BIOMEDICAL COMPUTER SYSTEMS
PORTLAND, OREGON U.S.A • .

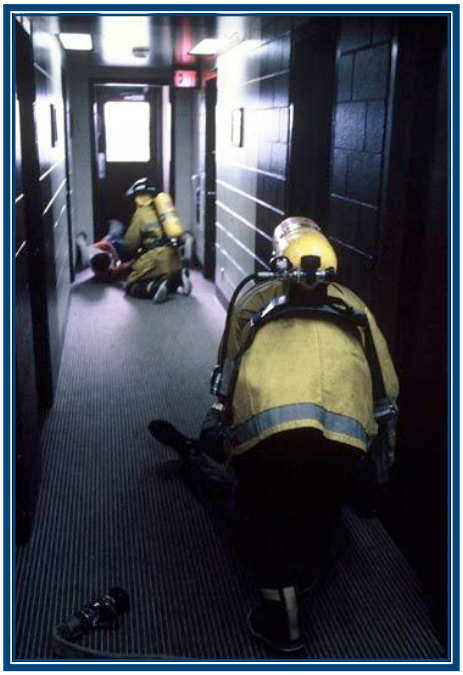
TASK RELEVANT AND RISK REDUCTION FITNESS PROGRAMS

for Military and Public Safety Career Fields

Biomedical Computer Systems (BCS) was established in 1986 to conduct research and provide professional consultation for those in physically demanding occupational career fields. More than 10 years of research in the laboratory and in the field involving several hundred military and civilian personnel led to the development of a software program that guides the administration of a (1) medically safe and valid assessment of caradiorespiratory capacity and fitness-for-duty, and (2) personalized training prescription for enhancing cardiorespiratory health and risk reduction. That software program was registered as No. 766-391 by the U.S. Patent Office on 29 Oct, 1997.

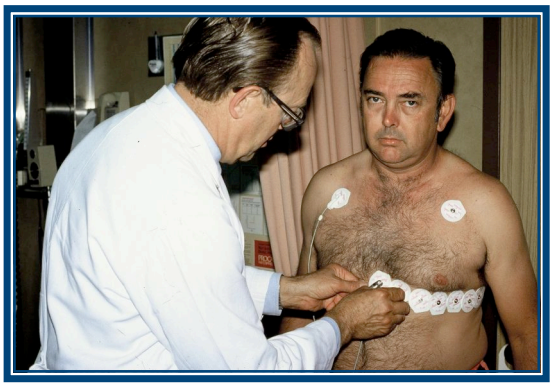
Our approach it to provide a complete system, including all equipment, software, and hands-on training for the implementation of a complete cardiorespiratory health and fitness assessment and training program.

- Our success in this field can be summarized by the list of some of the major organizations subscribing to our program as listed in Addendum I of this document.
- The credibility of our research and the significance of our occupationally-relevant programs can be judged by a review of the academic achievements of our founder and CEO Dr. Loren G. Myhre as summarized in Addendum II of this document.



BACKGROUND

Cardiorespiratory Health and Fitness for Public Safety Personnel



Aerobic capacity *(cardiorespiratory capacity; $VO_{2\ max}$)*

… for Fitness

The validity of aerobic capacity as the best single measure for predicting overall work capacity is without debate.

"Cardiorespiratory endurance refers to the ability of the heart, lungs, and blood vessels to function optimally at rest and during exercise. Exercise scientists agree that this fitness component is the most important quality of a physically fit body."[1]

… for risk reduction
(occupational relevance)

Sedentary lifestyle results I n a more rapid decline in aerobic capacity and a dramatic **31 fold increase** in the risk of death during infrequent periods of strenuous physical activity.[2]

[1] Strauss, R.H. Sports Medicine, W.B. Saunders, Philadelphia, 1984, p. 459.
[2] Giri,S. J. Am. Med. Assn. 1999

Muscular Strength and Endurance for Total Fitness

Fitness-for-duty for a number of physically demanding tasks requires measures of both $VO_{2\ max}$ and muscular strength.

- We have studied a variety of weight lifting tests to determine the one(s) that best correlate with fitness-for-duty.
- Scores for three of these tests were combined with a measure of $VO_{2\ max}$. providing a single measure, the "Firefighter Fitness Index®", or "FFI.
- The FFI ranges from 0 to 140 and it has been validated for accurately predicting overall physical capability to perform strenuous tasks; it is age and gender blind.

Validity of Measures of Cardiorespiratory Capacity

PROGRAM VALIDITY:

BCS cycle ergometry for predicting aerobic capacity:

The U.S. Air Force School of Aerospace Medicine[3] determined the aerobic capacity (exhaustive treadmill exercise with indirect calorimetry) for 99 individuals (58 male, 41 females). Aerobic capacity was then predicted from the BCS computer-guided cycle ergometry method.

- The correlation between these measures was 0.87.
- The difference between cycle vs. treadmill scores averaged -1.35 ml/kg/min for the males and +1.33 ml/kg/min for the females.

Subsequently, the past-president of the American College of Sports Medicine, Dr. Michael L. Pollack, conducted a similar study at the University of Florida.[4]

- Dr. Michael Pollack studied 103 males and 104 females.
- The correlation between treadmill and cycle test scores was 0.85.
- The difference between treadmill runs to exhaustion and sub-maximal cycle ergometer scores averaged -2.2 ml/kg/min for the males and +2.2 ml/kg/min for the females.

[3] Myhre, L.G., G. Tolan, D. Bauer, Fischer, J.R., Jr. Validation of Submaximal Cycle Ergometry for Estimating Aerobic Capacity. U.S. Air Force Armstrong Laboratory, Brooks AFB TX, 1997 (Confidential Research Report).

[4] Pollack, M.L., L. Garzarella, D. DeHoyos, W. Brechue, M. Beekley, G. Werber, and D.G. Lowenghal. The Cross-Validation of the United States Air Force Submaximal Cycle Ergometer Test to Estimate Aerobic Capacity. AL/CF-TR-1994-0046, Brooks AFB TX, June 1994.

Task Relevance

TASK RELEVANCE:
Aerobic capacity and muscular strength:

The U.S. Air Force School of Aerospace Medicine studied 272 male and 7 female career fire fighters. Performance on a standardized Air Force rescue exercise was closely related to each individual's level of fitness as measured by the BCS cycle ergometry prediction for aerobic capacity and selected measures of muscular strength.

MILITARY

- The time required to complete the rescue task averaged 6 min 17 sec for those with $VO_{2\ max}$ averaging 39.4 ml/kg/min.
- Performance declined with declining $VO_{2\ max}$, and required an average of 30+ minutes for those with $VO_{2\ max}$ levels averaging < 25.0 ml/kg/min.

TASK RELEVANCE:
Firefighter Fitness Index (FFI®)

Firefighter Fitness Index®: The FFI was developed in an attempt to combine three of the most valuable measures of physical fitness (e.g., aerobic capacity, muscular strength, and muscular endurance) in providing a single, comprehensive score that reflects overall physical capability to perform the most strenuous of fire ground tasks.

CIVILIAN

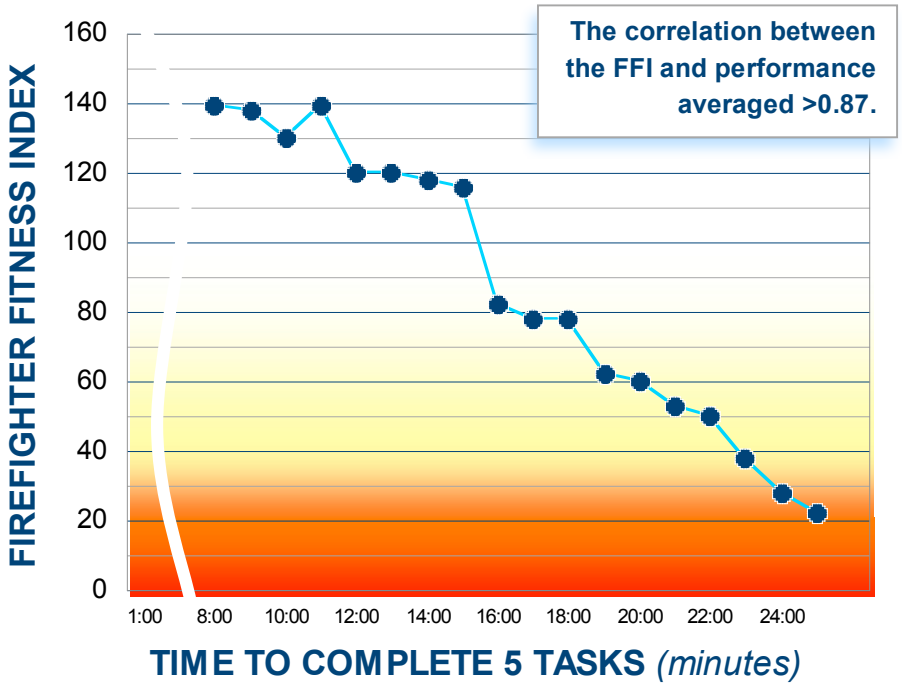
- The FFI is both age and gender blind, and each of the three fitness test variables is weighted to reflect its relative importance in calculating the value that best predicts performance.
- FFI values range from 0 to 140 and the average for a 29-year old male fire fighter is between 75 and 82.
- The FFI was validated against performance in more than 150 athletes competing in the "World's Toughest Firefighter" games held on successive years in 1995 (Honolulu), 1996 (Edmonton), and 1997 (Las Vegas)[6].

[6] Myhre, L.G. and W.H. Grimm. Unpublished data.

TASK RELEVANCE:

Firefighter Fitness Index (FFI®) *CONTINUED*

The World's Toughest Firefighter in Honolulu scored 139; second place scored 138 and the rank order of performance declined in direct proportion to the decline in the FFI. The last place competitor scored 24 points.




EDMONTON, 1996

Summary

The Biomedical Computer Systems' Program for Enhancing Cardiorespiratory Health and Fitness for Military and Public Safety Personnel provides a scientifically valid measure of fitness-for-duty for a variety of physically demanding tasks. It is especially valuable for identifying personnel who would be placed at significant risk while attempting to perform tasks in the presence of a heat stress burden imposed by fire/chemical/biological warfare protective equipment, the environment or a combination of the two.

BCS professionals deliver and install all equipment required to implement this completely computer-guided program and then they provide hands-on training to certify that the designated program administrators are prepared to administer this program with the highest level of safety and quality control.

This program is particularly precise in providing:

1. Entry level health and fitness-for-duty assessment.
2. Periodic assessment to provide incumbents with an early awareness of the onset of risks to health and/or performance capability.
3. Professional computer-generated prescription for the on-duty personalized cardiorespiratory conditioning program.

Perhaps the best summary of this program was given by the Director of Occupational Medicine, U.S. Navy Base, Portsmouth, Virginia (see Addendum II).

Addendum I

Public Safety, Health and Wellness, and Medical Programs that have implemented the Biomedical Computer Systems' program for enhancing the health and task-relevant fitness for professional fire fighter and law enforcement personnel.

FIRE DEPARTMENTS

- Cleveland, Ohio
- East Cleveland, Ohio
- Euclid, Ohio
- Tony Peligreno –
  216-410-4716 cell; 440-835-0146 H
- Mentor, Ohio
- North Olmstad, Ohio
- Toledo, Ohio
- Dayton, Ohio
- Lincoln Park, Mich
- Jackson, Mich
- Janesville, Wis
- Burnsville, Minn
- Myrtle Beach, SC
  Larry Branch – 843-450-7173
- Torrance, Calif
  Tim Macatee – 310-344-1490 (cell)
- Federal Way, Wash
- Tyler, Texas
- Houston, Texas
- San Angelo, Texas
  Eddie Chrane – 325-676-6695
- Abilene, Texas

HEALTH/FITNESS INSTITUTES

- General Electric Energy
  Jennifer Dye – 864-254-4212
- Power Station, Greenville, SC

CITY POLICE DEPARTMENTS

- Appleton, Wis
- Dayton, Ohio

OCCUPATIONAL MEDICINE PROGRAMS

- Miami Valley Hospital
  Joy Eyler - 937-208-3899
- Dayton, Ohio
- San Onfre Nuclear Power Plant
- San Onfre, Calif

INTERNATIONAL (Fire Departments)

- Erfurt, Germany
- Mannheim, Germany
- Halle, Germany
- Dresden, Germany
- Bosch, Inc
  Chief Dieter Schmidt; schmifico@t-online.de
- Stuttgart, Germany
- Saipan International Airport Fire Department
- AirServices, Australia
  (all airport fire departments in Australia)

MILITARY FIRE DEPARTMENTS

- U.S. Air Force
  (all USAF fire departments in the U.S. , Europe, Asia) Since 1990
- U,S, Navy Fire
  (all USN fire departments in the U.S., Europe, Asia since 1990)
- U.S. Army Fire
  (all USA fire departments in the U.S., Europe, Asia since 1990)
- NATO Fire Departments
  (Geilenkirchen – 1994)

  [Master Sergeant Wade Grimm (ret); former chief of U.S. Air Force Fire Fighter Fitness Initiative; 850-398-3073 (cell)]

Addendum II

NOTE: *This is a copy of an official letter from the Head of Occupational Medicine in one of the largest U.S. Naval Bases to the Chief of that Naval Base's Fire Department. This letter was written following Dr. Alexander's review of the BCS program being implemented in Chief Butler's Department.*

MEMORANDUM

12334
4 Nov 93
11/M03206

FROM: Heat, Occupational Medicine Department,
Naval Medical Center, Portsmouth

TO: Chief David Butler, Naval Base Fire Department,
1653 Morris Street, Norfolk, VA 23511

SUBJECT: FIREFIGHTER PHYSICAL FITNESS PROGRAM

1. On 3 Nov 1993 I was given a thorough briefing and demonstration of the proposed physical conditioning program for our firefighters by Chief Ken Gregory. While I anticipated being favorably impressed by the program, it surpassed what I had hoped for. I enthusiastically endorse the immediate initiation of this program.

2. Unlike some well-meaning, but misguided, approaches to improved fitness, this program is medically sound and has judicious guidelines. It correctly tailors the recommended fitness schedule to the individual firefighter and provides a safe and reasonable 16 week cycle of gradual improvement.

3. Because of the large margin of safety that is integral to the testing, it is my opinion that all current firefighters not on limited or restricted duty are medically cleared to enter this program. This is by virtue of their having current medical examinations clearing them, as firefighters,. To engage in potentially far more taxing physical exertion than this program provides. As an additional precaution, the computer generated questions asked of each participant prior to beginning the baseline testing screens those who should seek medical approval and stops their evaluation. These firefighters should seek evaluation at their occupational health clinic before proceeding with the program. If necessary, we will obtain guidance from an individuals' private physician. I expect very few would not be medically cleared, and in these rare cases I frankly would question their fitness for duty as firefighters.

4. This is a program which has been a long time in coming, and I am delighted that firefighters how have this command-sanctioned opportunity to safely improve their levels of conditioning. I want to commend you on the quality of the program. Chief Gregory has received excellent training, and I'm convinced his enthusiasm for this undertaking will be infectious. The testing and training equipment and the work-out spaces I saw at Fire Station Two were first-rate. Perhaps getting started was expensive, but the benefits of a continued program will be enormous. Simply put, improving the fitness level of our firefighters will decrease cardiovascular-related illness and save lives.

5. When questions or concerns arise, as I'm sure they will, please don't hesitate to contact me at 444-1420.

J.C, ALEXANDER
CAPT, MC, USN

Physical Fitness and Emergency Task Performance

Myhre, L.G., D.M. Tucker, D.H. Bauer, J.R. Fischer, Jr., W.H. Grimm, C.R. Tattersfield, W.T. Wells. Relationship between selected measures of physical fitness and performance of a simulated fire fighting emergency task. AL/CF-TR-1996-0143, U.S. Air Force Armstrong Laboratory, January 1997.

NOTE: The fact that this study was conducted on a total of 279 professional fire fighters places it in a class by itself. No other research, anywhere, has been reported studying carefully determined measures of physical fitness for over 100 fire fighters to be compared with a standardized, meticulously controlled U.S. Government endorsed firefighting performance task. The high correlation between measures of aerobic capacity (as measured by Biomedical Computer Systems' comptuterized cycle ergometry) and time required to complete this task confirms the validity of these measures for predicting success and failure on the fire ground. Although all 279 fire fighters had successfully passed the official U.S. Air Force annual physical fitness test (e.g., 1.5 mile run for time), 25% if those tested scored below 36 ml/kg/min on the cycle test and they required from 11 min 42 sec to 30+ minutes to complete this test which was accomplished in an average of 3 min 15 sec by the top 25% scoring an average of 45.5 ml/kg/min on the BCS test.

Cardiorespiratory Capacity and Work in the Heat

Myhre, Loren G. and D. J. Long. Relationship between cardiorespiratory capacity and a fire fighter's tolerance to work in the heat. City of Houston Fire Department, Houston, Texas, October, 1998.

ABSTRACT: Twenty male professional fire fighters with medical clearance for unrestricted duty and fully acclimated to work in the heat volunteered to participate in this study. Measures of aerobic capacity, muscular strength, and body composition were used for calculating the "Firefighter Fitness Index®" for each of the subjects. The fire fighters were fitted with skin and core temperature sensors and a chest-lead transmitter for monitoring body temperatures and heart rate continuously during these experiments. After donning their own personal turnout gear and self-contained breathing apparatus the subjects proceeded to perform a standardized regimen of fire ground activities (Tair 36.3° C; Tglobe 52.7° C; RH 62%) which included intermittent brief exposures to burn building temperatures exceeding 305° C. Fire fighters were instructed to give it their best effort, continuing until either core temperature reaches 39.9° C, or until she/he voluntarily removes her-/himself from the experiment. Work tolerance times ranged from 21 minutes for the least fit ($VO_{2\,max}$ 25.9 ml/kg/min) to 39.8 minutes for the fire fighter with the highest level of cardiovascular capacity ($VO_{2\,max}$ 67.6 ml/kg/min).

Cardiorespiratory Capacity and Female Fire Fighters

Myhre, Loren G. and D.J. Long. Relationship between cardiorespiratory capacity and female fire fighter's tolerance to work in the heat. City of Houston Fire Department, Houston, Texas, August, 2000.

ABSTRACT: Eighteen female and seven male professional fire fighters with medical clearance for unrestricted duty and fully acclimated to work in the heat volunteered to participate in this study. Measures of aerobic capacity, muscular strength, and body composition were used for calculating the "Firefighter Fitness Index"® for each of the subjects. The fire fighters were fitted with skin and core temperature sensors and a chest-lead transmitter for monitoring body temperatures and heart rate continuously during these experiments. After donning their own personal turnout gear and self-contained breathing apparatus the subjects proceeded to perform a standardized regimen of fire ground activities (Tair 27.2° C; Tglobe 36.1° C; RH 62%) which included intermittent brief exposures to burn building temperatures exceeding 326° C. Fire fighters were instructed to give it their best effort, continuing until either core temperature reaches 39.9° C, or until she/he voluntarily removes her-/himself from the experiment. Work tolerance times ranged from 15 minutes for the least fit ($VO_{2\ max}$ 26.7 ml/kg/min) to 52 minutes for the fire fighter with the highest level of cardiovascular capacity ($VO_{2\ max}$ 66.3 ml/kg/min). By gender work tolerance times averaged 25.3 and 34.3 minutes for the female and male fire fighters, respectively.

Metabolic Heat Retention: Neoprene vs. Breathable Moisture Barriers

Myhre, L.G., M.T. Walsh, C. Wedige, L.L. Laubach, and T. Miszko. Comparing the effects of neoprene vs. breathable moisture barriers on the retention of metabolic heat in working fire fighters. City of San Antonio Fire Department, San Antonio, Texas 1996.

ABSTRACT: Eighteen professional fire fighters performed a series of light intensity exercise (58% $VO_{2\ max}$) experiments in a warm environment (37./5° C; 41% RH) while wearing garments with either a neoprene (control) or a breathable moisture barrier. The work tolerance times (WTT) averaged 43.9 +6.7 and **45**.4 +7.9 minutes for the control and six different brands of the breathable garments, respectively. Only when wearing the seventh garment was the WTT (52.6 +6.4 minutes)significantly different than for the control. Increases in core temperature during exercise were remarkably similar for all exp[merriments differing by not m ore than 0.2° C after 44 minutes of work/heat exposure. Mean skin temperatures increased progressively with work in all experiments, but increased slightly more rapidly when wearing the control garment; this difference was manifest in final values averaging 39.1° C for the control vs. averages ranging from 37.8 to 38.6° C for he seven breathable garments. The total grams of sweat passing through the breathable membranes was of little significance for possible evaporative cooling, averaging from a low of 1.6% to a high of 16.1% of the total sweat secreted for garments #3 and #4, respectively. Although there of the breathable garments appeared to impose slightly, but significantly less thermal burden than did the control, it has yet to be determined whether these garments would perform as well as the control in protecting the fire fighter form the excessive heat/flame found on the fire ground..

Firefighter Fitness Index® and the World's Toughest Firefighter® Competition

Myhre, L.G. and W.H. Grimm. Validity of the Firefighter Fitness Index® for predicting performance in the World's Toughest Firefighter® competition 1995, 1996, and 1997. Biomedical Computer Systems' reference materials, 1998.

ABSTRACT: Professional fire fighters representing fire departments in Europe, Australia, New Zealand, The United Kingdom, Canada, and the United States gathered to compete in the "World's Toughest Firefighter"® games held in Honolulu, Edmonton, and Las Vegas. Prior to the competition, a sample consisting of 88 male and 10 female firefighters were randomly selected to participate in a study to determine the relationship between specific measures of physical fitness and time required to complete the standard regimen of five strenuous simulated fire ground tasks. Aerobic capacity and was determined by the Biomedical Computer Systems' computerized cycle ergometer program which, when combined with three measures of muscular strength/endurance yields the "Firefighter Fitness Index"® (FFI) which was designed to provide an age and gender blind accurate predictor of firefighter fitness-for-duty. The values for the FFI range from 0 to 140 and by luck both the best and poorest performers were included in the test sample. The best total time for the competition (8 min 34 sec) was achieved by the fire fighter scoring 139 in the FFI. The second place fire fighter (FFI = 138) finished in 8 min 42 sec. The poorest performer scored 42 on the FFI and required 27 min 10 sec to complete the same task. Performance time increased nearly in proportion to the decrease in FFI score and the correlation between these variables was highly significant (r = - 0.84).