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SYSTEMS ANALYSIS OF PHYSIOLOGICAL PERFORMANCE RELATED TO STRESSES SUCH AS THOSE EXPERIENCED IN HIGH PERFORMANCE AIR CRAFT

Richard F. Walters

California University

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13. ABSTRACT

Areas of USAF interest discussed in this report are: Continued refinement of a predictive model of human performance; Maintenance of indexed bibliographies of performance, peripheral circulation and energy exchange for distribution to interested researchers in other Air Force related research centers; Collection of exercise performance data on normal and athletic subjects, as well as initiating data collecting on certain types of patients with specific problems such as pulmonary or circulatory diseases; Development of a comprehensive data support system for research in human physiology; Development of a joint investigation of acceleration (in conjunction with investigators at the School of Aerospace Medicine, Brooks Air Force Base, San Antonio, Texas); Installation of programs developed at this center in other Air Force research centers, including the U.S. Air Force Academy and an Air Force supported research project at the University of Kentucky; Data analysis and interpretation, using tools developed at Davis, for other research units; Joint research with the Air Academy.

Details of illustrations in this document may be better studied on microfiche

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Summary of Contract Activities and Results

F44620-72-C-0011

October 1, 1971 through September 30, 1972

Systems Analysis of Physiological Performance Related to Stresses Such as Those Experienced in High Performance Air Craft

Support for research through this area represents a continuation of research support [redacted], which terminated September 30, 1971. A report summarizing results of that research pointed to several objectives which remain continuing objectives of the current effort. Among the areas of interest are:

1) Continued refinement of a predictive model of human performance.

2) Maintenance of indexed bibliographies of human performance, peripheral circulation and energy exchange for distribution to interested researchers in other Air Force related research centers.

3) Collection of exercise performance data on normal and athletic subjects, as well as initiating data collecting on certain types of patients with specific problems such as pulmonary or circulatory diseases.

4) Development of a comprehensive data support system for research in human physiology.

Other areas of investigation which have been incorporated into this year's effort have included:

5) Development of a joint investigation of acceleration (in conjunction with investigators at the School of Aerospace Medicine, Brooks Air Force Base, San Antonio, Texas).

6) Installation of programs developed at this center in other Air Force research centers; including the U.S. Air Force Academy and an Air Force supported research project at the University of Kentucky.

7) Data analysis and interpretation, using tools developed at Davis, for other research units.

8) Joint research with the Academy.

The activities and results described below reflect considerable progress in a number of these areas, and point also to areas where current research is extending investigations based on results obtained thus far this year.

1. Predictive Model Performance Under Environmental or Work Load Stress.

As reported last year, a preliminary model of performance had been created and demonstrated certain principles of human response to environmental stress. The model in its initial form pointed out many areas where further studies were required. During the past year, attempts have been made to define more precisely those areas where the model required greater precision in its definition, or where additional experimental work was required.

In the area of greater model precision, efforts during the year have been devoted to definition of sub-compartments within the body periphery. Thus, body compartments have been divided either into two or three sub-components, representing core, muscle and skin. Heat exchange between these components is described on the basis of conduction and blood flow, and the results appear to represent more accurately the response to thermal stress. However, the more specific compartmentalization of the system has also pointed out the need for further investigation of peripheral blood flow control mechanisms, and a new series of tests is now underway to further elucidate the distribution of deep and skin blood flow under work and environmental stress. Research on this topic is in the active experimentation phase at present, with results expected to be completed for preliminary reports during the current contract year.

Additional investigations on heat distribution in the system were stimulated by a visit from Dr. Paul Webb, whose consultation with research members pointed out the apparent capacity of the human system to vary the heat distribution between core and periphery more than is generally provided for in thermoregulatory models. These considerations are under investigation through the existing simulation model at present, and may lead to more detailed collection of thermal data from experimental subjects at rest and during exercise.

With the additional improvements on the data acquisition system and the arrival of a hypobaric chamber (see below), it is anticipated that experimental investigations directly aimed at elucidating problems encountered in model imperfections will increase during the current year.

2. Maintenance of Indexed Bibliographies.

Copies of microfiched reprints of key reprints relating to human performance, peripheral circulation and energy exchange have been prepared for several years, using an indexing scheme developed through project support. These copies are distributed, together with the index printout, to researchers at Brooks Air Force Base, Wright Patterson Air Force Base and the Air Force Academy. At present this set of libraries includes 781 references in the human performance library, 591 references pertaining to peripheral circulation, and 255 articles dealing with energy exchange.

The bibliographic search system, which initially was developed to run on an IBM 7044 computer has been converted to both interactive and batch versions on Burroughs equipment. As noted below, this program, which can be generalized to support any reprint library, has been made available to researchers at the Air Force Academy.

3. Collection of Exercise Performance Data on Human Subjects.

During the past year, equipment facilitating collection of experimental data from exercise tests has been actively used in the study of a large group of normal subjects ranging in age from 11 to over 60 years. These data have been collected in part through adult fitness programs conducted in collaboration with this project. In addition, a separate but related project has investigated effects of conditioning on policemen and firemen in the Davis community.

At present, the project members are testing the validity of a progressive performance test recently devised at this center to cover, in a single series of stepped performance levels, all types of subjects from patients to highly conditioned athletes.

A companion study of conditioning effects of altitude training is reported in item 6 below.

4. Development of a Comprehensive Data Support System for Research in Human Physiology.

The research covered by this topic includes: a) creation of an effective indexing mechanism for reprint files, together with the storage of the original reprints in condensed (microfiche) format; b) implementation of modeling capabilities through a general purpose simulation language (CSMP); c) creation of a data storage, retrieval and analysis system; and d) development of a data acquisition system for experimental studies that would facilitate transfer of results into forms that can be easily analyzed and compared by (c) above. Item (a) is covered in the section (2) of this report. The remaining items are discussed below.

A. Simulation. CSMP, a general purpose simulation language developed initially for IBM computers, has been converted to Burroughs equipment through this project. The language operates in two modes, batch and interactive. At present, the batch mode is operational on the Burroughs B-6700 computer, the modern system that will serve as the principal campus computer system for several years to come and also the same type of computer as has been installed recently at the Academy. The interactive version of CSMP was developed for the Burroughs B-5500, since the newer system did not support timesharing until recently.

The simulation language has been used in several activities, studying acceleration, components of the performance model, and testing a variety of hypotheses related to systems analysis of human performance in conjunction with this investigation. In addition, the language has been used for instruction both here and at the Academy, following installation of the system early in the current project year.

Upon completion of the timeshare support system for the Academy and this campus, CSMP will be made available to both schools once again in an interactive mode, and it will be somewhat more flexible than the current version. Conversion to the B-6700 timeshare system is now in the design stage.

B. Creation of a data storage, retrieval and analysis system (DSAP). In the first year of research under the previous grant (AFOSR #69-1659), an interactive data system was developed for IBM equipment. This system was active until the computer hosting the system was removed from the campus. Since that time, it was decided that the system should be redesigned for the B-6700 computer's timeshare system, whose arrival was delayed for a year. At present, it is anticipated that the timeshare system will become operational within the next few weeks, at which time the DSAP system will be tested in interactive mode. Prior to the availability of timesharing, it was possible to test the system only in batch mode. Since the entire philosophy of the data analysis portion of the system requires interaction between user, data files and analytical programs, it was not possible to combine the entire system in an operational test.

Despite these limitations, however, a great deal of progress has been made on this system. The input phases of data preparation is operational and has been tested with a set of experimental results from performance runs. The ability to perform extensive data manipulation and editing during the input phase is also operational, and a series of data sets have been created to verify this capability.

In the analysis area, several supporting programs are already operational on the preliminary timesharing currently available on the new computer. These include plotting packages, queries regarding specific operations to be performed, and other general purpose routines. The analytical programs to be incorporated into the system also exist, and it remains at present to incorporate them in a manner compatible with the work files of the total system. It is anticipated that this system will receive considerable attention during the next few months as time on the new computer is more readily available in timesharing.

C. Data acquisition system. The minutes of research meetings held in conjunction with this contract reflect the major progress that has been made in utilization of the data acquisition system. A portion of one set of minutes is submitted as attachment A to this report, indicating the full range of capabilities now available to the data acquisition system, and pointing out some of the applications that have been made of the system in recent months. A paper describing this activity is being prepared for submission at the present time.

5. Model Studies of Acceleration (in Conjunction with AMRL at Brooks).

Pursuant to a request from AMRL at Brooks Air Force Base, a portion of the efforts of this year's research were devoted to simulation studies of responses to acceleration. This investigation involved several conversations, both here and at Brooks, and resulted in the development of a model that does indeed explain basic acceleration effects on circulation using somewhat innovative principles that appear to have sound physiological basis. A report describing that model and its relation to the experimental data available from Brooks was submitted in conjunction with the Air Force Review and is attached to this project summary as attachment B.

6. Installation of Computer Programs at Other Air Force Research Centers.

During the year, contacts have been made with several research centers regarding the implementation of computer programs developed through contract support. In October, 1971, a series of computer programs were taken to the Air Force Academy and installed on the B-5500 that served as the central computer facility at that time. This installation included the following programs:

a. Bibliographic Indexing Program (interactive)

b. CSMP (interactive and batch)

c. Human Performance Model (interactive)

A demonstration of the modeling programs was held during that visit. Subsequently, the Academy has shifted from the B-5500 to a B-6700, and the B-5500 has been removed. Plans have been defined for the installation of B-6700 programs in the near future. The delivery date of these programs depends on the completion of Burroughs-supported software which is expected to be completed within the next few weeks. Following a testing and acceptance period for that software, members of the UCD project will visit the Academy and install the following software:

a. Bibliographic Support System (batch and/or interactive)
b. CSMP (interactive and batch, both revised and improved)
c. Performance model (updated)
d. Student Self-Evaluation System (interactive)
e. Data Storage, Retrieval and Analysis Program
f. Other UCD Software Requested by the Academy.

A workshop will be held in conjunction with this visit to demonstrate the programs and a conference on future software development will be scheduled for the same visit.

In preparation for the formal installation of the programs listed above, some preliminary software has already been shipped for evaluation of the installation procedures that would best serve this exchange.

At the University of Kentucky, a Raytheon computer similar to the one at UCD was received during the past contract year. Mr. Schultz, programmer for the data acquisition system, made two trips to the University of Kentucky to assist in startup of the Raytheon system. He brought with him systems software developed by this project, instructed technicians in system programming techniques and shared other elements of our experience with the members of that research group. A letter expressing appreciation for this assistance was received shortly thereafter, in which the hope was expressed that other collaboration could be arranged in the future.

7. Data Analysis at Davis of Research Data from Other Air Force Research Centers.

It is recognized that many Air Force research centers do not have hardware identical to configurations at Davis or the Academy. For this reason, efforts have been pursued to provide software services through project support, using the Davis campus computer. In this connection, data from the Academy has already been received in several ways, including direct transmission over telephone lines, and discussions are under way to permit transmission of data from other research centers.

Both Brooks and Wright Patterson researchers have expressed interest in this concept. Additionally, some researchers have voiced the hope that ways will be found for remote access of the Davis computer through federally leased telephone lines. This service has not been arranged as yet, owing to difficulties in securing appropriate permission for use of the federal lines.

8. Joint Research with Air Force Academy.

At present, the UCD project members are in close contact with members of the Departments of Electrical Engineering, Life Sciences, Astronautics and Computer Science, and Physical Education of the Academy. A number of collaborative projects have arisen from these contacts; among the most active is one involving exercise studies of Air Force cadets and trained cross-country runners from the Davis area. During the year, several groups of cadets have visited the Davis campus in order to partake in stress tests on the project equipment. In addition, a group of cross-country runners from Davis participated in a controlled study of the effects of altitude conditioning on sea level performance in highly conditioned athletes. Results of both of these investigations were reported by Major Watters at the Air Force Review Meeting in September, 1972. A copy of key information from that report is included in attachment C of this report. A more complete paper is nearing completion for submission as a journal publication at this time.

9. Summary of Publications Appearing or in Preparation.

The attached bibliography lists the principal publications that have already appeared during the present contract years. Copies of each of these publications are attached to the report. A paper describing the self-evaluation program to be installed at the Academy is included because of its interest to Air Force investigators, although it was not supported directly by the contract. Papers accepted for publication at present include a paper dealing with the microfiche/computer index bibliographic system developed through this research. This paper, submitted by Jerome Wilcox and R. F. Walters will be presented at the Society of Photogrammetric Engineers in February, 1973. In addition, the project has been invited to contribute a paper to the San Diego Biomedical Engineering Symposium, scheduled for January, 1973.

Papers in preparation at this time include a report by N. Miller and J. Green on the acceleration model described above and a paper describing the data acquisition system, prepared by several project members.

10. Other Activities.

Exchange visits to Air Force research centers. Project members have made several trips to research centers at Wright Patterson, Brooks and the Academy in preparation to discuss areas of common research interest. In addition, representatives of each of these laboratories have visited the Davis campus to review the project and to consult on specific areas of interest. Among the areas discussed have been thermoregulation, modeling of acceleration, exercise testing, computer assisted instruction, and data analysis.

Other visitors to the project have included:

a. Paul Webb, Ph.D., who spoke in one of the research meetings on the subject of "Circadian Periodicity in Human Metabolism," and who also discussed thermoregulatory problems of the performance model.

b. John Mitchell, Ph.D., University of Wisconsin, who spoke on "Modeling Muscle Blood Flow in Exercise."

c. George Swanson, Stanford University, who spoke on "Dynamic Forcing Functions in the Study of the Human Respiratory Controller."

11. Equipment Furnished by Government.

No equipment was purchased during the current contract year. However, at the request of project members, two items were shipped as government furnished equipment. The first was an analog tape recorder, similar in description to one currently in use at a UC Davis laboratory investigating circadian temperature variations. This item was received during the winter, 1972, and found to be in inoperable condition. A request to have it removed from accountable equipment inventory has been forwarded through the Office of Scientific Research, and to date no response has been received.

The second item is a six-man hypobaric chamber declared surplus at Wright Patterson Air Force Base in the spring, 1972. This equipment, accompanied by vacuum pumps and miscellaneous fittings, arrived on the Davis campus during the summer. Plans are now nearing completion for its installation in the human performance laboratory, where it will be used in conjunction with the current contract investigations. Funds supporting this installation will be derived almost entirely from campus support.

References

1. Adams, W.C., M.M. McHenry and E.M. Bernauer. Multistage Treadmill Walking Performance and Associated Cardiorespiratory Responses of Middle-Aged Men. Clinical Sciences 42: 355-370, 1972.

2. Schultz, Robert, Edmund Bernauer and Richard Walters. Human Performance Analysis Through Computer Support. The Program of Biomedical Engineering Society, 3rd Annual Meeting, April 7 and 8, 1972, p. 33.

University of California
Davis
School of Medicine

Research Meeting
Human Performance Physiology

AFOSR--#F44620-72-C-0011
NASA--#NGL 05-004-031

August 24, 1972

Research Discussion:

Status of Data Acquisition System. Bob Schultz and Wylie Harter gave a progress report on the current capabilities and utilization received by the data acquisition system, which now includes a mini-computer, a mass spectrometer, and other sensing equipment appropriate for exercise studies. Their report will be incorporated in part into a paper describing the system to be submitted for publication in the near future.

1. Wave form accuracy through digitization. Electrocardiogram. During the past year, a number of new capabilities have been added to the system. One of the interesting tests that were performed to determine the accuracy of the analog-to-digital conversion capabilities of the computer was a series of play-backs to electrocardiograms using different sample rates. The electrocardiogram was first displayed on a strip chart recorder as it came from the recorder. The wave form was then digitized through the analog-to-digital converter, and reproduced once again in strip chart form by using the computer's digital-to-analog output. The resultant wave forms are reproduced in the accompanying charts (Figures 1,2,3), showing the wave form obtained from sample rates of 1000, 500, 200, 100, 50 and 25 samples per second, respectively. The accuracy of the wave form reconstruction

at sample rates above 50 samples per second is considered sufficient for most purposes of experimentation. Plans to incorporate total electrocardiogram signals in on-line processing have not yet been introduced, but it appears likely that this approach will be investigated during the coming months.

2. Computer control of recording strip chart electrocardiograms. In addition to providing for digitization of the electrocardiogram, the computer has also been programmed to send a signal to the electrocardiogram recorder to start the paper moving for a tracing. This signal is being used to ensure regular trace recordings during experimental runs at the present time. The tracing also includes an event marker that is computer controlled, as shown on Figures 4, 5 and 6. The event marker could be used for several purposes; in this case it is being used to record input from another device used in regular experimental procedures: an R-wave detector (see below).

3. Improved reliability through the R-wave detector. A device available to the project on long-term loan from NASA is being used to recognize R-waves despite muscle artifacts during exercise. Figure 5 indicates the ability of the detector to function accurately despite large amounts of noise on the recording, using the technique described in (2) above. This improvement in detection of heart rate has been a major asset in running large numbers of subjects, since a great deal of set up and confirmation time has in the past been related to setting the threshold for heart rate interrupt. The availability of a reliable R-wave detector opens the door for other types of programming, such as monitoring intervals between heart beats as a measure for arrythmias and indirectly as an indicator of premature ventricular contractions. Some programming will be undertaken in the near future to study various ways in which this capability can be more fully used. One alternative might be to record a continuous loop of several seconds of the total ECG, and to write it on disk when an unexpected event occurs. In addition, a variety of warning signals might be programmed as deemed appropriate.

4. Temperature amplifier channels. Four temperature channels are now available in the system. Two of them are capable of measuring from 15°C to 35°C; the other two have variable gains that can be set for 5, 10 or 20 degrees. Calibration has been built in so that the thermistors' representation of various temperatures can be stored for purposes of comparison before the experiments begin.

5. Treadmill. The treadmill has been outfitted with a new, medium-speed gear that permits running subjects in ranges appropriate for both athletes and post-coronary patients. Previously, the gear ratios available were suitable for only one or the other, and had to be switched when different subject groups came in. In addition, the computer has been used to calibrate the speeds shown on the dial of the treadmill, and an accurate calibration chart is now available on the laboratory wall, printed out by the computer teletype.

In addition, the treadmill now has controlled speed and elevation under computer command. The speed portion of the control is functional and has been completely checked out. The elevation treadmill wiring is complete and will be installed within the next few days. Sinusoidal forcing functions in speed can be programmed to occur so gradually that the subject cannot detect the incremental steps that approximate the sinusoidal function. It is anticipated that similar elevation shifts will be possible. Owing to the nature of the treadmill lowering mechanism, sinusoids of 42 second half-cycles will be the most rapid possible. It is not anticipated that more rapid changes will be required covering the complete range of the elevation.

6. Teletype silencer. A sound-proofing box for the teletype has been constructed in the laboratory, similar to one available commercially but at a fraction of the commercial price. This reduction in sound should materially aid in reducing noise levels during experimentation.

7. The magnetic card input system is now revised to permit greater flexibility in merging new data to existing files. The program now blocks records to reduce input costs on the Burroughs central computer. It also permits changes to be made on the input file, using disk as intermediate storage. The program then goes into the normal input phase using magnetic card data and permitting card-to-card editing. New editing capabilities include substituting special characters for other characters within a certain range of the data columns. This feature was added when it was found that the letter "l" is frequently used for the number one in typing, and a substitution becomes necessary only in the numeric fields. With the new program this is now possible.

8. Data communications. Several modifications to the communications capability of the system are contemplated in the near future. At present, the data communications clock is based on RC circuitry which exhibits some drift. A shift in this configuration to a crystal oscillator and computer controlled modulo/n adjustment of frequency should permit a far greater range of data input signals, adjusted to the input device. In this manner it will be possible to accept other devices, such as Hazeltine CRT's and similar higher speed systems. In addition, it will be possible to plan for still higher band rates as the couplers are available. This modification is in the design stage, with implementation scheduled for the early fall.

Project Applications

During the summer, the system has received a great deal of experimental use, both by project members and by associated groups who have assisted in developing some more extensive program capabilities for the system. Some of these projects are listed below.

1. Adult fitness program. Over 200 adults from the local community have subscribed to an adult fitness program established by Dr. Wilmore. This program has run all of its subjects on the system. Additional tests are contemplated in the next few months.

2. Investigation of conditioning program effects on performance levels of policemen and firemen. Two groups of 20 firemen and policemen are participating in a study of the effects of conditioning programs on their performance levels.

A control group is to be tested at the start and completion of the experimental period. The exercise group will be evaluated before, during and after the period. To date, the 40 subjects have been tested once, and the exercise group is in the process of undergoing its second evaluation. A final check will be run at the end of the exercise schedules, in the early fall.

3. Altitude effects on training for sea level athletes. Dr. Adams' investigation, reported in other meeting minutes, used the treadmill system extensively during the course of the seven week study. More than 100 runs were conducted on the system in conjunction with this investigation.

4. Grammar school children. A new study involving grammar school children is about to begin. Because of scheduling limitations on the system and the requirement to continue developmental work, approximately half of these subjects will be tested manually. Workers have come to recognize, however, that the availability of the system provides sufficient increase in speed and reliability that few investigators connected with the project are willing to use manual methods any longer.

5. Digitization and special data reduction of analog data from respiratory investigation of animals. A series of tests investigating the effects of sinusoidal, ramp and step changes in carbon dioxide concentration of inspired air in chickens was recorded on analog tape by some investigators. These data were then digitized on the data system, writing a digital tape for subsequent analysis on the campus computer. The project was undertaken in part to gain experience in digitizing analog tapes, and in part to ascertain the manner in which such data can be conveniently prepared for use on the campus computer.

System Reliability

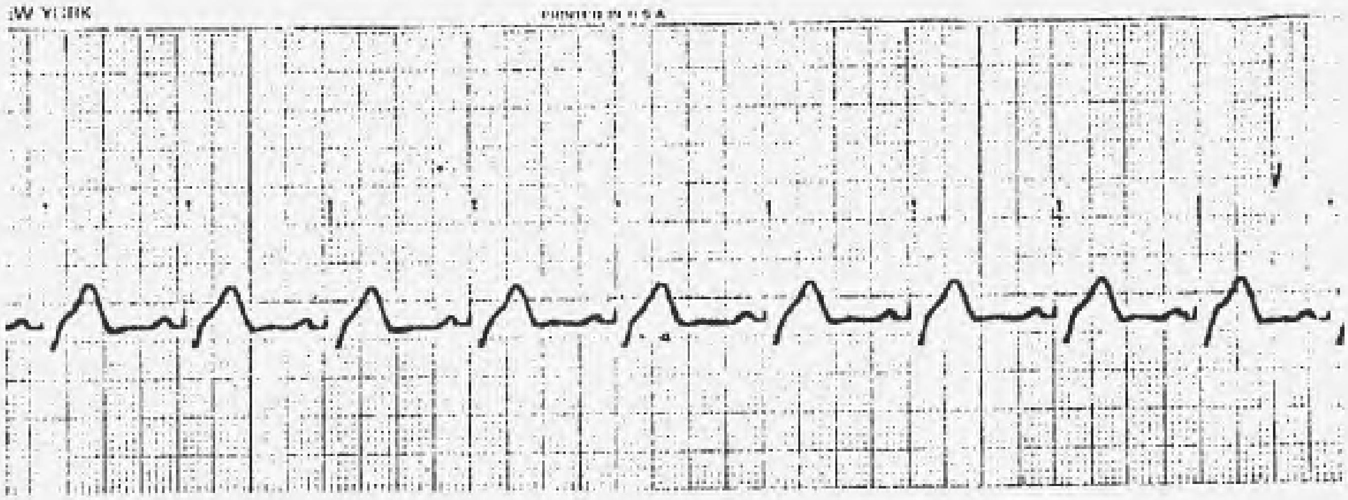
During the summer, the system has been extensively used, both for development and for actual experiments. There has been one hardware failure of serious proportions during that period of nearly constant daytime use: the upper core module developed an intermittent, then a solid failure of one bit in the 2^{14}th position. This failure was the result of imperfect soldering during manufacture, evidently because the solder did not enter this connection when the board was dipped. The failure was detected by Mr. Harter, however, without resorting to manufacturer's assistance, and was corrected within a few days. Since that time the system has functioned without problems.

A minor problem on magnetic tape compatibility with the campus computer has been temporarily rectified by calibrating the tape using a campus tape for calibration. A more permanent solution may be required by the manufacturer in the near future.

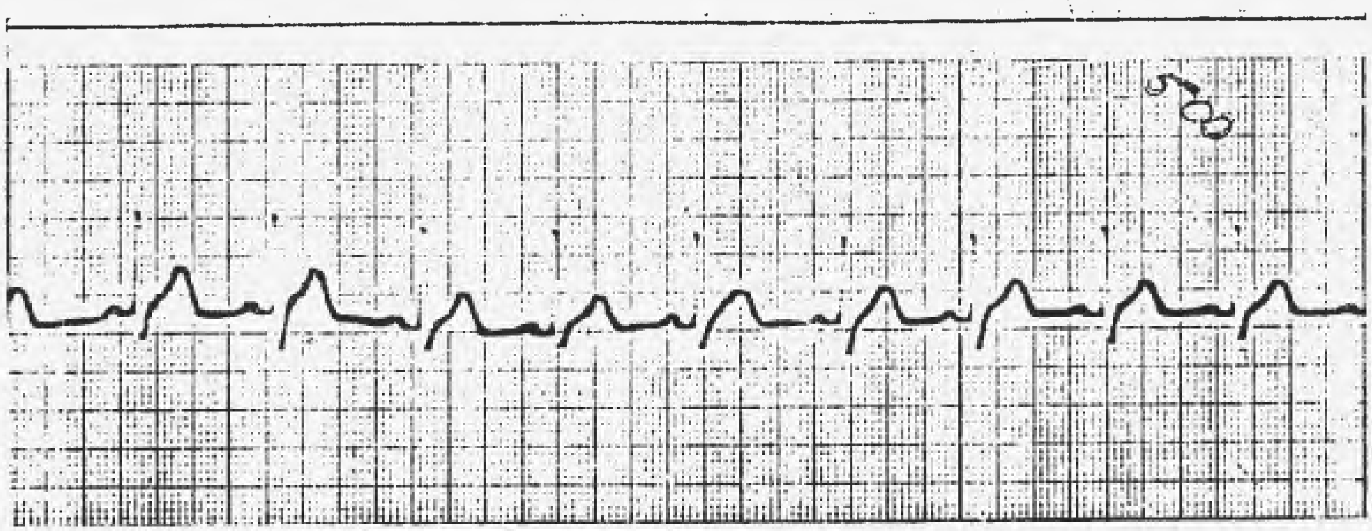
Experience in System Operation

Because of the large numbers of experiments performed during the summer, it has been advisable to train other individuals to operate the system. A significant group of other people are now developing competence in running experimental programs, and the system is performing well with their use.

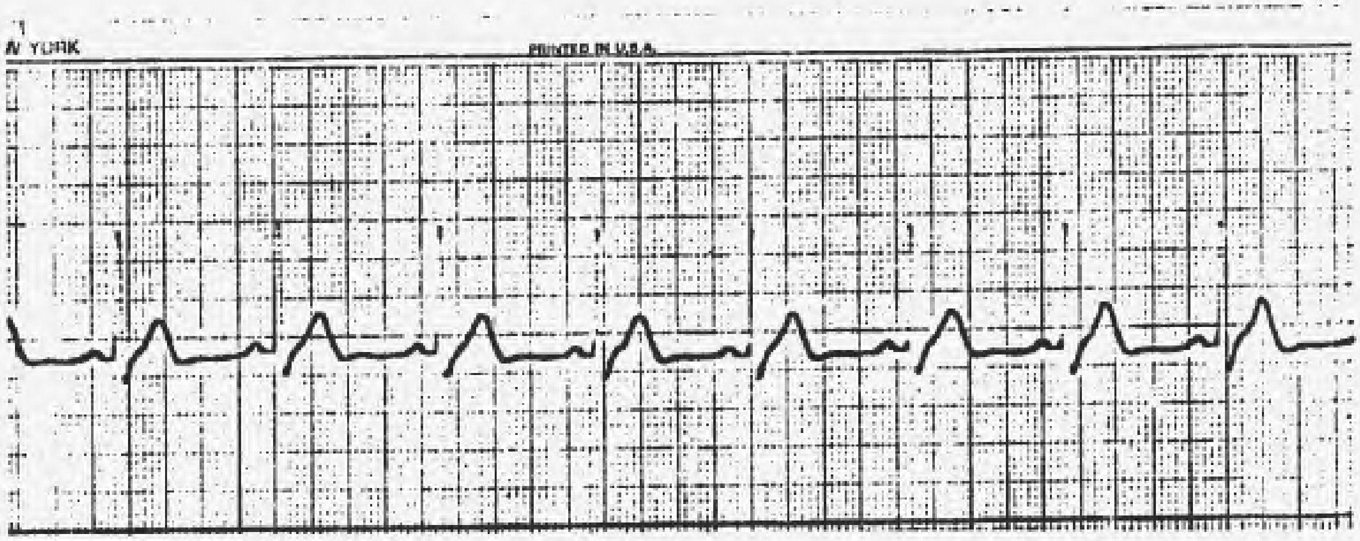
Figure 1



1000 Samples per Second

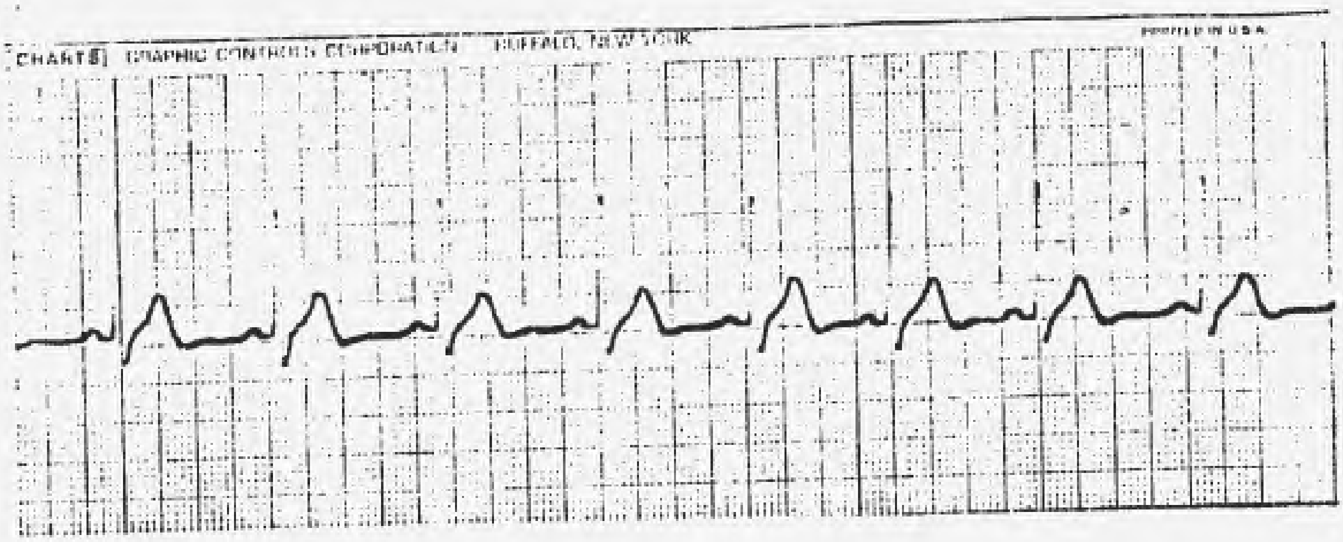


500 Samples per Second

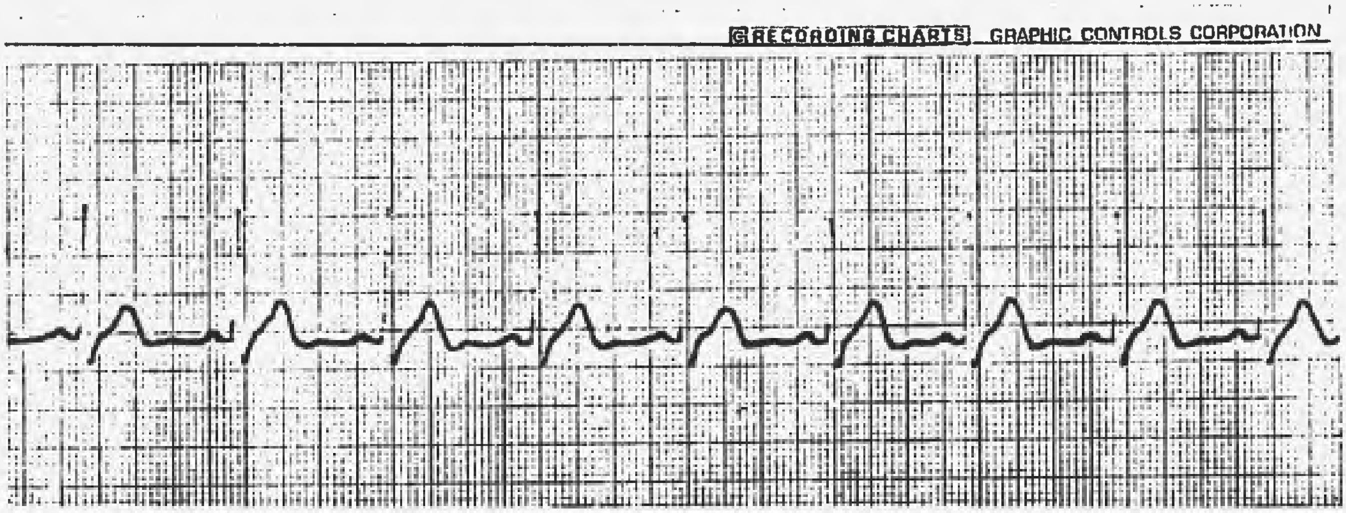


250 Samples per Second

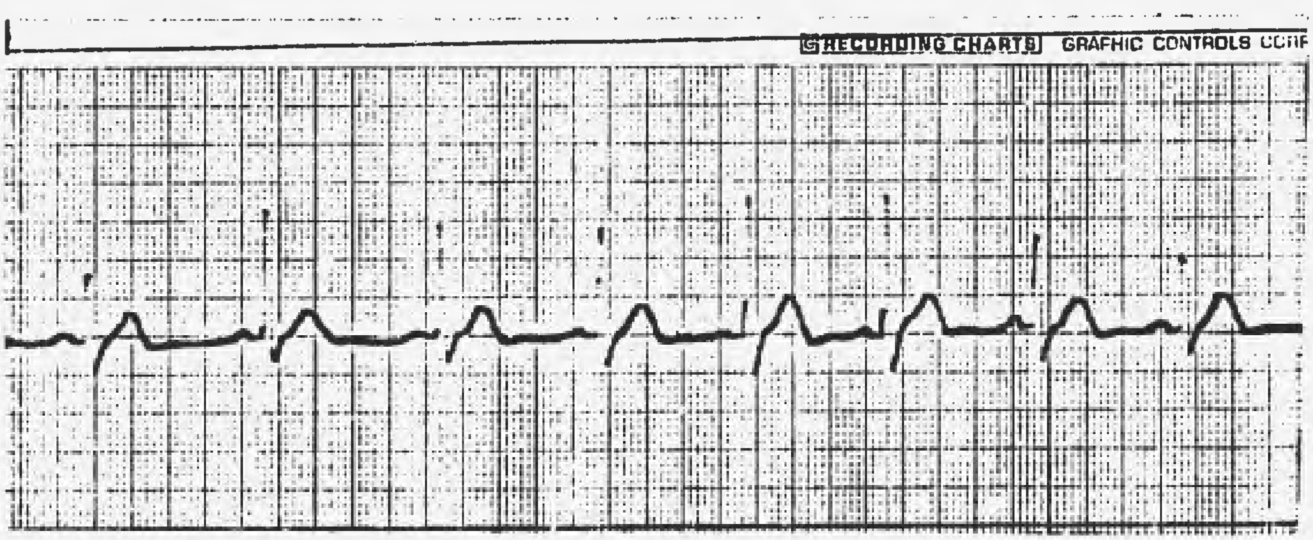
Figure 2



200 Samples per Second

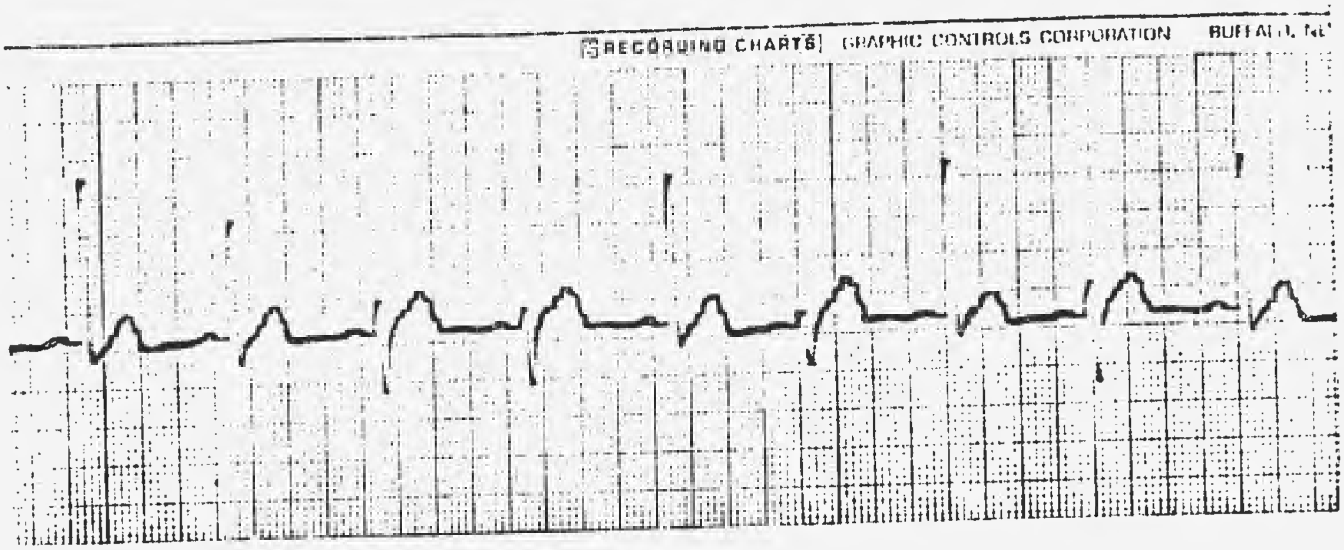


100 Samples per Second



50 Samples per Second

Figure 3



25 Samples per Second

Figure 4

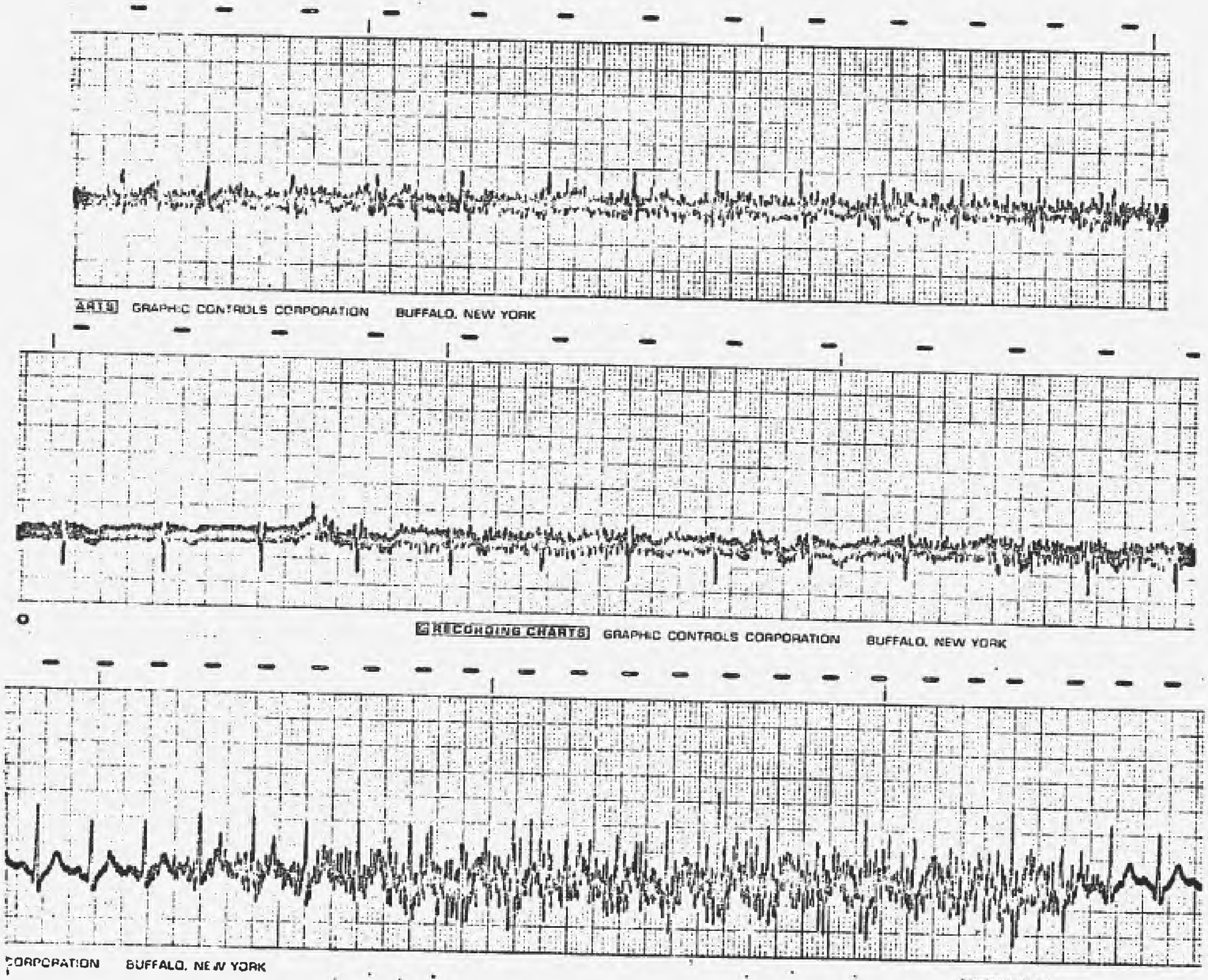
RECORDING CHARTS GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
CORPORATION BUFFALO NEW YORK
PRINTED IN U.S.A.

Figure 5


RECORDING CHARTS GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
PRINTED IN U S A
NO. ECG 100
RECORDING CHARTS
GRAPHIC CONTROLS CORPORATION BUFFALO

18

Figure 6


CHARTS GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
RECORDING CHARTS GRAPHIC CONTROLS CORPORATION BUFFALO, NEW YORK
CORPORATION BUFFALO, NEW YORK
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Attachment B

REVIEW OF AIR FORCE-SPONSORED BASIC RESEARCH IN ENVIRONMENTAL AND ACCELERATION PHYSIOLOGY

26-27 September 1972
at Aerospace Medical Research Laboratory
Air Force Systems Command
Wright-Patterson AFB, Ohio

Air Force Office of Scientific Research
1400 Wilson Blvd., Arlington VA 22209

Air Force Progress Report
(AFOSR #F44620-72-C-0011)
September 1, 1972
N.C. Miller, J.F. Green and R.F. Walters

A Model to Describe Gravitational Effects on the Circulatory System

A study was begun to formulate a mathematical model describing the effects of brief acceleration stress in dogs. A primary goal has been to take a very simple view of the circulatory system and demonstrate that many essential physiological characteristics are exhibited in such a representation. The model is based on the concept of venous return in which the heart is treated as a perfect pump able to move all the blood it receives.

There are two compartments in the model, one for the pulmonary system and one for the systemic system. Systemic and pulmonary arterial and venous resistances are lumped into single constant terms. Venous compliance of both the pulmonary and arterial systems are conceptually placed within the small veins downstream from the capillaries. A characteristic upstream venous pressure is determined as a function of this compliance and the volume within the compliant areas. Systemic and pulmonary arterial compliances are considered negligible relative to that of the small veins. The venous return is equal to the right heart output, and is determined by the ratio of the pressure difference between the characteristic upstream systemic venous pressure and the right atrial pressure to the systemic venous resistance. Similarly, cardiac output is equal to the pulmonary venous return which is in turn determined by the difference between the characteristic upstream pulmonary venous pressure and left atrial pressure divided by the pulmonary venous resistance. The change in volume of each compartment is found from the time-integral of the difference between flow into and out of the compartment.

The two halves of the heart and the pulmonary system are on the same horizontal axis and are separated from the systemic compliant compartment by some finite distance. When the body is tilted from the horizontal to the vertical position, or under conditions of increasing $+G_z$ stress, the pressure within the systemic compliant area falls relative to the right atrial pressure due to hydrostatic effects, therefore reducing venous return. This drop in venous return is transmitted through the pulmonary system as a decrease in cardiac output, which causes a drop in systemic arterial pressure at constant systemic arterial resistance.

Literature values for cardiac output, systemic and pulmonary venous compliance and upstream pressures were used to calculate the various resistances and the volume of each compartment. To find the arterial pressure at any point in the body, for example at eye level, the hydrostatic difference is computed for the acceleration magnitude and the distance between the aortic root and that point.

Comparing the passive model predictions with experimental measurements shows qualitatively accurate results. In an attempt to describe living systems more completely, a simple control scheme was formulated that would act in such a way as to reduce the effects of acceleration stress. In this scheme, a decrease in arterial pressure serves as the stimulus causing a decrease in systemic venous compliance. This decreased compliance raises the upstream systemic venous pressure, which in turn causes an increase in venous return, elevating cardiac output, and thus increasing arterial pressure once more to meet the demands on the system.

It has been tentatively demonstrated that much of the effects of acceleration stress on arterial pressure can be duplicated by this very simple control scheme. However, the explanation fails to describe responses under decreasing $+G_z$ stress (or increasing $-G_z$ stress), and examining the causes of this failure suggests that the characteristics of the heart must be considered under these circumstances.

Future efforts will concentrate on improving the description of the gross system and then examining the adequecy of the approximations obtained using this preliminary model.

Other Activities

1. Effects of Altitude Training on Cross-Country Runners. A joint project between U.C. Davis and the Air Force Academy studying the effects of altitude conditioning on sea level performance was completed during the past summer. Details of this experiment are reported in a separate progress note presented at this meeting.

2. Improvements in Experimental Data Acquisition System. During the past year, the data acquisition system has undergone several improvements and refinements, expanding the range of experiments that can be conducted as well as increasing significantly the reliability and accuracy of on-line measurements. This system has been in nearly constant use during the past four months, studying normal male and female subjects, athletes, and post-coronary bypass patients.

Major improvements to the system include: (1) addition of a mass spectrometer to extend respiratory measurements to a breath-by-breath range of accuracy; (2) completion of feedback computer control of treadmill speed and elevation, such that work levels can be adjusted on the basis of any combination of physiological input signals from the subject as well as in accordance with sinusoidal or other forcing functions; (3) addition of temperature sensing devices, permitting up to four separate temperature transducers to be recorded simultaneously; (4) addition of a heart rate detector (on long-term loan from NASA) that greatly improves the accuracy and reliability of the experimental program by recognizing R-waves in the midst of substantial muscle-generated artifacts; and (5) initial development of graphic display for on-line portrayal of observed or calculated results.

In addition, the system has been used for remote data entry through magnetic card, using editing programs written specifically for that purpose. Data are typed on magnetic cards, then the typewriter is coupled through telephone lines to the data system, and an industry-compatible digital tape is written to permit subsequent data analysis and tabulation.

Publications Appearing Through Project Support During Past Year

Adams, W.C., McHenry, M.M. and Bernauer, E.M. Multistage Treadmill Walking Performance and Associated Cardiorespiratory Responses of Middle-Aged Men. Clinical Science, Vol. 42: 355-370, 1972.

Schultz, Robert, Bernauer, E., and Walters, R. Human Performance Analysis Through Computer Support. Program of Biomedical Engineering Society, 3rd Annual Meeting, Abstract No. 33, 1972.

Proceedings of the 1972 Conference on Computers in Undergraduate Curricula

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INITIAL DEVELOPMENT OF INDIVIDUALIZED INSTRUCTION WITH COMPUTER SUPPORT

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Richard F. Walters, Gail M. Nishimoto
John M. Horowitz, Ray E. Burger
University of California
Davis, California
Telephone: (916) 752-3241

Effective use of computers in the learning process can be achieved only after a great deal of patient preparation, testing, evaluation and evolution. The road already travelled blurs rapidly for those whose sights are set on the new horizons opened by achievements already secured. These visionaries will naturally wish to share their most recent successes and to chart the road ahead; their guidance is essential. For those who follow in turn, painfully tracing the fading steps of the pioneers in this field, it often seems that the gap is too great, the signposts too few, and the pitfalls too numerous ever to attain those plateaus considered old hat by the experts. This paper is an attempt to add a few signposts to the beginning of the road, in the hopes that effective computer support of the learning process may become a major highway rather than a limited thoroughfare. More specifically, this report describes a series of simple programs that provide self-evaluation for the student, course review for the instructor, and an opportunity to proceed into more sophisticated computer-supported instruction.

Instructional use of computers has developed slowly for several reasons, including problems of developing adequate hardware and software support, dollar costs of entry and continuation in computer support, incomplete understanding of the most appropriate methodologies suitable for computer technology, the time required for significant educational returns on the initial preparation of instructional material and a significant lag in the acceptance of computer approaches to learning. Although all these factors play a role in computer use for instruction, the problems of operational cost, methodology and short-term returns offer the greatest promise for creative solutions.

Operational costs of a time-shared system can be allocated to the computational steps performed, the storage of information in machine-readable form, and data communication. The additional costs of timesharing can be divided between the computation and communication costs of the system. The major opportunities for realizing savings exist in the use of teaching strategies that minimize storage of large files. Additionally, the time spent by a student at a remote terminal dictates the number of terminals, communications lines and entry ports that the system must provide for a class. Some cost savings can therefore be realized by restricting the student's computer time to those experiences offering learning benefit.

The instructor who seeks to use a computer as a teaching aid is confronted with a need not only to familiarize himself with the unique characteristics of the computer, but also to define with considerable precision his teaching objectives so as to utilize this auxiliary technology effectively. It often happens that the computerization of a learning segment is undertaken without adequate planning, and the results are usually unfortunate. Furthermore, when the instructor has his objectives well in mind he may not be sufficiently aware of the computer technology to take full advantage of the versatilities available to him.

A major factor affecting the initiation of computer-related instruction is the time required for a system to deliver effective learning experiences. A typical first encounter with computer implementation of a learning sequence would begin with systems problems when the equipment is first installed, followed by a protracted period of program creation and implementation, then followed by a still longer time for preliminary testing of the material, evaluation and modification prior to introduction in a course. Attempts to by-pass this sequence by acquiring available programmed instruction usually fail to involve the instructor sufficiently in the development process to educate him to the merits and weaknesses of this technique.

As a result of the factors described above, persons wishing to introduce computer technology in the instructional process find themselves on the horns of a dilemma, faced with tradeoffs between effective instruction, inexpensive implementation and the time required for startup. There is no single solution to this problem; however, the technique described below appears to serve as an effective entry point without major drawbacks in any of the problem areas cited above.

Historically, the Davis campus of the University of California had done little to implement on-line computer support prior to 1970. The major step that had been taken was to acquire a third generation computer system capable of supporting timesharing, and to back that system up with an existing timesharing system during conversion to the new equipment. In addition, some attempts to explore instructional use of computers had been initiated, notably within the school of medicine and the department of electrical engineering. Animal physiology, on the other hand, had been exploring the merits of individualized instruction from other methodological approaches, aimed at increasing the opportunities for independent study and self-evaluation. In the summer of 1971, the department of animal physiology and the Office of Medical Education decided to attempt a joint development program that would enhance self-evaluation for both departments.

The faculty of the department of animal physiology were faced with rapidly increasing enrollment in an already large undergraduate class in systemic physiology. In order to maintain instructional quality, these faculty had evolved a team teaching concept of optional lectures supplemented by audiovisual material containing the same concepts, by self-tests administered with a hand-scored see-through board and by small tutorial sessions. The School of Medicine also offers team-taught courses, interdisciplinary in nature, as a part of its regular core curriculum. The course committees for these courses include representatives of the Office of Medical Education who have responsibility for the delivery and evaluation of courses and also for the development of new teaching methodologies, including computer support. Here, too, students were anxious to receive increased self-evaluative experiences. The opportunity to combine forces appeared favorable, and as a result the two schools decided to work together in designing a single program for self-evaluation. Design of the methodology was accomplished in joint sessions; the program was introduced simultaneously in both schools, using slightly different formats as described below.

Description of Self-Evaluation System

The computer supported self-evaluation system provides for the entry of answers to problem sets so that students can review these tests by means of a computer terminal, receiving immediate tutorial guidance while their responses are stored in a file available for review by the instructor. Three interactive computer programs were written to support this process: the first for entering the answer key, the second to be used by the student in taking the self-test, and the third for use by the instructor to evaluate overall student performance in a given course segment. In addition, the programs use two disk files, one containing student identification and the second a set of comments directed to individual students.

In entering the answer key (fig. 1) the instructor (or a teaching assistant) is first asked to provide a title for the self-test, and then to specify certain procedural options such as the type of identification required and the decision to provide or withhold the correct answer. The next step is to enter correct answers to each question. The program was designed to eliminate computer storage of questions for several reasons. Since questions can be easily typed and duplicated for distribution, keypunching and storage of the questions are unnecessary and expensive. The time required for a student to consider individual problems is not productive in terms of the man-machine interaction, and it might be better accomplished away from the terminal so as to save on connect costs as well as freeing the terminal for other students' use. In contrast, however, the answer options are more flexible than the normal multiple choice tests typical of most computer-scored experiences: they may be either numeric or include combinations of alphanumeric characters. Numeric answers are considered correct if they fall within a specified range of the "correct" response. Typically, an instructor will use a mixture of numeric, true/false, single word and multiple choice responses in a given test.

Following entry of the answers, the instructor then enters feedback responses for incorrect answers. These responses may direct the student to specific reference material, contain suggestions for review or instruct the student to contact a tutor for clarification. The responses may be recalled on the basis of a single incorrect answer or a combination of errors, depending on the instructor's judgement.

At the conclusion of the instructor's session, there will be stored on disk a series of answers, tutorial comments for the combinations of incorrect answers, and a separate file of personal comments for students. At this point the problem set is ready for the second step, during which the student enters his answers. Prior to his arrival at the terminal, each student will have received a problem set which he is instructed to review on his own before talking it over with the computer. He is usually encouraged to use those auxiliary aids appropriate for the course segment and to delay his session at the terminal until he is reasonably satisfied that he understands each question. When he signs on, giving his name and/or his code number, any comments stored under his name will be displayed before he enters his answers. The program then requests the answers to the problem set, giving the student an opportunity to review and correct typographical or other errors before they are scored (fig. 2). When the student indicates that he is satisfied with his answers, his performance is evaluated. He is given his overall score, informed as to which questions he missed, and then provided the tutorial information appropriate to his incorrect responses. He is then free to leave the terminal. Usually a student will require five minutes or less for a set of twenty to thirty questions.

```
RUN EXAM

 -BOJ- OEXAM
YOU ARE ABOUT TO ENTER THE ANSWERS FOR A QUIZ.
PLEASE ANSWER ALL QUESTIONS THAT I ASK, SO THAT
I CAN QUIZ THE STUDENTS ACCORDING TO YOUR WISHES.
EACH TIME I EXPECT A RESPONSE FROM YOU I WILL TYPE
A "?".  PLEASE WAIT FOR IT TO APPEAR BEFORE YOU TYPE
YOUR RESPONSE.  PLEASE END EACH RESPONSE WITH A
SHIFT/XMIT.  IF YOU MAKE A MISTAKE AND HAVE NOT HIT
THE SHIFT/XMIT THEN USE THE LEFT ARROW TO BACK UP
TO THE WORD IN ERROR AND CORRECT BY USING THE INSERT
CHARACTER KEY (I/C), DELETE CHARACTER KEY (D/C),
OR RETYPE FROM THAT POINT ON.

ENTER EXAM TITLE OR TYPE "STOP"
?PHYSIOLOGY REVIEW #1

WHAT IS THE MAXIMUM NUMBER OF TIMES A STUDENT
MAY TAKE THE EXAM?
?1

NUMBER OF QUESTIONS?
?4

 ANSWERS, PLEASE
  1.?VENTILATION
  2.?TRUE
  3.?A
  4.?2,43

IF YOU WISH TO MAKE ANY CHANGES IN THE ANSWERS
TYPE QUESTION NUMBER, SPACE AND NEW ANSWER.
YOU MAY MAKE AS MANY CHANGES AS YOU WISH, WHEN DONE
TYPE STOP.
?STOP

WOULD YOU LIKE ME TO GIVE THE STUDENT THE
CORRECT ANSWERS FOR THOSE QUESTIONS HE
ANSWERS INCORRECTLY? (YES OR NO)
?YES

WILL STUDENT GIVE NAME, NUMBER OR BOTH?
(TYPE "NAME", "NUMBER", OR "BOTH".)
?BOTH

WILL NAMES AND/OR NUMBERS BE SUPPLIED FOR THOSE STUDENTS WHO
 WILL PARTICIPATE?
?YES

WOULD YOU LIKE COMMENTS DISPLAYED IF
STUDENTS MISS QUESTIONS? (YES OR NO)
?YES

FOR EACH COMMENT YOU ENTER, YOU MUST GIVE AN
"OR" STRING AND AN "AND" STRING.
     A STRING IS A LIST OF QUESTION NUMBERS
SEPARATED BY SPACES. (E.G. 1 2 5).
     IF IT IS AN "OR" STRING THEN THE COMMENT
WILL BE DISPLAYED IF THE STUDENT MISSES ANY ONE
OF THE QUESTIONS LISTED.
     IF IT IS AN "AND" STRING THEN THE STUDENT
MUST MISS ALL QUESTIONS IN THE LIST FOR THE
COMMENT TO BE DISPLAYED.
     YOU MAY ENTER AS MANY COMMENTS FOR DISPLAY
AS YOU WISH, BUT EACH MUST HAVE BOTH TYPES OF STRINGS.
(IF YOU ONLY WISH TO GIVE ONE STRING, HIT SHIFT/XMIT
WHEN THE OTHER IS REQUESTED.)

ENTER "OR" STRING FOR COMMENT    1
? 1 4
ENTER "AND" STRING FOR COMMENT    1
?
ENTER TEXT OF COMMENT    1    END TEXT WITH AN ASTERISK (*).
?Q.1 OR Q.4   A REVIEW OF BASIC RESPIRATORY PROCESSES IS ADVISED.
?             PLEASE SEE CHAPTER 5 OF TEXT.*

MORE COMMENTS?(YES OR NO)
?YES
ENTER "OR" STRING FOR COMMENT    2
?
ENTER "AND" STRING FOR COMMENT    2
? 2 3
ENTER TEXT OF COMMENT    2    END TEXT WITH AN ASTERISK (*).
?Q.2 AND Q.3  PLEASE REVIEW CHAPTER 3 ON ACTION POTENTIAL.*

MORE COMMENTS?(YES OR NO)
?NO
```

FIGURE 1

RUN GETIT

-BØJ- OGETIT

```
WHAT IS YØUR NUMBER AND NAME?
(NUMBER, SPACE, LAST NAME, SPACE, FIRST NAME)
?30 CASEY KAREN

KAREN, SEE ME IF YØU NEED HELP BEFØRE THE NEXT EXAM.  DR. H

PHYSIØLØGY REVIEW #1

INTRØDUCTIØN NECESSARY? (YES ØR NØ)
?NØ

PLEASE ANSWER ALL   4 QUESTIØNS.

   1.?VENTILATIØN
   2.?FALSE
   3.?B
   4.?2.43

WHICH ØPTIØN?
   D FØR DISPLAY.
   C FØR CHANGES.
   N FØR NØ CHANGES AND NØ DISPLAY.
   HELP FØR HELP.

?N

YØU ANSWERED THE FØLLØWING   2 QUESTIØN(S) INCØRRECTLY.
QUESTIØN         GIVEN ANSWER          CØRRECT ANSWER
    2               FALSE                 TRUE
    3               B                     A

SEE THE FØLLØWING REFERENCES AND CØMMENTS FØR HELP.  I WILL PAUSE
AND TYPE A ? BEFØRE EACH CØMMENT.  WHEN YØU ARE
READY FØR ME TØ PRØCEED, HIT SHIFT/XMIT.

Q.2 AND Q.3  PLEASE REVIEW CHAPTER 3 ØN ACTIØN PØTENTIAL.

SØRRY, KAREN ....BETTER LUCK NEXT TIME.

YØUR SESSIØN HAS BEEN CØMPLETED.
THANK YØU
```

FIGURE 2

```
R TELLME

 -HØJ- OTELLME

WØULD YØU LIKE RESULTS PRINTED (P) AT CØMPUTER CENTER ØR
DISPLAYED (D) AT YØUR TERMINAL NØW? (P ØR D)
?D


  QUIZ WAS TAKEN    3 TIME(S).


PLEASE TYPE ØNE ØF THE FØLLØWING:
  1 FØR INDIVIDUAL STUDENT RESULTS.
  2 FØR FREQUENCY DISTRIBUTIØN ØF GIVEN ANSWERS.
  3 FØR TØTAL NUMBER ØF INCØRRECT RESPØNSES FØR EACH QUESTIØN.
  4 FØR BØTH 1 AND 2.
  5 FØR BØTH 1 AND 3.

?4
STUDENT HAS ENTERED BØTH NUMBER AND NAME.
TYPE ØNE ØF THE FØLLØWING-
  1 FØR RESULTS SØRTED BY NUMBER WITH NAME INCLUDED.
  2 FØR RESULTS SØRTED BY NUMBER WITH NAME NØT INCLUDED.
  3 FØR RESULTS SØRTED BY NAME WITH NUMBER INCLUDED.
  4 FØR RESULTS SØRTED BY NAME WITH NUMBER NØT INCLUDED.

?3
WØULD YØU LIKE SCØRES ØNLY (TYPE 1),
ØR SCØRES AND RESPØNSES GIVEN TØ QUESTIØNS MISSED (TYPE 2).
?2

SØRTING...


CAMPBELL JEAN          10
QUESTIØN    GIVEN ANSWER
   3          D
TØTAL NUMBER INCØRRECT IS    1

CASEY KARE             30
QUESTIØN    GIVEN ANSWER
   2          FALSE
   3          B
TØTAL NUMBER INCØRRECT IS    2

KRAM RØBE              20
QUESTIØN    GIVEN ANSWER
   2          FALSE
TØTAL NUMBER INCØRRECT IS    1


  QUIZ WAS TAKEN    3 TIME(S).


QUESTIØN*CØRRECT           INCØRRECT          TIMES*TØTAL
         ANSWER              ANSWER           GIVEN*TIMES
                              GIVEN                 MISSED
                             FALSE              2
   2    TRUE                                          2

   3    A                    B                  1
                             D                  1
                                                      2
```


FIGURE 3

The student's responses are stored in a file that is available for the course committee to review at appropriate intervals. The summaries provided include information on individual student progress as well as class performance (fig. 3).

The resulting system has been used in several modes, two of which are illustrated in the following section. The ability of the program to adapt to each of these modalities is an indication of its flexibility, a characteristic that has already led to its adoption by a number of other courses in various departments on the Davis campus.

Animal Physiology 110: A Comprehensive Upper Division Course

The department offers an advanced undergraduate class in systemic physiology to all students wishing to enroll. This policy, together with the success of the course itself has led to an increase in enrollment from 215 in 1970 to 384 students in the fall of 1971. The course is given through a lecture series supported by eight associated laboratory sections of 24 students each and 30 tutorial sessions with from three to twelve students.

The concept of team teaching has been thoroughly embraced by the instructors of this class. Course committee meetings are held weekly to discuss progress, review specific problem areas and outline material to be presented in the following week. Tutors, most of whom are graduate students in physiology, participate in these discussions, representing "their" class and forwarding constructive suggestions for improvements in the course. The responsibilities for disseminating information and monitoring student progress are thus shared by faculty, tutors, auxiliary audiovisual aids, and - the computer.

The role of self-evaluation in this course is illustrated in Fig. 4. Optional problem sets are handed to the student at the beginning of each week. The problem sets are written to increase the student's understanding of designated course material, identify his particular weaknesses and direct him to further sources for review. These problem sets are thus not tests but learning aids, used to prepare the student for lecture material that will be presented subsequently. When the student has completed his review of the problem sets, he enters his answers through a terminal. The computer scores his work, noting the incorrect responses and directing him to appropriate remedial information. The student may then, by finding the correct responses and discussing his revisions with his tutor, receive full credit for the entire problem set. A weighted point system provides incentive for the poorer student by offering him more bonus points for successfully completing the problem set.

While the student is completing his review, the tutors are also able to review the collective performance of their students, using the summary program described above. They are thus in a position to direct the tutorial discussions to areas most pertinent to their class. They are aided in choosing the appropriate methodological approach for their discussions by the weekly meetings of the course committee, during which the students' problems are reviewed and the appropriate points for discussion are considered. The task of clarifying difficult concepts is made somewhat easier for the tutors by limiting tutorial discussions to one week's material. The tutors find that this approach offers them a challenge that they can meet, and also an effective means for improving their own depth of understanding of some of the more difficult concepts. For their part, the undergraduates use the discussion sessions to clarify individual points that remain unclear after their independent study, to participate in group discussions about physiology, and to forward information through the tutors to the instructors regarding the progress of the course.

The problem sets are intended to be introductory to the lectures. Each instructor spends from three to four hours preparing a problem set that will permit him to extend his lectures into concepts that require an understanding of basic principles. For example, it is difficult for undergraduates to appreciate the dual interpretation of certain physiological observations, such as the sensory encoding of information by the central nervous system. Since the text adopts the approach of "specific receptors", a problem set was designed to help the student pick out the arguments used by the author to support his views. The problem set, together with supplemental reading was followed by two lectures, one which adhered to the interpretation in the text, tracing specific pathways for receptors within the central nervous system. The second lecture, delivered by a different instructor, presented an alternative concept requiring more complex encoding and multiple sensory pathways as a part of the central nervous system's information processing function. Exposure of alternative concepts is greatly enhanced by the knowledge that students had already reviewed the problem sets and were thus well informed about the basic concepts prior to presentation of the more complex alternatives.

Introduction of this system came at a time when the campus computer system was just beginning to accept a full-fledged timesharing responsibility, and a series of problems accompanied the operation from the start, including sporadic malfunctions of the remote terminals, the host computer and the systems software. Despite these major inconveniences, the

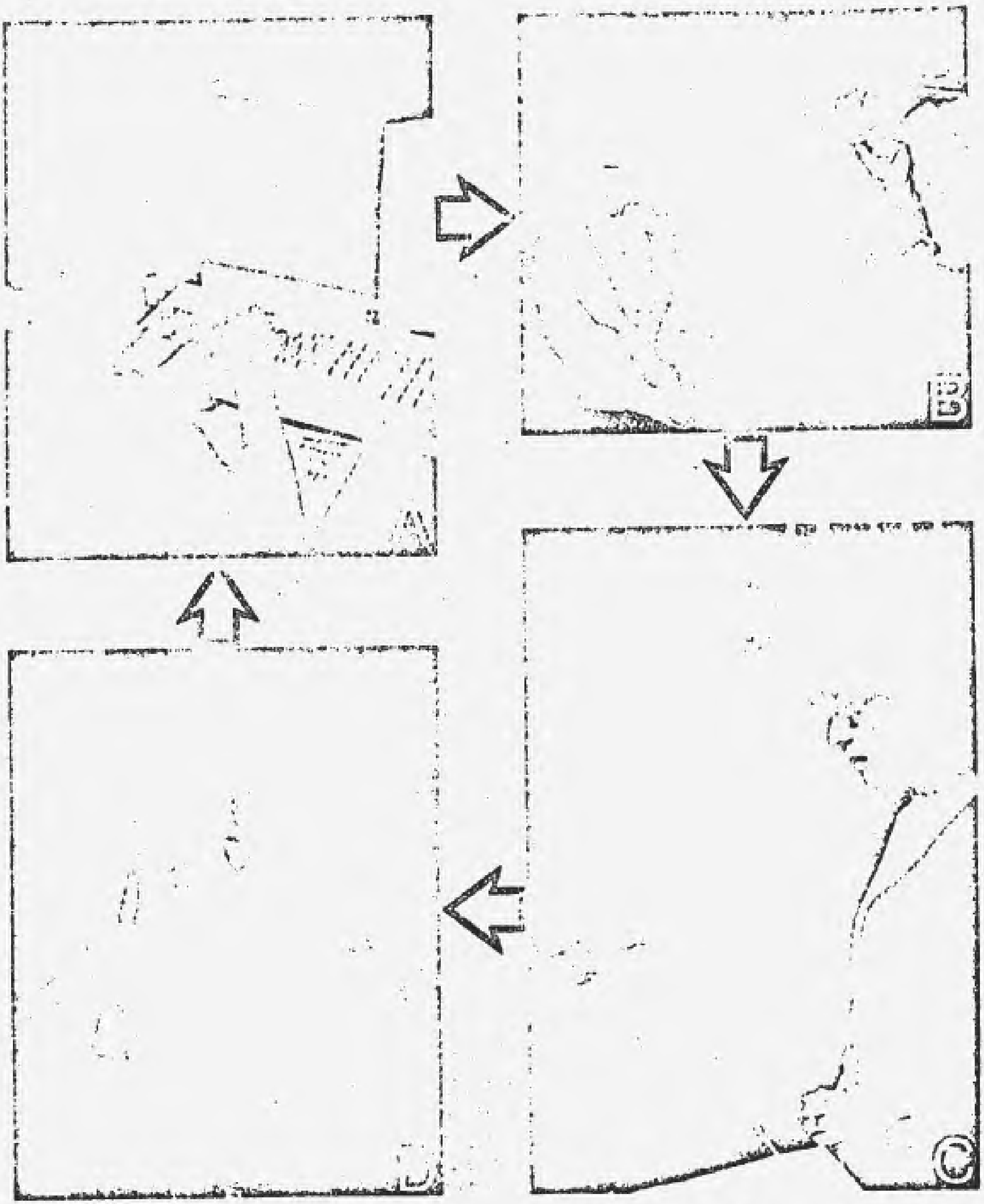

FIGURE 4. Integration of computer terminals into a large undergraduate physiology course. A student reviews background factual information (A); hears a discussion of general concepts in a large lecture (B); participates in a laboratory (C); and discusses ideas in a small tutorial session. (D)

overall reaction of the students was favorable to the system. Their enthusiasm stems partly from the manner in which this experiment was presented to them, partly from the sense of community developed by the tutorial discussion sessions, and partly because the program filled a real need identified by the student. In addition, the program designers worked throughout the quarter to modify the program in accordance with suggestions made by instructors and students. Several important changes were implemented in this fashion during the fall of 1971.

Human Physiology 298: A Specialized Graduate Course

The School of Medicine at UC Davis offers an interdisciplinary core curriculum supplemented by departmental electives. One instructor, teaching a class in renal physiology to three medical and ten graduate students, was interested in using the self-evaluation system to measure student comprehension of the lecture material already presented. Accordingly, he designed short problem sets for the students to work out within a day or two following presentation of the lecture material. The feedback received by the students was used to guide their study in a manner similar to that described above. The instructor was thus able to scan overall student performance and adjust subsequent lectures. A single terminal was available for the class during the quarter, and it was occupied only a small portion of the time by the class.

Student reaction to the system was generally favorable in this class as well. The computer aid was highly valued by the instructor. He willingly accepted the additional time spent in preparing meaningful comments to be displayed when a wrong answer was chosen in view of the time saved by having the computer score, grade, and record results of individual students.

System Implementation and Performance

The self-evaluation system was designed, coded and debugged during the summer of 1971. Several initial meetings were held to design the system early in the summer. Coding was done in ALGOL by one of the authors (GHN) as a part time activity in the latter part of the summer. The total effort involved in initial implementation coding was less than two weeks.

After the programs were introduced in the fall quarter, 1971, a number of program modifications were implemented requiring an additional week of design, coding and testing. Additional changes are planned for the winter quarter; however, the system is fully operational in its present form and will be used in several classes during the winter and spring quarters.

Future Plans

The self-evaluation system meets the criteria of providing a simple entry point into the instructional use of computers. However, this system is also designed to serve as the start of a modular development effort. Some of the plans currently under discussion are described below.

The generation of self-evaluation problem sets will be expanded to permit representative selection, with computer support, of an appropriate group of questions from a library of problems or questions that has been indexed by subject matter or complexity. Although this step would increase the cost for creating problem sets, it might greatly increase the number of separate problem groups that could be made available to students, allowing a single class to have more experiences in self-evaluation.

Certain primitive branching instructions will be introduced, such as skipping past questions if the performance level is adequate, repetition of certain questions following presentation of more detailed tutorial information than is currently entered, and the acceptance of more complex word answer alternatives. This approach would not develop into a complete CAI system, in that specific incorrect responses would not be anticipated. Extension to a complete tutorial language is feasible, but would be a later step in the development of this system.

The system will also be expanded by coupling it to simulation, specially designed supplemental problem sets or other related learning programs. In this method of learning, one feedback response from the self-evaluation would be to call up or recommend to the student a tutorial program available on the computer. Alternatively, a self-test problem set may be presented at the end of the auxiliary program to reinforce key concepts.

Summary

The problems of computer entry into instructional support can be overcome by simple programs with effective instructional objectives. One such program system, aimed at providing students with self-evaluation through problem sets and furnishing faculty with details of student performance, has been designed for use in both large and small classes at UC Davis. This system was designed and implemented during the summer of 1971, then introduced simultaneously in

three classes during the fall quarter. Student reactions, despite problems in the operating system, were highly favorable. The opportunities to extend the system into more complicated instructional methodologies appear promising, but the main effect has been to gain short term benefits without sacrificing either quality or long term potential. It is felt that the underlying philosophy has considerable appeal for institutions that are just beginning to consider use of computer support for instruction.

The Efficacy of Synergistic Medium Altitude Training on $\dot{V}O_2$ max and Endurance Running Performance

Preliminary Status Report

Introduction.

There is a popular notion among some national coaches and international athletes that hard endurance training of already well-conditioned middle-distance runners at medium altitude has a potentiating effect on $\dot{V}O_2$ max and running performance time at sea level. In fact, at least one nation with a contingent of international class distance runners did a substantial portion of their immediate pre-Olympic training out of the country at medium altitude to allegedly better prepare them for Olympic racing at Munich (near sea level).

Research studies from experimental designs not primarily conceived to answer this specific question have yielded equivocal results (Buskirk et al, 1967; Daniels and Oldridge, 1970; Dill and Adams, 1971; Faulkner et al, 1968; Pugh, 1967; Reeves et al, 1967; and Saltin, 1967). Dill and Adams (1971) concluded that discrepancies in findings could be attributed to the complexity of interrelated factors and to differences in training intensities while at altitude. They also concluded that it was uncertain whether their observed 4.2% increase in sea level $\dot{V}O_2$ max post-altitude was a training effect from the heavy exercise schedule at altitude and the periodic maximum runs, or was a synergistic effect of medium altitude stress during hard endurance training.

Experimental Design.

The purpose of the present study was to determine if there is a potentiating effect of training at medium altitude (as opposed to similar intensity of training at sea level, alone) on sea level $\dot{V}O_2$ max and running performance. Two groups of six runners who had completed a season of middle-distance competition within two weeks of the experiment's initiation served as subjects. They were matched for $\dot{V}O_2$ max, 2-mile run time, and age. One group, (Group 1) trained for three weeks at Davis (covering 12 miles per day at 75% of their sea level $\dot{V}O_2$ max), while the other, (Group 2) trained for three weeks at the Air Force Academy (an equivalent amount of mileage at an intensity requiring 75% of $\dot{V}O_2$ max at 2,300 m altitude). After three weeks the groups exchanged sites for continuance of a similar training program for an additional three weeks. Near-exhaustive $\dot{V}O_2$ max treadmill tests and two-mile competitive efforts were interspersed at optimum intervals throughout the experiment. Subjects were transported to and from the Academy by air.

Methods and Procedures.

Each subject underwent pre-experimental tests including $\dot{V}O_2$ max treadmill runs, basic anthropometrics, and determination of resting blood volume (CO rebreathing method), hemoglobin and hematocrit. Seasonal best two-mile times (or an equivalent derived from best seasonal competitive 1-, 3-, or 6-mile run times) were utilized in matching groups. Measurements taken during the $\dot{V}O_2$ max treadmill tests included heart rate via ECG, standard respiratory metabolism parameters, and post-exercise venous blood lactate. Additional venous blood samples were taken periodically for resting blood volume, hemoglobin and hematocrit determinations. During the altitude sojourn, the subjects remained within the limits of the Academy grounds. They were fed a normal, well-balanced diet and billeted in dormitory rooms. While at Davis, the subjects lived at sites of their choice, essentially as they would during the school year. Aside from meeting the experimental conditions specified above, they were free to maintain their normal living regimen.

Results.

Basic characteristics of the subjects are given in Table 1. Closer matching on the basis of $\dot{V}O_2$ max and best 2-mile run time for the season was not possible due to personal commitments of some of the subjects just prior to the experiment's initiation.

Group mean values for physiological parameters are given in Table 2. On the basis of all Davis (SL) time trial results, the subjects performed at 98.3% of their seasonal best 2-mile run times. Initial 2-mile run times at altitude were increased by 9.8% over best times for the season. Both groups demonstrated improved performance in the second trial at altitude (12 and 14 sec, respectively). Immediate post-altitude 2-mile performance for Group 1 was 7 sec better, while if one assumes a SL time trial control of 9:30 for Group 2, their mean post-altitude time was 8 sec poorer.

Treadmill run times were reduced at altitude in both groups by nearly 2:30 ($\bar{x}$ of both groups, from 11:20 to 8:55). Both groups demonstrated slightly longer run times post-altitude (approximately 15-20 sec), although Group 2 performed significantly poorer the first day post-altitude. Explanation of this phenomenon is somewhat puzzling, as there was a slight reduction in post-altitude $\dot{V}O_2$ max (1-2%). $\dot{V}O_2$ max at altitude was reduced 16.6% from pre-experiment SL control values in both groups, with no clear-cut time course pattern in either. Slightly higher post-altitude blood lactates (2-4%) indicated that the subjects may have pushed themselves farther into anaerobiosis in these treadmill runs. There was no appreciable difference between pre-altitude and altitude lactate values.

Maximal heart rate was depressed at altitude in both groups (4.3 and 3.1%, respectively). Pulmonary ventilation (BTPS) was 5-9% higher at altitude. There was no apparent consistent altitude effect on the respiratory rate or respiratory quotient at maximum tolerable effort on the treadmill.

Pre-experiment mean blood volume (BV) for all subjects was found to be 11% of body weight (BW), which is considerably more than the 8% normally found for sedentary, normal young men. It should be noted that BW was gradually reduced at altitude (1.5 kg in Group 1 and 1.3 kg in Group 2), which is not an uncommon finding among trained runners. Undoubtedly, the vast majority of BW loss was the result of loss in body fluids. This contention is substantiated by increased plasma volume (derived from blood cell volume as assessed by the CO method and calculated from Hct), which was elevated 10-15% post-altitude, without a substantial parallel increase on BV. The rate of water loss and the subsequent post-altitude compensation varied with individuals. Both groups also demonstrated an increased hemoglobin ($\bar{x}$ = 9.2%) during their three-week altitude sojourn. Interpretation of BV and related data is incomplete at this time.

Conclusions.

Statistical analysis of the data has not yet been completed. However, within that limitation and those inherent in the experimental design, the following tentative conclusions would appear to be warranted at this time:

1. Initial 2-mile time trial performance was reduced 7.1% at an altitude of 2,300 m.
2. Within three weeks continual residence at altitude, 2-mile performance time was improved 13 sec (about 2%).
3. Since one group did better in the 2-mile time trial upon return to SL and the other poorer, it is unclear whether equivalent training at 2,300 meters altitude facilitates improved performance at SL.
4. Mean $\dot{V}O_2$ max was reduced approximately 16% in both groups at altitude, with only a slight increase evidenced during the 3-week sojourn.
5. Mean immediate post-altitude $\dot{V}O_2$ max in both groups was reduced 1-2% over pre-altitude values.
6. Blood volume per unit of BW was approximately 30% greater in the runners than in young men of similar age and weight. There was no appreciable change in BV at altitude.
7. Body weight loss at altitude was 2% of total BW which, in view of the increased Hct and PV, must be interpreted as body fluid loss.

References.

1. Buskirk, E.R. et al. Maximal performance at altitude and on return from altitude in conditioned runners. J. Appl. Physiol. 23:259-266, 1967.

2. Daniels, J., and N. Oldridge. The effects of alternate exposure to altitude and sea level on world-class middle-distance runners. Med. Sci. Sports. 2:107-112, 1970.

3. Dill, D.B., and W.C. Adams. Maximal oxygen uptake at sea level and at 3,090-m altitude in high school champion runners. J. Appl. Physiol. 30:854-859, 1971.

4. Faulkner, J.A. et al. Maximum aerobic capacity and running performance at altitude. J. Appl. Physiol. 24:685-691, 1968.

5. Pugh, L.G.C.E. Athletes at altitude. J. Physiol. 192:619-646, 1967.

6. Reeves, J.T. et al. Regulation of ventilation during exercise at 10,200 feet in athletes born at low altitude. J. Appl. Physiol. 22:546-554, 1967.

7. Saltin, B. Aerobic and anaerobic work capacity at 2,300 meters. Med. Thorac. 24:205-210, 1967.

TABLE 1. Basic characteristics and performances of runners

Subj.	Age, yr	Ht, cm	Wt, kg	VC, L	Resid-ual vol, L	Body Fat %	Pre-exper $\dot{V}O_2$ max, ml/min·kg	1972 Best Compet. 2-mile min & s
				GROUP I				
MD	18.2	178.5	65.4	5.02	1.03	5.00	73.7	9:18
DH	21.1	179.6	62.9	4.80	0.97	5.23	72.8	9:01**
EH	22.7	180.9	57.0	4.41	1.68	6.91	76.2	8:47*
SH	18.7	175.3	68.2	5.49	0.79	8.21	72.0	9:32*
JM	21.5	179.3	62.3	5.73	1.85	2.62	76.2	9:11**
JS	18.6	180.9	61.8	5.05	1.33	5.71	73.4	9:11**
Mean	20.1	179.1	62.9	5.08	1.28	5.61	74.0	9:12
				GROUP II				
JA	22.0	178.0	67.6	5.66	1.42	8.36	70.1	9:20
ED	19.1	176.0	60.4	5.30	1.59	0.01	71.3	9:06
WH	21.1	178.6	67.9	6.70	1.21	9.74	70.0	9:25*
NH	23.5	177.2	57.1	5.92	2.18	6.63	77.5	9:09
SM	17.3	179.1	63.0	5.38	1.28	5.02	75.2	8:58
JV	20.4	194.9	71.1	6.77	1.82	2.56	70.1	9:31*
Mean	20.6	180.6	64.5	5.96	1.58	5.39	72.4	9:15

* 3,000 m Steeplechase

** Estimated from other events (1-m, 3-m, 6-m)

TABLE 2. Group Mean Values for Physiological Parameters

	2-mile min & sec	Tm run time min & sec.	$\dot{V}O_2$ max L/min	Lactate mg/100 ml	HR max beats/min	$\dot{V}_E$(BTPS) L/min	RR breaths/min	RQ	BW kg	Hct	Hb
GROUP I											
Pre-Exp. SL Control	9:12	11:23	4.661	105	191	153	62	1.02	63.0	---	----
$\bar{x}$ SL	9:26	11:18	4.570	114	188	152	61	1.02	62.6	42.9	14.6
$\bar{x}$ Altitude	10:02	8:58	3.884	116	180	166	62	1.03	61.8	44.5	15.8
Immediate Post-Altitude	9:17	11:45	4.521	118	190	156	62	0.99	61.3	45.0	15.4
GROUP 2											
Pre-Exp. SL Control	9:15	11:08	4.746	104	196	160	56	1.03	64.8	43.6	14.1
$\bar{x}$ Altitude	10:03	8:50	3.960	105	190	166	54	1.02	64.0	45.1	15.5
Immediate Post-Altitude	9:40	10:25	4.511	109	192	154	54	0.99	63.5	45.4	14.5
$\bar{x}$ Post-Altitude	9:34	11:24	4.603	106	192	158	55	1.01	64.1	43.2	14.2