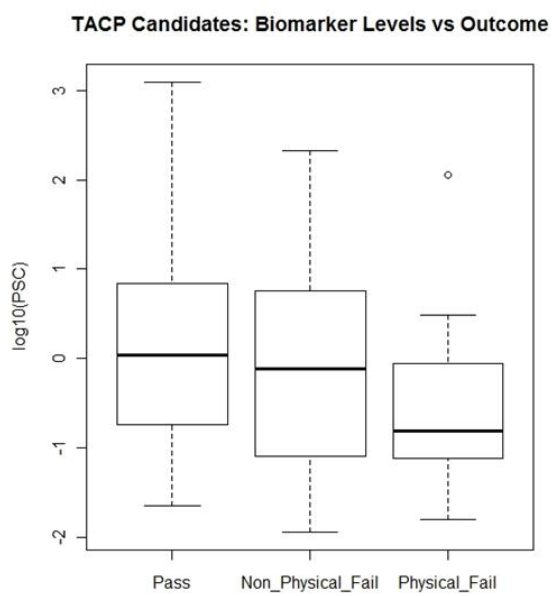
Goals and Accomplishments

Four major research goals were set forth in the contract and accomplished during performance:

1. Protocol execution and sample collection, SOW 2.2- Prior to collection of data or saliva samples all study participants were apprised as to the purpose and extent of the study and informed consent was obtained. Execution of the protocol required minimal intervention in the normal progress of TACP training.

The study comprised four TACP training classes, designated H78, E79, F79, H79, during the period from August 2007 through February 2009. Data were collected fordemographic characteristics (age, height, weight, etc) as well as physical performance measures (pull-ups, push-ups, run times, etc) of entering trainees. Additional physical performance data was collected periodically during the course of the study. Emotional "intelligence" data was collected using the Bar-On EQi inventory instrument.

Saliva samples were collected from study participants at the beginning of the training class and at "stressor" events during training. Approximately 5 ml of saliva were collected prior to the physical stress and an additional 5 ml collected as soon as practical afterwards. Samples were immediately placed on ice and then transferred to -80°C for temporary storage before shipment to Hyperion Biotechnology in San Antonio.



2. Discovery of biomarkers associated with training outcome, SOW 2.3- Comparison of the composition of saliva samples from failed and successful candidates, using proprietary bioinformatics tool, PeakQuest™, did not reveal biomarkers specifically associated with failure/success. However, previously discovered biomarkers associated with fatigue caused by prolonged physical exertion were identified as being important determinants of success/failure. As shown in the figure, levels of the fatigue biomarker discovered previously are associated with failures associated with inability to meet physical performance requirements (p=0.039 Kruskal-Wallis, non-parametric test). Levels of the biomarker, shown in the y-axis are 10-fold lower in those that did not succeed for physical performance reasons versus those subjects that did pass or failed for other reasons. The result is remarkable because only a single sample of saliva, obtained before the start of indoctrination training was evaluated.

3. Analysis of Data, SOW 2.4

Description of the TACP population

The population of candidates that succeed and failed TACP training was compared by calculating median values of the different parameters and associated variances. The median values, standard deviations, and p-values associated with t-tests for demographic features of candidates are provided in table 1 below. Table 1 shows that success is associated with being older and has greater physical capability as measured by run time (non-parametric Kruskal-Wallis statistical test used in this case instead of the t-test), pushups, crunches and pullups.

Table 1, Comparison of demographic and physical test scores of TACP candidates.

Parameter	Success				Failure				p-value
	N	Median	Mean	STD	N	Median	Mean	STD	
HEIGHT	57	70	69.9	2.2	53	70	70.2	2.9	N.S.
WEIGHT	57	173	170.8	17.6	53	167	166.3	15.9	N.S.
AGE	59	21	21.7	3.6	60	19.5	20.5	3.0	0.042
PUSHUPS	58	49	49.8	7.7	52	42	43.9	8.2	<0.001
CRUNCHES	58	58	58.0	6.2	52	53.5	53.8	6.8	0.001
RUN	58	9.9	9.9	0.7	54	10.4	10.1	2.2	0.006
PULLUPS	57	10	10.4	3.9	52	7.5	7.8	3.6	0.001
AFQT	55	72	72.9	14.5	53	74	72.9	13.7	N.S.
BIOMARKER	48	0.7	12.3	33.1	40	0.3	15.7	40.4	N.S.

Table 2 describes the rates of failure for each of 6 different causes.

Table 2, Reasons attributed for failing TACP training and prevalence. The total number of candidates considered is 122. The total number of succeeding is 63 (51.6%) and the number failing, 59 (48.4%).

Reason	Number	Percent
Academic- Inability to meet standards for classroom instruction.	6	4.92%
Administrative- Disciplinary problems leading to dismissal from training.	4	3.28%
Medical- Includes injuries sustained during training leading to disqualification.	21	17.21%
Physical Performance Failure- Candidate unable to meet minimum physical performance requirements, example, time to complete ruck march.	9	7.38%
Quit- Candidate decides not to continue.	19	15.57%

Table 3, Psychological test scores of TACP candidates.

	Success			Failure			p-value
Trait	Median	Mean	Standard	Median	Mean	Standard	
INCONSISTENCY	5.6	5.7	2.9	5.6	5.6	2.8	N.S.
POSITIVE IMPATY	99	99.1	12.8	99	100.0	12.5	N.S.
TOTAL EQI	97	97.4	13.9	102	101.5	12.3	N.S.
INTRAPERSONAL	100	99.4	14.4	103	101.8	12.9	N.S.
SELF REGARD	102	98.9	15.4	105	102.4	12.6	N.S.
EMOTIONAL	98	98.6	14.1	101	100.3	15.3	N.S.
ASSERTIVENES	103	103.1	14.0	103	104.9	12.5	N.S.
INDEPENDENCE	97	97.3	13.6	97	96.6	12.7	N.S.
SELF ACTUALIZATION	101.5	100.3	14.5	106	102.8	15.1	N.S.
INTERPERSONAL	95.5	94.7	13.1	102	97.4	15.9	N.S.
EMPATHY	89.5	91.6	13.4	98	96.0	16.3	N.S.
SOCIAL RESPONSIBILITY	97.5	93.3	13.7	102	96.6	16.5	N.S.
STRESS MANAGEMENT	99.5	98.1	14.2	100	99.1	16.0	N.S.
STRESS TOLERANCE	97.5	99.4	15.9	104	103.7	13.1	N.S.
IMPULSE CONTROL	101	101.9	17.3	105	106.3	13.4	N.S.
ADAPTABILITY	95.5	97.3	15.5	101	100.5	13.5	N.S.
REALITY TEST	96.5	96.9	13.2	104	102.9	10.4	0.012
FLEXIBILITY	96.5	95.9	15.0	100	102.1	11.1	0.018
PROBLEM SOLVING	98.5	98.5	15.4	107	105.5	12.2	0.011
GENERAL MOOD	96.5	98.2	13.0	97	99.5	11.1	N.S.
OPTIMISM	100	98.5	16.6	105	102.2	12.5	N.S.
HAPPINESS	100	97.5	17.8	102	101.4	14.1	N.S.

Table 3, shows that reality test, flexibility and problem solving are lower (better) in successful TACP candidates compared to those that fail.

Table 4, shows the results of a questionnaire (Appendix A8) that was specifically designed for this program.

Table 4, Results from a questionnaire given to TACP candidates at the beginning of training. Success, n=57; fail, n=53.

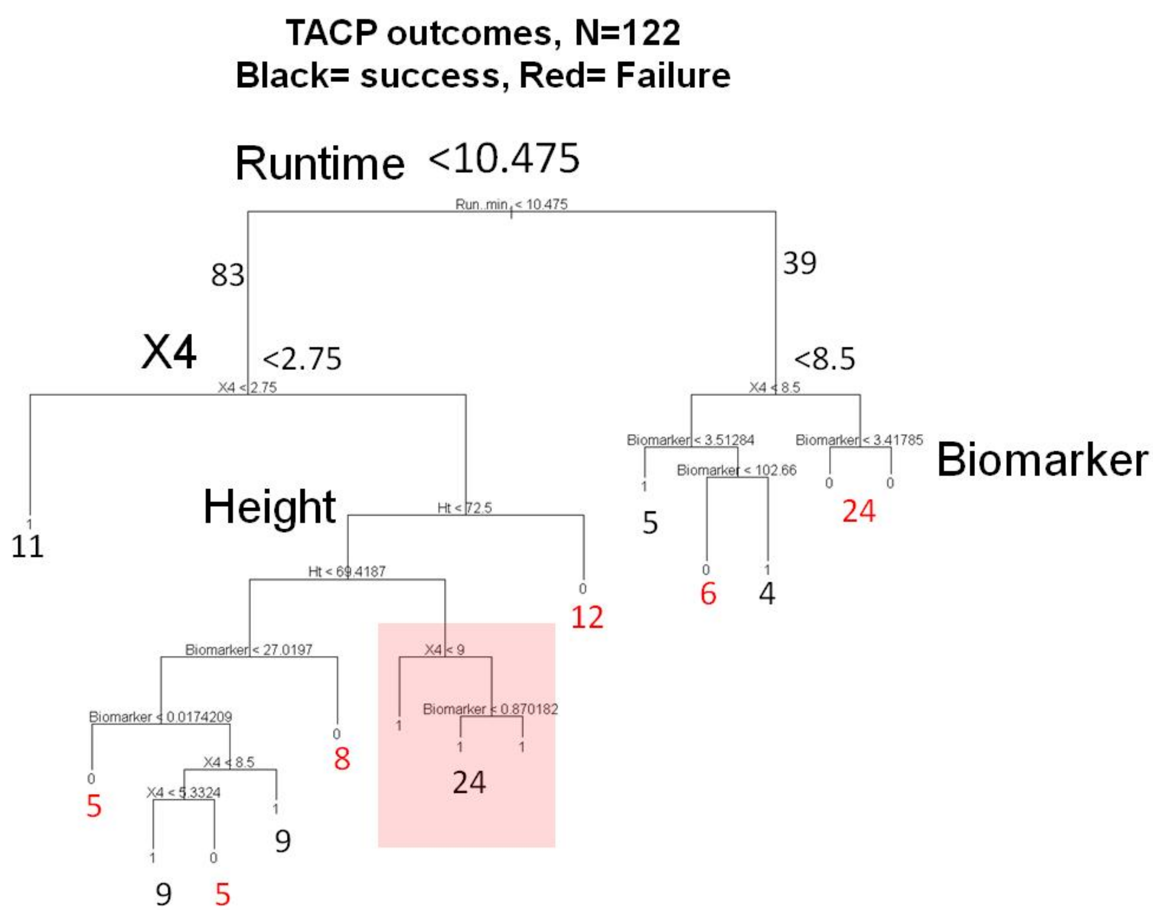
Question	Success			Failure			p-value
	Median	Mean	Standard	Median	Mean	Standard	
1	2	2.2	1.4	2	2.0	1.5	N.S.
1a	7	6.5	4.7	5	5.3	4.3	N.S.
2	9	9.6	7.2	9	9.9	5.9	N.S.
3	6	7.1	4.7	5	7.7	6.1	N.S.
4	6	8.7	9.2	8	9.2	6.1	N.S.
5	6.5	7.1	4.2	6	7.8	6.1	N.S.
6	6	5.4	1.5	5	5.0	1.6	N.S.
7	2	2.9	1.3	2	2.9	1.4	N.S.
8	9	8.9	4.3	8	8.9	4.7	N.S.
9	3	2.9	1.3	3	2.8	1.1	N.S.
10	1	0.7	0.4	1	0.7	0.4	N.S.
11	1	0.9	0.8	1	1.3	0.8	0.026
12	1	0.8	0.4	1	0.8	0.4	N.S.
13	0	0.4	0.5	0	0.5	0.5	N.S.
14	2	2.3	1.3	1	1.8	0.9	0.018
15	5	4.5	0.7	4	3.6	1.2	<0.001
16	3	2.9	0.8	3	2.6	0.8	0.044
18	3	2.8	0.8	3	2.5	1.0	N.S.
20	0	1.0	1.8	0	1.2	1.7	N.S.
21	1	1.0	1.0	2	1.5	1.4	N.S.

Table 3, shows that candidates succeeding during training have distinctly different responses to questions 11, 14, 15, 16 and 20.

When taken together the data demonstrate that the survey instruments detect differences in multiple parameters suggesting that building a predictive model is at least possible.

Building a predictive mathematical model of TACP success

The classification tree approach determined that only three variables, of the 54 that were input initially, only three were necessary to produce a model that predicts success and outcome in the TACP population. Inclusion of additional variables did not significantly increase predictive power, whereas dropping one of the four variables selected had a strong, negative impact on predictive power. The four variables included are: 1) the runtime for 1.5 miles evaluated at the start of the training cycle, 2) X4 or question 4 of the special questionnaire in table 4, which is the number of miles run per week during the last year, 3) the height of the individual summarized in table 1, and 4) level of the biomarker index measured at the outset of training which is also summarized in table 1. The order of importance is: Runtime>>X4> (biomarker=height). Interestingly, of the four variables included in the model, only the runtime is statistically significantly different between the groups that succeed and fail. Figure 2 below also shows that clusters of success and failure occur in a complex manner. For example, of the group of 39 individuals with runtimes >10.475 minutes (first right hand branch from the top), those that run <8.5 miles per week (X4< 8.5, second level in the figure) will pass if their biomarker index is either less than 3.5 (5 individuals succeed) or greater than 102.66 (4 individuals succeed), whereas those with biomarker index values in between these limits will fail (6).



The predictive value of the model was determined and the results are shown in table 5. The results show that 31 individuals would be correctly identified at the outset of the training cycles as destined to fail training. If interventions could have effectively been brought to bear on these individuals, the overall failure rate would be reduced from 48.3 to 23.0%.

Table 5, Ability of the statistical model to predict success and failure in TACP candidates. Accuracy is the percent predicted to pass or fail that were correctly predicted to pass or fail. Sensitivity is the percentage of individuals that were predicted to fail that actually did fail within a given type or reason of failure. Specificity is the percent predicted not to fail (succeed) for a given reason divided by the number of those who did not fail for that reason.

Reason	Total Failing (Actual)	Total Failing (Predicted)	Correctly Predicted	Accuracy	Sensitivity	Specificity
Academic	6	5	3	80%	50%	98%
Administrative	4	5	3	80%	75%	98%
Medical	21	16	10	73%	48%	94%
Physical Performance Failure	9	5	4	78%	44%	99%
Quit	19	21	11	69%	58%	90%

4. Development of BMT/TACP Assessment Tools, SOW 2.5- In addition to the algorithm described above, a simple calculator was developed for the input of specific variables to generate the probability of failure for individual TACP trainees. The algorithm is converted very simply into an EXCEL spreadsheet. A copy of the spreadsheet is given below.

Predict Failure	
Height	72
Run Time (Min.)	12
X4	10
Biomarker	0
Probability of Failure	1
Predicted Outcome	Failure

The formula in the cell called "Probability of Failure", in the figure 3 above is:

```
=IF(OR(ISBLANK(C3),ISBLANK(C4),ISBLANK(C5),ISBLANK(C6)),"",IF(C4<10.4,IF(C3<72.5,IF
(C3<66.5,0.8,IF(C3<70.5,IF(C5<5.5,0,IF(C6<2.00971,0.2308,0.7)),0)),0.7),IF(C5<8.5,IF(C5
<3.5,0.8571,0.375),1)))
```

Where C3 is the value input for height in inches, C4 is the Run Time in minutes, C5 is the answer to question 4 (X4), and C6 is the biomarker index. The calculator reproduces all major branches of the predictive tree shown in figure 2.

III. Key Research Accomplishments

- Collection data on trainee performance in TACP training.
- Generation and preliminary characterization of salivary biomarker profiles for large cohort of TACP trainees.
- Correlation of psychological testing, demographic information, physical performance and salivary biomarker profile data with successful completion of TACP training.
- Develop a mathematical model that predicts failure/success using candidate data as input.

IV. Reportable Outcomes

Manuscripts and Presentations: A manuscript is in preparation describing the results that were found during the performance of this research. The title of the manuscript is: "A quantitative method for predicting training success in the TACP pipeline." The manuscript will be submitted to military medicine for review. An invited presentation was delivered to the 720th Special Tactics Group/AFSOC at Hurlburt AFB on 14 October 2009. This PowerPoint presentation detailing the finding from this program is provided in the appendix of this report.

Patents and Licenses: The data that was generated here was used to support the patent application made on 11 September 2009, application number 61/241,519, inventors, John E. Kalns, and Darren J. Michaels, entitled: METHODS AND COMPOSITIONS FOR BIOMARKERS OF FATIGUE, FITNESS AND PHYSICAL PERFORMANCE CAPACITY.

Degrees Supported: No academic degrees were supported by this work.

Cell Lines, Tissue Repositories: Saliva sample archive containing approximately 200 samples obtained from TACP candidates.

Informatics: Predictive Calculator for assessment of probability of failure in TACP training contribution to refinement of Biomarker Discovery Software.

Funding applied for based on this award: A white paper has been submitted by Hyperion Biotechnology, Inc. to the Air Force Surgeon General (AFSG) seeking support for more research to refine the model and evaluate changes in the composition of TACP candidates over time. This white paper was submitted in December 2009.

Research Applied for based on experience supported by this award: "Salivary Biomarkers for Distinguishing Unipolar and Bipolar Depressive Disorders". National Institutes of Health Opportunity Number: PA-09-045 Program Title: Development of Biomarkers for Mental Health Research and Clinical Use (SBIR[R43/R44]). Grant application submitted December 2009.

V. CONCLUSIONS

The approach used here suggests that data can be used to predict failure and success in the TACP training pipeline. A relatively number large numbers of inputs, 54, were incorporated into the initial model, however only four are needed to predict outcome. Interestingly, even though the psychological assessment demonstrated statistically significant differences between groups that passed and those that failed, none of the psychological measures were useful in modeling overall failure and success. The predictive model sought to predict all types of failure. It is likely that specific models may prove useful in modeling different types of failures, i.e. physical performance failure, quitting. This approach was explored here however the relatively small numbers of failures occurring in any one type precluded meaningful application of this approach. Similarly, different types of data may predict success for different types of career fields characterized by high rates of failure during initial training (example Para Rescue) or attrition after qualification (example sensor operators). The approach used here may be broadly applicable to many career fields. The biomarker index was found to be predictive of outcome even though the sample that was evaluated here was obtained prior to the start of training. We hypothesize that measures of the biomarker during the training regime may greatly increase the ability to correctly identify those at risk for medical or physical performance disqualification during training. The biomarker may thus be a very useful guide enabling instructors to focus more attention on individuals at risk of failure. Further, the approach given here can be used to determine the impact of interventions (improved training regimes, diet, etc) on success rates.

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