CALCUTTA

Please send your comments and criticisms to Dr. R.N. Sen.

SYLLABUS FOR M.Sc. (PHYSIOLOGY) WITH SPECIALIZATION IN IN WORK PHYSIOLOGY AND ERGONOMICS

In addition to the detailed study of the general course on basic human sciences the following topics are included in the syllabus for the specialization in Work Physiology and Ergonomics; the course also includes six weeks' approved industrial and/or other experience.

1. INTRODUCTION

Definition scope, use and application of the subject in agriculture, industry, home, office, defence services (army, navy and air forces) and in the society as a whole.

2. BACKGROUND AND APPLICATION OF DIFFERENT DISCIPLINES

Brief history of the development of the subject and its relation with other human sciences. Future possibilities for the development of the subject in tune with the development of technology.

3. INSTRUMENTATION

Principles of instrumentation used in Work Physiology and Ergonomics.

Current and static electricity; potential difference; potentiometers - grounded and ungrounded; capacitance; current and ohm's law in series and parallel circuits; power in electrical circuits; the whoatstone bridge; capacitance bridge; time constant; electromagnetic induction; motor and moving coil galvanometer; sinewaves; harmonic voltage - combination of resistance; industance and capacitance; impedance and resonance; oscillations; damping.

Electrolytic cells; polarisations; electrode potential.

Effect of temperature on resistance; thermocouples; thermoinic emission; thermoinic valves; semiconductors; diodes; rectification; transistors-'npn' and 'pnp' types; as switches and amplifiers; FETs; thermistors; simple amplifiers; coupling; push/pull amplifiers; balanced amplifiers; biological amplifiers; cathode follower; linear and nonlinear elements; operational or zero frequency amplifiers; summing amplifiers; multipliers; dividers;

Noise and interference.

Elementary logic circuits:- multivibrators; monostables; bistables; trigging; schmitt trigger; 'AND' gate; 'OR' gate; 'NAND' gate; 'NOR' gate.

Integrators - potset mode; reset mode; hold mode; operate mode; continuous analogue integration; constant reset time integration; constant reset level integration (comparators); absolute value circuits; elementary net work analysis; mode, loop equations; amplitude and phase response; stochastic concept of complex frequency; transient and steady state terms; damped and undamped sinusoid; log/dB method; frequency asymptote. Definitions of frequency response; bandwilth effects of cascading elements; optimum matching; fidelity.

Function generators - sine, square, saw-tooth; noise etc wave generators.

Principles of measurements of length or displacement, area and volume; mass and force; time and frequency; velocity and acceleration; temperature and heat flow; pressure and high vacuum; ultrasonics; fluid flowrate; electrolytic conductivity, measurements of pH, p^{O_2}, p^{CO_2} etc.; chromatography; chart-recording instruments.

4. SYSTEM DESIGN

Study of characteristics of man, machine/equipment and environment and their interactions; system design; optimization of man-machine-environment systems; problems of conflicting requirements.

5. ANTHROPOMETRY

Physical dimensions of human body as a working machine - size and motion relation - static and dynamic body measurements - analysis of the anthropometric data with reference to known human engineering requirements - "standard" or "average" worker - work space layout - use of anthropometry in the design of seat furniture, clothing; head-hand- and footwears, etc., somatotyping; methods of measurements of body composition; body fat, muscle mass, etc., and their relatio to human performance in sports and industry.

6. BIOENGINEERING

Biophysics and biomechanics of human skeleto-muscular systems - angular movements of limbs - goniometry; mechanics of arm and hand - power and precision grips - control and power of movements of the hands, feet, etc - control mechanis manual and pedal controls; power-assisted controls - effects of control knobs' shape, size, color, and layout on performance; principle and importance of the direction of motion stereotypes. Ergonomic evaluation of the design of engineering hand-tools, typewriters, etc. Control systems (boom, dipperstick, joystick, etc) of agricultural ploughing machines, tractors, combine harvestors, digging, drilling and ditching machines, cranes, planes, boats, ships, air and railway control rooms etc, design of prosthetic devices.

The mechanics of different postures - lying, sitting, standing, walking, running, lifting and carrying load; analysis of posture and movements - postural sway; force - velocity - acceleration relationships of muscular work including the activities in sports and industry; maintenance of postural equilibrium and muscular co-ordination; kinesiological analysis.

7. BIOENERGETICS

Biochemistry and bioenergetics of muscular contraction and relaxation; fuel for muscle work; growth, repair and adaptation.

Physiology of static and dynamic work and efficiency:

Work demand and individual capability; cardio-respiratory aspects of work; aerobic work - classification of work loads and duration of work - intermittent and prolonged work; anaerobic work - oxygen debt - lactic acid production - maximum aerobic and anaerobic power; effects of different factors, such as age, sex, body build, motivation, training, tactics, nutrition, etc in limiting capacity for work; energy cost of different habitual activity - daily energy demand. Physiology of backache.

8. ELECTROPHYSIOLOGICAL BEHAVIOUR OF MUSCLE AND NEUROMUSCULAR FUNCTION OF HUMAN OPERATOR

Measurement of muscular activity - myography, electromyography and other techniques - muscle tone and reflex activities; sustained and rhythmic isometric and isotonic muscular contractions; muscle analysis of physical skill - motor performance and fatigue study by cine film analysis; cyclography; force-time curve of reflex activity.

9. PSYCHOPHYSIOLOGY OF WORK

The role of special senses, especially vision and hearing in performance; human sensitivity to heat, light and sound - perceptual leads; illumination levels, glare and discomfort; flicker phenomenon - critical fusion frequency; eye movement and voluntary activity and spontaneous blinking; signal detection and target recognition; forced - choice situation; problems of radar watching; single channel theory. Methods of presenting information; recognition, readability and intangibility of signs; display of different types - qualitative, quantitative and representational displays - visual and auditory displays; control and display relationships - stereotypes - panel layout.

Problems of traffic behaviour at intersections; different factors affecting attention - inspection tasks and efficiency - solutions of problems in factory situations, information theory; training and skill; learning curve and learning time; measurement of skill; communication theory.

Noise and vibration, smell and taste:

Human sensitivity to noise and vibration - their interactions; methods of measurements of levels of noise and vibration; equal loudness contours; problem of hearing loss and auditory damage with industrial and other noise; effects of music and performance; smell and taste on performance.

10. PHYSICAL AND MENTAL LOADS: PSYCHOPHYSIOLOGICAL CONSIDERATION

The problem and measurement of physical and mental loads and fatigue; monotony - relation of fatigue, rest pauses and work output - problems of continuous and repetitive work - problems of shift work - circadian (diurnal) rhythm. Effects of change of the rhythm on different body systems.

Neurophysiology and neuropsychology of human operator; short-term and long-term memory. Psychophysiological criteria for the design and validation of man, machine, environment systems; principles and basis for helping the design of building, i.e. dwelling houses, schools, colleges, offices, hospitals; fire and police stations, factories, post offices; vehicles, railway coaches etc; subjective and objective assessments for the evaluation of the design of consumer products - questionnaire technique.

11. WORK MEASUREMENT

Work, time and motion study and comparison of different operations and elements; methods of improving productivity - operational research - stock and inventory control; process course analysis - flow charts; PERT, MERT and other techniques; quality control.

12. ENVIRONMENTAL PHYSIOLOGY

Physical, chemical, physiological and psychophysiological aspects of the working environments; bodily and mental responses to changes in environment, e.g., climate - (a) physical aspects of environment - effects of hot and cold conditions (physical factors - air temperature, humidity, thermal radiations, air movement - methods of measurements); (b) physiological and psychophysiological aspects of environment - effects of heat and cold exposures - steel mills, cold store etc; heat and cold stress indices; limits of tolerance; environmental factors limiting work output - heat disorders - methods of protection - thermal barrier - protective clothing and suits; acclimatization; principles of construction and use of climatic (psychrometric) and sound-proof chambers. Methods of assessment of heat balance - (thermal exchanges between men at work and environment); body temperature regulation during work; water balance; rectal, oral, aural and skin temperatures; heat storage. (c) Chemical aspects of environment: effects of industrial hazards, e.g. dusts, smokes, fumes (pneumoconeosis, byssinosis) etc. Harmful effects of bad environment - air and water pollution; reduction of environmental load. Allowable limits (MAC = maximum allowable concentrations) of occupational exposure to potentially toxic substances eonveyed by air - methods and concepts; toxicity of the penetration of substances by oral, inhalatory and cutaneous routes; adaptation; cumulation potentials; synergism; the problem of threhold concentrations in workers entrusted with the fulfilment of important tasks; short-term and long-term effects - shortlasting allergies; longlasting - carinogenics and teratogenics, mutagenicity. (d) Altitude and Space Physiology: effects of high and low barometric pressures on work capacity; physiological adaptation of altitude dwellers and highlanders in comparison to sea-level dwellers; physiology of mountaineering. Effects of different types of acceleration and decelaration of man in motion (in aircrafts); human tolerance and performance. Effects of positive, negative and zero G forces. Human centrifuge; weightlessness and performance. Disorientation - gravitation cues; visual illusion; oculogyral illusion; fascination; isolation. (e) Aquatic physiology: physiology of surface and underwater swimming and deep-sea diving; physiological problems in pressurization and decompression; protection from decompression; underwater construction work in sealed caissons; problems of speech intengibility and communication with use of helium in submarine; effects of long-term living in submarines; phenomena of sensory deprivation; design of naval equipment for use of seamen; simulation experiments; capabilities and nutrition of seamen and divers.

13. INTRODUCTORY CYBERNETICS

Elementary knowledge of cybernetics information feedback; open and closed loop control systems involving the human worker; transfer functions - monitering systems; automation and their control problems. Biological and mathematical models.

14. SAFETY, HEALTH AND WELFARE

Safety, health and welfare of workers; trade union and management attitudes; safety factors - ergonomics versus accidents - accident prevention - safety guard and devices. Training, classification and selection of workers, aptitude and intelligence tests; attitude and morale surveys, psychological resistance against proposed changes in existing systems and its solution. Workers' compensation systems.

15. FACTORY ACT

Principal factory acts and regulations to guard safety, efficiency, health and welfare of workers.

16. COMPARATIVE ERGONOMICS

Important differences in the application of science and technology in different places, countries etc; ecological and genetical differences - social and cultural differences.

17. BIOMATHEMATICS AND BIOSTATISTICS

Special mathematics and statistics required for investigations in the field of Work Physiology and Ergonomics; principles and methods in digital and analogue computation; principles in the use of modern computers in the solution of ergonomic and cybernetic problems. Simulation.

18. GUIDE TO STUDENTS

Guide to information retrieval; guide to design and organisation of research projects and surveys, analysis and presentation of the results; guide to proper expression and delivery of lectures on scientific topics; guide to attendance and conduction of interviews.

Evaluation of the merits and demerits of the specilization - feedback for modification in the next year.

PRACTICAL/DEMONSTRATIONS

1. Experiments on the principles of instrumentation for measurements of different parameters.
2. Determination of body dimensions by anthropometric equipment. "Workshop" on the design of seat, work space, etc. Determination of body composition.
3. Experiments with the actions of muscles, use of geniometer, dynamometer, etc.; location of motor points; velocity of nerve impulse.
4. Ergonomic evaluation of the design of different control knobs, hand tools (screw drivers, pliers, scissors) etc.
5. Experiments on taking different physiological responses (heart rate, blood pressure, respiratory rate, pulmonary ventilation, oxygen consumption, sweat rate, oral, aural, rectal and skin temperatures) during graded work on step test, bicycle ergometer, treadmill tests etc.; - use of gas analysis apparatus - aerobic and anaerobic power - oxygen debt; evaluation of maximal physical capacity; experiments on energy expenditure; Pulmonary Function Tests, Lung volumes.
6. Biochemical estimations in blood and urine (lactic acid, glucose, creatinine, chloride, Po_2, Pco_2 etc) during rest, work and recovery; histochemical methods for estimation of glycogen etc.
7. Experiments with the measurements of muscular activity - myography and electromyography - cyclographic techniques.

8. Motor skill and performance analysis - cine film analysis.

9. Experiments with vision and hearing, olfaction and taste. Methods of measurements of illumination and noise levels - audiometry, olfactometer, taste acuity. Experiments on semicircular canals.

10. Determination of thermal, lighting and acoustic conditions of the environment.

11. Determination of chemical conditions of the environment. Determination of concentrations of dusts, fumes, vapours etc.; bacterial content of air.

12. "Workshop" on information retrieval, experimental design, analysis and presentation of results and delivery of scientific lectures.

13. "Workshop" on biomathematics and biostatistics.

DUTTA S.P., GANGULY T.

Physiological cost of work under hot dry climates in Indian industry

Ind Jour Prod Res. XIII 5 Sept 75

WILD R.

On the selection of mass production systems

Int Jnl Prod Res XIII 5 443-462

CENTRAL LABOUR INSTITUTE
INDUSTRIAL PHYSIOLOGY DIVISION

P.N. Saha
Deputy Director(Phy)

Off Eastern Express Highway,
Sion, Bombay - 400022.

DO No. 93/6/76-CLI

Dated the 22nd May, 1976

Dear Prof. Wisner,

Some time in the month of March I wrote to you a letter. Hope you received it.

Only last week I could send the documents you had left with me, along with few of my departmental publications. I am extremely sorry for this delay.

The article about which I had mentioned in my previous letter is not yet ready. However, I hope I shall be able to communicate the same to you shortly for publication in a suitable journal.

Kindest regards,

Yours Sincerely,

P. N. Saha

Prof. A. Wisner,
Director-Cum-Professor of
Work Physiology & Erogonomics.
Laboratoire da Physiologie du Travail
et Ergonomic du Conservatoire
National des Arts et Metiers
41 rue GAY - LUSSAC
75.014 PARIS.
FRANCE.

P.S. Along with your documents I have sent bio-data of my brother-in-law Mr. R. N. Ghosh who is interested in a suitable assignment abroad. Could you kindly help him, you will also find my bio-data inside that packet. P.N.S.

158

हवाई पत्र
AEROGRAMME

1976

Prof. A. Wisner,
Director-Cum-Professor of
Work Physiology & Erogonomics
Laboratoire da Physiologie du Travail
et Ergonomic du Conservatoire
National des Arts et Metiers
41 rue GAY - LUSSAC.
FRANCE.

पहला मोड़ FIRST FOLD

दूसरा मोड़ SECOND FOLD

इस पत्र के अन्दर कुछ न रखिये NO ENCLOSURES ALLOWED

भेजने वाले का नाम और पता SENDER'S NAME AND ADDRESS

Mr. P.N. Saha,
Deputy Director(Phy)
Central Labour Institute,
Off Eastern Express Highway,
Sion, Bombay - 400022.

पिन PIN 400022

भारत INDIA

सत्यमेव जयते

भारत सरकार, श्रम मंत्रालय
राष्ट्रीय श्रम विज्ञान केन्द्र
Govt. of India, Ministry of Labour
CENTRAL LABOUR INSTITUTE
(Bharat Sarkar, Shram Mantralaya)
(Rashtriya Shram Vigyan Kendra)

टेलीफ़ोन / Phone: 482203
तार: सेलाबीन्स्, माटुंगा, बम्बई- 400 019
Gram: 'CELABINS' Matunga, Bombay-400 019

INDUSTRIAL PHYSIOLOGY DIVISION
इस्टर्न एक्सप्रेस हायवे, शीव, बम्बई-४०० ०२२
Eastern Express Highway
Sion, Bombay-400 022

P. N. SAHA
DEPUTY DIRECTOR & HEAD

क्रमांक / No. 93/6/76-CLI

दिनांक / Date 24th March, 1976

Dear Prof. Wisner,

I hope on completion of your I.L.O. assignment you returned to your country and settled down. I am sorry I could not write to you earlier.

I am sending under separate cover the papers you had left with me, along with some of my departmental publications. Kindly let me know after you receive them.

You may perhaps recall that during your short visit to our Institute we had discussed with you about research work in the fields of Biomechanics, Vibrations and other related aspects of Ergonomics. During our discussion I had mentioned to you that I was interested in the research work done in the above fields in different parts of the world and as such I requested you for some literatures on the work done by you and your associates and by any other scientists in your country in the fields just mentioned. It would be highly appreciated if you could kindly make it convenient to spare some time and provide me with the related papers/ reprints/reports at your earliest.

I understand from our Director General, Brig. G. R. Chainani, that you wish to get an article on work capacity of Indian workers for publication in a well-reputed journal in your country. I hope I shall be able to contribute an article entitled "Aerobic capacity of steel workers in India". I am already on the job and it is hoped that within a month it would be possible for me to send the article to you.

..2

It was a great pleasure for me to have an opportunity to meet you. Though for a very short period, it was really enjoyable and the discussion was also quite fruitful. Hope we get similar opportunity in the future.

I will

With kindest regards,

Yours sincerely,

A. Wisner

Prof. A. Wisner
Director-cum-Professor of Work
Physiology & Ergonomics
Laboratoire da Physiologie du Travail
et Ergonomie du Conservatoire National
des Arts et Metiers
41 rue GAY-LUSSAC
75.014 PARIS
FRANCE

UNIVERSITÉ CALCUTTA

(PRANAB KUMAR NAG)

ASIE DU SUD-EST

Calcutta, 23 June, 1975.

Dr. A. Wisner
Département des Sciences
de l'Homme au Travail
Physiologie Du Travail
Ergonomie.
Paris. 75005.

Dear Sir:

Although I had received your letter, dated 3.6.75 on 9.6.75, I could not write you in time. I had gone to NewDelhi and met the officers for Cultural Exchange Programme of both Ministry of Education and social welfare and Council of Scientific and Industrial Research.

It is highly important and urgent from my part to inform you about the paraphernalias of the officers of Cultural Exchange Programme.

Firstly, the ministry of Education and Social welfare has some fellowship for the students to go France on some special subject. They advertise in the news paper for those fellowships and select the candidates. The candidates for there fellowship are already selected for the session 1975-76. Though I do have an invitation from a France laboratory, they will not honour it unless they receive any request from the office of the Cultural Exchange Programme, France.

Further I wish to mention that these fellowships are only at the pre-doctoral level not post-doctoral.

Secondly, Council of Scientific and Industrial Research, India has a convention of exchange with the CNRS, France. But this exchange programme is only for the CSIR employees. Although I am a research scho of CSIR I will not be included in those schemes. They too demand prior reques from the office of the Exchange programme France.

So I don't know how far I'll be able to proceed in the matter. Coming at this stage I don't have any other alternative except to state the fact fran The main objective of my interest to join in your laboratory is to work in a good, organized laboratory so that I ca learn different methodologies for my fut application. It may be an undue reque - will it be possible for you to move through the office of the Cultural Exchange programme, France?

Alternatively, I myself can arra the travel fare if you could kindly giv me a chance of assurance of getting a fellowship there.

Any way, I am moving all the w I can write you frankly that I am ver interested to work with you in some fundamental aspects of our study.

3 Juin 1975

Monsieur Pranab Kumar Nag
Department of Physiology
CALCUTTA UNIVERSITY
92 Acharrya Prafulla Chandra Road
CALCUTTA 700009 (Indes)

Cher ami,

Je ne saisis pas très bien le sens de votre lettre du 25 Mai. Je vous ai effectivement invité personnellement à venir travailler au laboratoire, mais cette invitation ne comporte de ma part aucun financement de votre voyage et de votre séjour, car je ne dispose personnellement d'aucuns fonds pour cela.

L'ensemble des bourses attribuées pour les Universités françaises (qui appartiennent toutes à l'Etat) passent par le Service Culturel des Affaires Etrangères. Je ne vois donc aucun moyen d'assurer le financement de votre voyage sans passer par la voie officielle de l'Ambassade de France.

Toutefois, on m'a précisé au Centre National de la Recherche Scientifique et au Ministère des Affaires Etrangères, qu'un volume très important d'échanges entre la République Indienne et la France était prévu par un accord culturel en cours de signature.

J'espère que vous pourrez surmonter les difficultés administratives que vous semblez rencontrer, et vous prie d'agréer, cher ami, l'expression de mes sentiments très cordiaux.

A. Wisner

N.B. J'envoie, sous un autre pli, au Docteur Sen, un livre que nous venons de faire paraître sur "Age et contraintes de travail" et qui contient quatre articles portant sur l'évaluation quantitative des mouvements des yeux.

dated 25th May, 1975

To

Dr. A.Wisner
Département des Sciences de l'Homme au travail
Physiologie du Travail Ergonomie
41 Rue Gay-Lussac, 75005 Paris.

Dear Sir:

I have received your letter, dated 7th May, on 17th of this month. During this time we are engaged for a thermal comfort study in a coal mine.

Based on your invitation, now I am urgently preparing for the completion of my thesis. Recently we have sent a paper on load handling for the publication in the Journal of Applied Physiology and a few papers are now under process.

Though I have written to the Council of Scientific & Industrial Research, New Delhi, I am yet to receive any reply from them. By this time many informations I have received from Passport office, Ministry of External Affairs. If it is a direct invitation from you, there is no problem of getting passport. But if it is through Govt. of India, Cultural Exchange Programme, it is a bit difficult to have 'no objection certificate' and 'P' form and in many of the times they curtail financial grants. Please let me know in detail sequentially so that I can proceed for the preparation of my journey.

If possible, along with your next letter please supply me some related reprints regarding quantitative assessment of Electrooculography.

With kindest regards

Yours Sincerely

(Pranab kumar Nag)

From:

Pranab kumar Nag
Department of Physiology
Calcutta University
92 Acharrya Prafulla Chandra Road
Calcutta 700009. India.

Asie SE

19 Mars 1975

Monsieur Vietor
Direction du Personnel - PHILIPS
Bât. EDU 4
Overseas
EINDHOVEN
(Pays Bas)

Copie : Mr Kalsbeek

Cher Monsieur,

J'ai tardé à vous remercier de l'appui efficace que vous m'avez donné pour visiter l'usine Philips de Calcutta, car j'espérais pouvoir vous visiter à Eindhoven dans un délai bref. Cela n'est malheureusement pas possible, toutefois j'espère qu'en Avril ou Mai je serai assez disponible pour vous demander un rendez-vous.

S'il vous arrivait de passer à Paris, je serais très heureux de vous accueillir.

Ce qui est fait par Philips à Calcutta est très intéressant, surtout si on met cet effort en relation avec l'extraordinaire situation de cette ville. Ce qui me paraît non moins intéressant, c'est de voir que, dans un contexte social si profondément différent du nôtre, des problèmes analogues se posent (charge mentale, vieillissement précoce, etc ...).

Je vous prie d'agréer, cher Monsieur, avec mes remerciements, l'expression de mes sentiments dévoués.

A. Wisner

7 Mai 1975

Monsieur le Docteur Prabab Nag
Dept. of Physiology
92. Acharrya Prafulla
Chandra Road
Calcutta- 200009
(India)

Cher ami,

Je suis heureux de voir,par votre lettre du 2 mai, que nos projets avancent.

Il est certain qu'il vaut mieux que vous finissiez votre thèse avant de venir ici.

Vous pouvez modifier les dates de votre séjour, en fonction de cela.

Je dois, toutefois, vous signaler que les périodes actives du laboratoire se situent du 1er Septembre au 1er Juillet avec un arrêt de 10 jours à Noël - 25 Décembre-5 Janvier - et un arrêt de 15 jours à Pâques (autour du 1er Avril).

Il faut que vous comptiez aussi probablement un mois pour vous installer à Paris, et suivre un enseignement intensif de français.

Choisissez vous-même vos dates en fonction de ces données.

Recevez, cher ami, l'expression de mes sentiments très cordiaux.

A. Wisner

Date: 2nd May, 1975.

To
Dr. A. Wisner
Prof. of Work Physiol. & Ergonomics
Paris, France.

Dear Sir:

Thank you very much for your letter, dated 22nd April'75. Really I am grateful to you for your kind invitation to join in the research schemes in your laboratory. My teacher, Dr. Sen also has expressed his heartiest pleasure in this regard. He expects we'll be able to do some work for the greater benefit of science.

Already I have written a letter to the Council of Scientific & Industrial Research and immediately I'll try for my passport. If it needs I'll go to Delhi and the difficulties regarding permission and other thing, I'll let you know in time.

By this time, I am to finish the last portion of my Ph.D. work and to write it. So if it is necessary, will it be

possible for you to modify the time for two or three months?

With kindest regards

Yours sincerely

Pranab Kumar Nag.

BY AIR MAIL
PAR AVION

Dr. A. WISNER
PROF. OF WORK PHYSIOLOGY & ERGONOMICS.
DÉPARTEMENT DES SCIENCES DE L'HOMME AU TRAVAIL.
41, RUE GAY-LUSSAC,
75005 PARIS . FRANCE

From:
Pranab Nag.
Dept. of Physiology.
92. Acharya Prafulla
ch. Road.
Calcutta - 700009.
INDIA.

15 Avril 1975

Monsieur Pranab Kumar Nag
Department of Physiology
UNIVERSITY COLLEGE OF SCIENCE ET TECHNOLOGY
CALCUTTA UNIVERSITY
92 Acharrya Prafulla Chandra Road
CALCUTTA 700009

Cher ami,

J'ai été très heureux d'avoir de vos nouvelles et de celles de votre laboratoire que j'admire et j'aime beaucoup.

Je vais réfléchir sur votre lettre et en discuter avec les spécialistes de la charge de travail au laboratoire. Nous allons vous adresser des tirés à part.

Par ailleurs, je vais me renseigner sur les possibilités qui existent de vous faire venir au laboratoire avec une bourse de chercheur confirmé, car nous serions très heureux de vous avoir parmi nous pendant quelque temps.

Il me semble qu'une durée d'un an serait nécessaire. Je serais heureux d'avoir votre accord sur ce point.

Je vous prie de transmettre au Docteur Sen et à vos collègues mes meilleures amitiés. Recevez, cher ami, l'expression de mes sentiments très cordiaux.

A. Wisner

From:

dated: 6th April'75.

Pranab kumar Nag
Department of Physiology
Work Physiology & Ergonomics Div.
University College of Science & Technology.
Calcutta University.
92 Acharrya Prafulla Chandra Road.
Calcutta 700009. India.

To:

Prof. A.Y.Wisner
Professor of Work Physiology& Ergonomics.
Conservatoire National des Arts et Metiers.
41 Rue Gay-Lussac,
Paris 5. France.

Respected Sir:

I hope you could remember me. In Calcutta, we had come almost to a mutual understanding that if I accept french letter you would not mind to write me. Of course, I'll write always in English. I know a little bit french; in writting I can understand but I cannot write well. From now on when it needs I'll write you in English. Please excuse me on this reasonable basis.

Regarding my research problems, if you don't mind, I do like to have some suggestions from you. Few months back we had attempted to observe the state of fatigue of the workers on some repetitive light and fast operation, like priting and packaging etc. We had carried out both physiological and productivity studies simultaneously. Based on the results of physiological responses the work load was found to be light and not fatiguing. Only thing the high accumulation of lactic acid in blood throught out the day indicated that probably there was some sort of local fatigue being gradually developed. Whereas, the productivity studies definitely indicated fall in performance and production level. With the consideration of these results we attempted electrophysiological studies, EMG,EOG and parieto-frontal waves. There was no problem with EMG. But I was really thinking how to analyze EOG either in quantitave or qualitative basis.

In this regard, I expect some suggestions from you, and if it is possible for you to supply me some related reprints I'll be very much grateful.

Beside this, while you are talking with Dr. Sen you had mentioned about post-doctoral fellowship in your laboratory. Please let me know in detail. If it is interesting to me I'll be very happy to join ypu at your convenience and to be trained up in your personal guidance.

Thanking you.

Yours Sincerely
Pranab kumar Nag.
(Pranab kumar Nag)

15 Avril 1975

Monsieur B. Fortin
Directeur du Cabinet
Direction Générale du B.I.T.
CH 1211 GENEVE 22

Monsieur le Directeur,

Au cours d'un bref voyage que j'ai fait en Asie du Sud-Est en Février dernier, j'ai passé trois jours dans le laboratoire de Physiologie du Travail de l'Université Technique de Calcutta, que dirige le Docteur Sen. Il s'agit d'une unité remarquable qui me paraît devoir être encouragée de toutes les façons.

Deux problèmes se posent dans l'immédiat :

- l'attribution de crédits d'investissement, même modestes, car ce laboratoire, qui fait des recherches dans la rude réalité du Bengale et qui enseigne beaucoup, ne possède même pas un sonomètre,

- une bourse de séjour d'un an en France (dans notre laboratoire) pour Monsieur Pranab Kumar Nag, excellent chercheur déjà titulaire d'un doctorat de Physiologie.

Je me doute bien que les décisions correspondant à ces demandes ne se prennent pas à votre niveau, mais dans la perspective de la promotion des conditions de travail dans les pays en développement, cette action me paraît très importante. Aussi serais-je heureux que vous m'indiquiez les voies efficaces pour réussir et qu'éventuellement vous apportiez à cette demande le soutien de la Direction Générale du B.I.T.

Veuillez agréer, Monsieur le Directeur, l'expression de mes sentiments dévoués.

A. Wisner

Monsieur Gérard BONNOT	L'Express 25, rue de Berri 75008 PARIS
Monsieur BOULLOCHE	Rapporteur de la Commission de la Science et de la Technologie Assemblée Parlementaire du Conseil de l'Europe Avenue de l'Europe 67006 STRASBOURG
Monsieur C. BOZON	Chef du S.A.E.I. au Matet Compagnie THOMSON C.S.F. 55, rue Brillat Savarin 75013 PARIS
Monsieur Bernard BRIZAY	Entreprise 13, rue Saint Georges 75009 PARIS
Monsieur BRONOEL	Laboratoire d'Electrolyse du C.N.R.S. 1, Place Aristide Briand 92190 MEUDON
Monsieur A. BROUSSE	Délégué Général à l'A.N.R.T. 44, rue Copernic 75016 PARIS

.../...

Mm MUKHERJEE

Council for
Scientific and
industrial Research.

Rafi Marg
New Delhi 1
10.00.1

India

22 Avril 1975

Monsieur Pranab Kumar Nag
Department of Physiology
UNIVERSITY COLLEGE OF SCIENCE AND TECHNOLOGY
CALCUTTA UNIVERSITY
92 Acharrya Prafulla Chandra Road
CALCUTTA 700009

Cher ami,

Le Gouvernement indien et le Gouvernement français sont en train de signer une convention d'échange de chercheurs, et il semble que nous aurions beaucoup de succès si nous étions parmi les premiers à proposer quelque chose.

Il faut que vous adressiez votre demande au Council for Scientific and industrial research, Rasi Marg, New Delhi 1, 10.00.1, en joignant la lettre d'invitation ci-jointe.

Si votre démarche rencontre des difficultés, veuillez me le faire savoir afin que je vois ce que je peux faire de Paris.

Bien amicalement à vous,

A. Wisner

22 Avril 1975

Monsieur Pranab Kumar Nag
Department of Physiology
UNIVERSITY COLLEGE OF SCIENCE AND TECHNOLOGY - CALCUTTA UNIVERSITY
92 Acharrya Prafulla Chandra Road
CALCUTTA 700009 (Inde)

Cher Monsieur,

Lors d'un récent séjour à Calcutta, j'ai eu le plaisir de visiter le laboratoire de Physiologie du Travail de l'University College of Science and Technology, que dirige le Docteur R.N. Sen. J'ai été très impressionné par la qualité remarquable des travaux scientifiques qui y sont poursuivis, et j'ai trouvé le plus grand intérêt aux entretiens que j'ai eus au sein de votre équipe.

Ainsi que nous en étions convenus avec le Docteur R.N. Sen et vous-même, j'ai le plaisir de vous inviter à venir travailler au sein du laboratoire de Physiologie du Travail et Ergonomie du Conservatoire National des Arts et Métiers, pour une durée d'un an à dater du 1er Janvier 1976. Au cas où cette période ne vous conviendrait pas, il serait possible de la modifier.

Je ne dispose pas, à titre personnel, de bourses de voyage et de séjour. Aussi conviendrait-il de faire les démarches nécessaires, dans le cadre de l'accord culturel entre l'Inde et la France, ou bien encore auprès d'Organisations internationales.

Vos travaux pourraient porter sur les domaines suivants, qui sont actuellement ceux du laboratoire :

- la charge mentale et ses corrélats neuro-physiologiques,
- repérage spatial du point de vue psychologique et neuro-physiologique,
- le sommeil des travailleurs vieillissants en relation avec les horaires de travail,

.../...

- la voix criée et la communication dans des groupes de travailleurs de langues différentes,

- évolution de l'état ostéo-articulaire des travailleurs, en fonction de l'âge,

- la méthodologie ergonomique.

Je vous prie d'agréer, cher Monsieur, l'expression de mes sentiments les meilleurs.

Docteur A. Wisner

Professeur au Conservatoire
National des Arts et Métiers

TELEGRAM : SCIENCE, CAL-700 009

PHONE : 35-9186/89 (four lines)

DEPARTMENT OF PHYSIOLOGY

UNIVERSITY OF CALCUTTA

University Colleges of Science & Technology
92, ACHARYYA PRAFULLACHANDRA ROAD
CALCUTTA-700 009
INDIA

Ref. No.....

Dated...2nd..Feb!75....., 19 .

To
Prof. A.Wisner
Bangkok.

Dear Prof. Wisner :

Many thanks for your kind letter dated 21st Jan.'75. Of course I remember you. You being one of the authority in Work Physiology & Ergonomics in France we would very much look forward for your visit to Calcutta during the week 10th to 14th Feb.'75.

Ihereby request you to kindly deliver one or two lectures on the topics of your choice for the post graduate and research students in Work Physiology & Ergonomics and for the members of the Physiological Society of India. We have provisionally fixed the afternoon at 2-30pm on 11th Feb. for one of your lectures. We will be very much pleased if you kindly confirm so that we could pre-circulate the topics, time and venu of your lectures. We can have discussions and some of your advice for our different problems on Work Physiology & Ergonomics; the date and time of the discussion will be according to your convenience.

If you kindly inform me earlier I will be extremely pleased to receive you at the airport. You can phone Prof. S.R.Maitra, Head of the Dept. of Physiology, in his residence 46-0524 after office hours from 7 pm to 9 am or you can keep a message for me at phone no. 55-6068 in any time or you can cantact us the above address.

Waiting to meet you.

Yours Sincerely

(Dr. R. N. Sen)

My home address :

Dr. R.N.Sen.
AA 258 (Ground floor)
Salt Lake City of V.I.P. Road.
Calcutta 700064.

CORRESPONDANCE

9 Avril 1976

Monsieur le Docteur J.L. Batra

Industrial and Management engineering programme.
Indian Institute of Technology
Post office I.I.T.
KANPUR-208016 U.P.
(Indes)

Cher Docteur Batra,

Je me réjouis du fait que votre Institut envisage de pourvoir un poste de Professeur Assistant ou de Maître de Conférence dans le domaine de la physiologie du travail et de l'ergonomie.

Je m'en réjouis non seulement comme un spécialiste de cette discipline, mais aussi en tant qu'expert du Bureau International du Travail auquel il a été donné de remplir récemment une mission en Asie du Sud-Est, dans la perspective du programme du Directeur Général du B.I.T. en vue de l'amélioration des conditions de travail.

Je serais particulièrement heureux si votre choix pouvait se porter sur Monsieur Pranab Kumar Nag, d'une part parce qu'il a été formé dans un laboratoire de physiologie du travail de réputation mondiale, celui que dirige le Docteur Rabindra Nath Sen et, d'autre part, du fait de sa valeur propre.

Le groupe de l'Université de Calcutta est très connu, aussi bien en France qu'en Angleterre, aux Etats-Unis ou au Japon. J'ai eu moi-même l'occasion, en 1974, de le visiter avec le plus grand intérêt. Parmi les collaborateurs du Docteur Sen, Monsieur Pranab Nag m'a semblé particulièrement remarquable par ses connaissances en physiologie, l'élégance de ses dispositifs expérimentaux, la clarté de ses résultats et leur relation avec la réalité du travail. Ses exposés permettaient de saisir rapidement le problème et d'en discuter les aspects les plus complexes.

.../...

J'ai d'ailleurs fait des démarches pour qu'il puisse venir passer quelque temps dans notre laboratoire à Paris, ce qui ne s'est pas révélé possible du fait de difficultés administratives.

J'espère qu'il vous sera possible de vous assurer la collaboration de Monsieur Pranab Kumar Nag dans la position la plus élevée dont dispose votre Institut.

Veuillez agréer, cher Docteur Batra, l'expression de mes sentiments dévoués.

Docteur A. Wisner

Professeur de Physiologie du Travail
et d'Ergonomie au Conservatoire
National des Arts et Métiers

INDUSTRIAL AND MANAGEMENT ENGINEERING PROGRAMME
INDIAN INSTITUTE OF TECHNOLOGY KANPUR
POST OFFICE I. I. T., KANPUR-208016, U. P. (INDIA)

Dr. J.L. Batra
Convener

Prof. A. Wisner
Dept. der Sciences de I'Homme au Travail
Physiologie Du Travail Ergonomic
41, Rue Gay-Lussac, 75005
Paris
FRANCE

Dear Prof. Wisner:

I have received an application from Mr. Pranab Kumar Nag requesting that his candidature be considered for a suitable faculty position in the Interdisciplinary Programme of Industrial and Management Engineering. In this regard he has given your name as a referee to evaluate his technical capabilities, so I request you to furnish us as much information as possible. We have openings in ~~all~~ two cadres namely Assistant Professors and Lecturers. Your judgement as to what type of appointment the candidate deserves will be held confidential. Since the selections will be finalized at an early date. An early reply is highly appreciated.

With kind regards,

Yours sincerely,

JLBatra

(J.L. Batra)

Telegram : TECHNOLOGY Telex : 032-296 Telephone : 40066

BY AIR MAIL

AEROGRAMME

INDIA POSTAGE Rs. 1·00 S

Prof. A. Wisner
Dept. der Sciences de I'Homme
au Travail
Physiologie Du Travail
Ergonomic
41, Rue Gay-Lussac, 75005
Paris, FRANCE

SENDER'S NAME & ADDRESS

INDIA POSTAGE Rs. 0·50 S

Dr. J.L. Batra
CONVENER
Industrial & Management Engg.
Indian Institute of Technology
KANPUR-208016

NO ENCLOSURES ALLOWED

S Rs. 0·10 INDIA POSTAGE

KANPUR 30 III 76

TAJ MAHAL 501

22 Janvier 1973

Monsieur P.L. Bali
F.56 Jawahar Bharan
University of Roorkee
ROORKEE (U.P.) PIN 247667
(Indes)

Cher Monsieur,

L'article "A biomechanical model of man for the study of vehicle seat and suspension" est malheureusement épuisé, mais je vous adresse ci-joint l'autre article que vous avez bien voulu me demander "Methods of improving work-place layout". Je dois vous signaler, toutefois, que des recherches ont été poursuivies depuis 10 ans dans ce domaine.

Celles qui sont relatives aux dimensions du poste de travail ont été développées par Monsieur Rebiffé, (18 rue des Fauvelles, Centre d'études de Paris, 92 La Garenne Colombes). Il a, en particulier, publié dans le livre de Grandjean "Posture assise", Taylor et Francis ed. 1969.

En ce qui concerne les vibrations, c'est Monsieur Berthoz qui continue à travailler dans ce domaine et je vous adresse ci-jointe la liste des comptes rendus de recherche du laboratoire. Nous nous ferons un plaisir de vous adresser les documents qui vous seraient utiles et que nous aurions encore en notre possession.

Veuillez agréer, cher Monsieur, l'expression de mes sentiments les meilleurs.

A. Wisner

Roorkee (U.P.) India
Dt Jan 6, 1973.

Dear Dr. Wisner,

Let me take this opportunity to wish you a happy prosperous and promising new year.

Sometime ago, following papers were contributed by you to the International Journal of Prod. Research.

(i) Methods of improving Work place Layout.
Vol 2, 1963. (PP-155).

(ii) A biomechanical model of man for study of Vehical Seat and suspension. Vol-3. (1964).

I am working here for My M.E. Thesis/Project at Univ of Roorkee. The above papers are needed by me for the purpose of reference. Would You Kindly make available Reprints/copies of these papers, to me. I shall be thankful to you for this assistance. An early response shall be appreciated.

With kindest regards,

Yours faithfully.

(P.L. BALI).

BY AIRMAIL

PAR AVION

हवाई पत्र

AEROGRAMME

भारत INDIA

5 n.P.

शरणार्थी सहायता

REFUGEE RELIEF

85P

INDIA

Dr. A. WISNER

Laboratoire de Physiologie du

Travail du Centre National

de la Recherche Scientifique

41, Rue Gay Lussac

PARIS. Ve (FRANCE).

पहला मोड़ FIRST FOLD

दूसरा मोड़ SECOND FOLD

इस पत्र के अन्दर कुछ न रखिये NO ENCLOSURES ALLOWED

भेजने वाले का नाम और पता :- SENDER'S NAME AND ADDRESS:-

P.L. Bali

F-56, Jawahar Bhavan,

University of Roorkee

Roorkee (U.P.) PIN 247667

भारत INDIA.

mean weight 45.50
mean height 1,63 m | 500 Workers medium

TABLE

TENTATIVE CLASSIFICATION OF STRAINS IN DIFFERENT TYPES OF JOBS ACCORDING TO THE PHYSIOLOGICAL RESPONSES OF YOUNG INDIAN WORKERS IN COMFORTABLE CLIMATES

Physiological Responses	Classification of strains in jobs					
	Very Light	Light	Moderately Heavy	Heavy	Very Heavy	Extremely Heavy
Oxygen uptake Litres per min.	< 0.35	0.35-0.70	0.70-1.05	1.05-1.40	1.40-1.75	> 1.75
Calories per min.	< 1.75	1.75-3.50	3.5-5.25	5.25-7.00	7.00-8.75	> 8.75
Heart rate per minute (beats)	< 75	75-100	100-125	125-150	150-175	> 175
Sweating rate ml/hr. average for 8-hour work		<140	140-280	280-420	420-560	> 560

TELEGRAM : SCIENCE, CAL-700 009

PHONE : 35-9186/89

DEPARTMENT OF PHYSIOLOGY

UNIVERSITY OF CALCUTTA

University Colleges of Science & Technology
92, ACHARYYA PRAFULLACHANDRA ROAD
CALCUTTA-700 009
INDIA

Ref. No.....

Dated.....11/2/....., 1975

Dr. SUNIL KUMAR DAS

1. Seeking reference for fatigue of the sweat gland in continuous work of very heavy type towards the end of the shift (6 or 7 hours of work) if any.

Gram 'Homeliness'

SPENCES HOTEL PVT. LTD.

933 CALCUTTA

No ..... Date 10/2

Particulars	Calling No.	Amount Rs.	P.
55/6068			40
8579186			40

..... Signature .....

Resident's Signature Operator on duty

Room No 167 If cash received .....

TELEGRAM : SCIENCE, CAL-700 009

PHONE : 35-9186/89

DEPARTMENT OF PHYSIOLOGY

UNIVERSITY OF CALCUTTA

University Colleges of Science & Technology
92, ACHARYYA PRAFULLACHANDRA ROAD
CALCUTTA-700 009
INDIA

Ref. No.....

Dated.....11/2/....., 1975

Dr. SUNIL KUMAR DAS

1. Seeking reference for fatigue of the sweat gland in continuous work of very heavy type towards the end of the shift (6 or 7 hours of work) if any.

ble : Homeliness
Calcutta

Estd.—1830

SPENCES HOTEL PVT. LTD.

4, WELLESLEY PLACE
CALCUTTA

Phone : 23-68
(10 lines)

Bill No. 718

me MR. WISNER PLAIN Room No. 167 Arrived on 10/2/25 at 11 A.M.
Rate ~~Rs~~ 1-NM Left on 12/2/25 at 10 AM

ught Forward Account No.

Date	Board & Lodging	Meals etc.	Wine	Cigars and Cigarettes	Telephone	Trunk Call	Charges Recoverable	Total Rs.
6 10	70 -				80			70
11	70 -							70
	140 -				- 80			140
						107	S. Charge	14
								154

E. & O. E.

For **Spences Hotel Pvt. Ltd**

THE ONLY FULLY AIR CONDITIONED HOTEL IN CALCUTTA

প্রফেসর এ. ভিস্‌নার

Laboratory Researches on Work Physiology and Ergonomics in view of practical applications.

Date :- 11th February, 1975

Venue: Lecture Theatre

Time: at 2-30 P.M.

ESTD. 1830

CABLE : HOMELINESS
CALCUTTA

PHONE : 23-6871 (10 LINES)

SPENCES HOTEL PVT. LTD.

ASIA'S FIRST FULLY
AIRCONDITIONED HOTEL

REGD. OFFICE : 4, WELLESLEY PLACE
CALCUTTA-1

(1)

Social problems - Social solutions

Technical " "

But contribution of Science

Dr SEN → this contribution. We also

~~give examples~~
different ~~problems~~ views

- Knowledge of people characteristics:

To whom the work has to be adopted?

- Knowledge of work (contribution of people)
  - Work analysis
  - measurement
- Programme → load
- Technical recommendation: ergonomics in engineering.

1) To whom adopted.

- Anthropometrical problems size forces.
  - to develop
  - to use → NIGEL CORLETT
  - to be systematic

sex age socio biological status

ESTD. 1830

CABLE : HOMELINESS
CALCUTTA

PHONE : 23-6871 (10 LINES)

SPENCES HOTEL PVT. LTD.

ASIA'S FIRST FULLY
AIRCONDITIONED HOTEL

REGD. OFFICE : 4, WELLESLEY PLACE
CALCUTTA-1

- degree of training training and ergonomics
- psychophysiological abilities
  - direct
  - with aids spectacles
  - stereotypes
- medical imagery

2) Work analysis What is the job? (place of work)

~~Work~~ Job - Work perception and reality
  - → for technical change
  - → ignorance
  - → variations
- Methods of diagnosis
  - postures
  - eye movements

3 Diagnosis of difficulties

physical load and heat
mental load → spatial orientation
auditive load - lighting
  → noise → intelligibility

ESTD. 1830

CABLE : HOMELINESS
CALCUTTA

PHONE : 23-6871 (10 LINES)

SPENCES HOTEL PVT. LTD.

ASIA'S FIRST FULLY
AIRCONDITIONED HOTEL

REGD. OFFICE : 4, WELLESLEY PLACE
CALCUTTA-1

4) ~~For~~ Preparing systematic solution (3)

to be in design department
engineering dept

→ well being ?

→ accidents and incidents

→ ~~quality~~ quantity and quality

→ cost of investments, repair

Condenser → ~~Heat~~ changes can take place but role of economical, ecological and technological structure : DR SEN does the best

হৃদ-রোগ বিশেষজ্ঞ
ডাক্তার যোগেন মৈত্র

DR. J. N. MAITRA

M.SC., M.B., D.P.H.T. D.M. F.C.S (LOND) ETC.
CARDIOLOGIST & PHYSICIAN
FORMERLY SENIOR HOUSE PHYSICIAN &
DEMONSTRATOR IN PHYSIOLOGY
MEDICAL COLLEGE CALCUTTA.
RESEARCH WORKER,
INDIAN COUNCIL OF MEDICAL
RESEACH (I.C.M.R.)

Phone ; 35-3343

"HEART CLINIC"
1, Dr, Kartik Bose Street,
(Formerly: 1 Corris Church Lane)
OPPOSITE AMHERST STREET. P. O.
CALCUTTA-9
Hours : 3—5 p.m.

Chamber :
22, KAYATALA LANE, CALCUTTA 29
Hours 6 – 8 p. m.

11-2-75

Dear Professor,

Kindly, Let me
have never knowledge
of Cor. Occlusion from
Paris (French School of
Cardiology
yours,
Dr. Maitra

INDIAN NATIONAL SCIENCE ACADEMY

(Formerly National Institute of Sciences of India)

CALCUTTA CHAPTER

Phone: 34-6585
46-9197

C/o. Institution of Chemists (India)
Chemical Department
Medical College, Calcutta-12

February 13, 1973

NOTICE

Dr. J. N. Maitra will deliver a lecture on "Nonthrombotic Coronary Occlusion" in the Lecture Theatre of the School of Tropical Medicine, Chittaranjan Avenue, Calcutta-12 on Monday, March 5, 1973 at 4-00 p.m.

Sd/- R. N. Chakravarti
Convener

ABSTRACT

CORONARY OCCLUSION (J. N. Maitra, 1926)

The occurrence of occlusion is due to atheromatosis of the coronary artery itself or of a small or larger branch. The primary atheroma is a simple greyish yellow deposit on the intimal surface. Slowly the deposit is organised and the atheromatous patches by coalescing together form a core, thereby diminishing blood flow through the lumen of the arterial system causing ischaemia of the muscle of the heart (**Myocardial Ischaemia**). This Coronary Insufficiency leads to progressive occlusion, If a "GIANT MOLECULE" is larger in diameter than the calibre of the vessel, it occludes the vessel and immediatly collateral vessel emerges out of the myocardium and the pain in the chest is transient. This transient attack is a warning. Such warnings of the attack, if neglected, result in course of time in complete occlusion and an **Infarct** may result. And, we call the result of occlusion by a separate name, **Infarcation** which is the result and not the cause of Occlusion and heart attack.

ATHEROMA is produced by "Giant Molecules". These "GIANT MOLECULES are a-cellular debris colloidal in nature much bigger in size than biggest protein molecule or a big carbon compound of 16 or 18 carbon chain. Its size and composition varies In different individual. The common "Giant Molecule" consists of lipins, lipo-proteins, Cholesterol, phospho-proteins, collagen, lecithin bodies with varying number of ENZYMES.

Work of these Enzymes is peculiarly specific and disappear after their work is over. SGOT, SGPT and many proteolytic and lipolytic Enzymes make their appearance and dis-appear as soon as their action is not wanted by the system. Take for instance proteolytic Enzyme. If its predominance is discovered you will find corrotion of muscular coat and an Aneurysm will ensue. Bursting of an Aneurysm on the arch of Aorta or even an Aneurysm of a small vessel inside the left ventricle may cause a Sudden Death.

Dr. Z. Fezfar, Cardiovascular Chief of the WHO's team has communicated to the speaker that a silent Occlusion producing in its course may give no manifestation of the catastrophe than a Sudden Death. P. Lukl of CZSSR has produced a statistics of about 2% of sudden deaths in his series in Czechslovachia where post mortem is compulsory.

Previously we left out terminal cases of coronary occlusion as irreversible in the terminal stage. But, very recently a Reuter news from Moscow (April 9, 1973) informs that a team of 5 USA Surgeons led by Surgeon Michael de Eakay operated on Professor M. Kaldyan, President, Soviet Academy of Sciences, Moscow, most successfully. The details have not been published in English language. It is reported that Moscow papers have given details of the Six and half hours' operation. Now, USA collaboration has shown that no case of Coronary Occlusion is now out of cure.

J. N. Maitra

Physiopathogeneses of Ischaemic Heart Disease

By J. N. Maitra & C. K. Chatterjee

I. Introduction

The Writers have got experience of over 1000 (One thousand) Cases of Check-up and follow-ups during the last four years to five years. Statistical data are in preparation of these cases as per advice of Dr. Z. Fezfar, the World Chief of WHO's Team on Cardiovascular Diseases.

Our experience are varied and instructive. (A) In a series we have come across symptoms, but no gross abnormality, but these incipient cases when followed up turn to be genuine coronaries ; (B) Very early cases, showing slight bowing of S - T's are symptom-free on our recipe, dietetic, rehabilitationary and medicinal. Both these types of incipient, early and easily amenable ones yet had to dicipline and get all right. Group (C) Moderately advanced cases showing symptoms and signs of ischemia by progressive diminution of calibres of coronaries, showing ischemic changes in walls, on one or on both right and left or saptal with radiological evidence of enlargement which has been vaguely interpreted as idopathic type but to writers they appear as due to occlusion of small or larger branches establishing immediate collateral circulation and thereby increasing the cardiac musculature, (D) Fairly advanced, rather irreversible cases as observed by the senior worker coming round marvellously on strict regimes of Rehabilitation, dieteting and follow-up and check-ups frequently. So, both writers have been convinced of relief or effective cure of the malady without any cynicism or pessimism.

II. Clinical Observation & Prognosis

The writers are indulgent to declare that cases given up, came up and surrendered to our observation, have returned to normal work and are earning their bread at 60 to 70 years of age. So, an optimism has drawned on the writers that any case of coronary affection should not be abandoned as incurable and the conditions arrived at must not be declared as irreversible. Case notes of at least a dozen patients will convince a clinician that the pathogenesis is prognostically not so gloomy as to be despaired of.

III. Post mortem findings are instructive

The Senior Worker, working under an ICMR Scheme had opportunities since 1926 and very many cases shown to senior Consultants and followed up from the advent of first symtoms down to the postmortem table has shown the development of atheromatosis generalised and affecting the whole coronary tree, showing the reversibility chance of complete cure and taking up normal functions in life. On the contrary the senior writer followed up cases and got report of death in sleep without any ostentatious evidence that they were going to die and this is the Terminal Type of Coronary Occlusion. .. This must be the only cause of death in a Society, where ideal conditions prevail of taking care of the sick and checking up of the healthy and following-up thus giving longivity upto 100 years.

IV. Conclusion

The writers do believe and strongly advocate that surgical intervention is necessary in no case of coronary involvement except congenital anomaly or badly involved valves due to rheumatic affection needing fingering or at best needing a plastic valve, and these need Cardiac Surgeons and marvellous technique will give new life to dying patients. In most coronary cases the future regarding work and longivity is not at all gloomy. They can lead fairly active life under more expert Rehabilitation. At present coronary heart patients and myopathy heart disease should not be handed over to the Surgeons' knife. The exact time of taking out heart from the donor has aroused a lot of controversy regarding Cardiac Transplant .... legally & ethically.

The final answer to incurable heart disease, at present, may be solved by artificial Heart Transplantation Committee on an All World basis and not on personal fads.

Both the Senior and the Junior writers are thankful to Superintendent of Dr. B. C. Roy Diagnostic and Research Laboratories and all Superintendents of Medical Colleges in Calcutta and S.S.K.M. Hospital for unstinted help and encouragement. Lastly, the whole thanks are due to Dr. J. C. Banerji, as it was sponsored by him, as our First Collaborator with the Senior Writer as the Main Investigator under Indian Council of of Medical Research. The last word of thanks are to Dr. Z. Fezfar, who had been giving the Senior Investigator by his Proforma instructions from Geneva and Dr. Takio Sama Moto of Japan for his ideas of Giant molecules forming with fat globules and not RBC's at all, but of fats, i.e. lipins, Cholesterol and NEFA, which serve as the real Atherogen in the atheromatosis, producing occlusion of coronaries by degrees and gradations in the whole catastrophy.

J. N. Maitra and C. K. Chatterjee.

TREATMENT OF HEART ATTACK (Progressive Coronary Occlusion)

J. N. Maitra, Cardiologist, Calcutta

I. The main treatment is preventive, rather prophylactic and physiologic life in regulation of habits and day to day hygiene in Food, Rest, Work and Relaxation. Writer's "TEN GOLDEN RULES" was circulated all over the world for the last 40 years. Dr. Z. Fezfar has communicated to the writer of the WISDOM of decades for prevention of heart attack and a longivity of 100 years. In India Punjabis are very seldom attacked with coronary artery disease. They chew hard food as Roti —i.e. hand-made whole-meal bread, baked in open fire and chew the hard bread with one item of food and a little sauce or chutni. The fact is that Saliva contains Enzyme (Ptyaline) containing double amount of Potassium and thiocyanate as a Potassium salt. In chewing, saliva is secreted and K or Potassium as thiocyanate is secreted. If one chews his food for some time he gets a dose of Hydrocyanic acid in the stomach by inter-action of HCI from the oxyntic cells of the stomach. The writer advises dilute HCN. B. P. dose (.3 ml containing .4 mg. of HCN.)

II. After dinner or lunch one must take at least 2 hours' Rest for allowing his digestive organs respite to digest food. ILO (Inrernational Labour Organisation) has recommended 4 hours' work, 2 hours' rest and 4 hours' work, thus dividing 8 hours in two shifts and getting 100% work out of any labour, skilled or unskilled. Winston (Sir) Churchill in his memoirs has pointed out that in all his activities he took Rest solemnly 2 hours after his lunch for Relaxation.

III. If the "heart attack" (Transient) or a "coronary kick" is felt resulting in ischaemia of the heart muscle or even a small infarct, one need not get frightened as it may be in words of an American, "God has given me warning to curb my activities," In acute attack morphia or pethidrine in massive doses must be given. A private practitioner of any experience may be trusted. He must advise and enforce Oxygen immediately, Glucose saline and sedation with definite instruction for Complete Bed Rest till E. C. G. as normal. If silent and massive infarction beyond ischamia is felt hope should not be given up. President of U.S.S.R. Academy of Sciences in Moscow was operated on by a team of 5 American Experts and an operation on his heart was performed successfully, (Coronary endartectomy). as reported in Moscow on 9. 4. 73 of the operation by Surgeon by Dr. Michael de Bakey as reported in Praveda. So, no coronary case should be given up as lost.

IV. No specific treatment has still been found satisfactory. A general private practitioner can manage mild and transient cases of heart attack by rest, sedatives or tranquilisers and hope with assurance. He knows how to treat shock now-a-days with newer knowledge. He will call for Oxygen cylinder and glucose saline. He has full sense of "CHECK-UP and FOLLOW-UP" and he knows that "CORONARY CARE UNITS" are being opened in the country at large.

V. Our ancient medicament advised chewing of Bitter Almonds and in China and U.S.S.R. quite recently Spain and a few countries are reverting to their old medicaments, Before the introduction of Sulfa drugs and Antibiotics the writer used to abort further heart attack by giving to a coronary sufferer 2 to 5 drops of dilute HCN manufactured by Bengal Chemical (B.C.P.W.) 0.3 ml containing 4.5 mg of Hydrocyanic acid in distilled water (Ordinary B.P. dose is 0.12 to 0.30 ml8 2 to 5 drops) in cold water, Vide American Heart Journal, December issue, 1939.)

Sorbitrate, Antro mid—S, Chlorofibrate, Inderol (ICI), Propranolol Hydrochloride. (B.P.) Perhexiline, Placebo etc. etc. have been used as remedies as Cholesterol dissolver or Coronary vasodilator with temporary result.

1. For immediate Relief

2. Permanent Relief 4 tabs after food B.D. 1 tab

Dr. J. N. Maitra

Welcome Address

On The Unveiling Ceremony of The Portrait of

National Professor Satyendranath Bose

by Dr. J. N. Maitra, Cardiologist, Calcutta.

Dear Friends, Hon'ble Education Minister (Professer Banerjee), Hon'ble Vice Chancellor, Professor S. N. Sen, and President of different Chambers of Merchants and Business Magnets of the City. It gives me the greatest pleasure and privilege to be associated with the name of illustrious son of Bengal, nay the whole of India and International workers of Physical and mathematical—rather statistical workers in association with world famous Noble Lauriate, Dr. Einstein. I am thankful to the committee of the Parisad for this opportunity to address you all as the Seniormost Vice-President of the Parishad.

My association with Professor Bose started in the Alumni association of the Presidency College. Afterwards we met at Book Company almost daily as it was a living Book Stall where all books were avaiable & Professor Bose was a vorecious reader.

Afterwards when he came back with full honours from the Dacca University as Khaira Professor of the University, we met almost daily.

As President of Physiological Society of India. I gave the address in Bengali & this endeared me to him. As a Research Scholar of the Presidency College, he pushed me through Calcutta Corporation as a Chairman of Education Committee to make free compulsory Primary Education in a part of the City. He pushed me through I. C. M. R. and gave me opportunities in the Indian Statical Institute for datametry in my work on Coronary Occlusion & by presiding over meetings, help me to write at least 4 articles and finally had my those papers published by Publicity Department of the government of West Bengal in Bengali. He was pushing me through world forum in my original work in heart disease in West Bengal. Like me he volunteered for very many workers like Dr. Shamadas Chatterjee for Bakreswar Project. In short late Professor Bose was a Fountain Head of original work all over India. He gave me the name as "Kekule of heart", as Kekule discovered 6-Carbon atomhaxagon.

Now, our Secretary will give you Plans and Programmes how to immortalize Professor Bose for his original talent for improving Art, Commerce and Industry in India.

It would be a great injustice to the great soul if I do not present to this Institution the only Copy available on the Planning of India after Freedom written by one of his Russia-trained pupil Dr. A. K. Shaha of the Dacca University. Problems of Agriculture and Energy as coal was the Primary advice of Professor Bose.

With these few words, I again accord you with words of welcome to immortalize Professor Bose.

20. 3. 74

Dr. J. N. M

Calcutta

THIS FORTNIGHT

February 1st to 15th 1975

CULTURAL EVENTS

Date/Time	Programme	Admission
Daily 12-30 to 1-30p.m. 4 to 5 p.m.	**Tourist Film Show** at Govt. of India Tourist Office 4, Shakespeare Sarani	Passes (First come first served basis)
Daily 7 p.m.	**Dance** Dances of India at Grand Hotel	Rs. 9/- Rs. 5/- (Students)
1st (Whole night)	**Music (Classical)** Ustad Vilayat Khan Night at Cassim Bazar Rajbari	Rs. 15/- 10/- 7/- 5/-
1st 6 p. m.	**Binode Smriti Musical Soiree** By Artistes at Rabindra Sadan	Rs 15/- 10/- 7/- 5/- 3/-
1st 6-30 p. m.	**Drama (Bengali)** Barbadhu at Pratap Memorial Hall	Rs 7/- 5/- 3/- 2/- 1/-
1st 6 p. m.	**Dance Drama** Shree Chaitanya at Thyagraj Hall	Tickets
1st & 2nd 6-30 p. m.	**Drama (Bengali)** Ek-Dui-Teen at Muktangan	Rs. 7/- 5/ 3-30, 3/- 2-30, 2/-
2nd 6 p. m.	**Music (Classical)** By Nikhil Banerjee Kishan Maharaj & Others at Cassim Bazar Rajbari	Rs. 10/- 7/- 5/- 3/-
2nd 6-30 p. m.	**Drama (Hindi)** Gagen Tale by Adakar at Max Muller Bhavan	Rs. 10/- 5/- 3/-
2nd & 9th 6 p. m.	**Drama (Hindi)** Bari Buaji by Anamika at Kala Mandir	Rs• 10/- 5/- 3/-
2nd 6-30 p. m.	**Drama Bengali)** Chandrahas by Jayma's Troupe at Thyagraj Hall	tickets
2nd 6 p. m.	**Drama** Alaler Gharer Dulal at Rabindra Sadan	tickets
3rd 6 p. m.	**Music (Classical)** by Ustad Bismillah Khan & Dipak Choudhury at Cassim Bazar Rajbari	Rs. 10/- 7/- 5/- 3/-
3rd 6 p. m.	**Dance Drama** Alibaba by Nrityaniketan at Thyagraj Hall	tickets
3rd 6-30 p. m.	**Dance Drama** Ankamalar Beshe by Pujarini at Rabindra Sadan	Rs. 10/- 7/- 5/- 3/-
4th 6 p. m.	**Dance (Classical)** by Sanjukta Panigrahi at Cassim Bazar Rajbari	Rs. 10/- 7/- 5/- 3/-

5th 6 p. m.	**Music (Classical)** by Ustad Amjad Ali Khan Shanta Prasad Mira Banerjee & others at Cassim Bazar Rajbari	Rs. 10/- 7/- 5/- 3/-
5th	**Pontu Laha Bengali Drama** by Theatre Unit at Rabindra Sadan	Rs. 10/- 8/- 5/- 3/- 2/-
6th & 7th 7 p. m. 8th at 8-30 p. m.	**Park Circus Musical Conference** by Park Union Club at Kala Mandir	Rs. 15/- 10/- 5/-
7th 6-30 p. m.	**Dance Drama** Chandalika by Belierina at Kala Mandir	Invitation
8th 5 p. m.	**Drama (Bengali)** Barricade by P. L. T. at Kala Mandir	Rs. 10/- 7/- 5/- 4/- 3/- 2/-
9th 6-30 p. m.	**Drama (Hindi)** Uljhi Akretyan at Max Muller Bhavan organised by Adakar	Rs. 10- 5/- 3/-
10th 7 p.m.	**The New York Harp Ensemble** Presented by the Calcutta School of Music Directed by Aristid von Wurtzler at Vidya Mandir, 1, Moira St. Calccutta-16	Tickets Enquire at 4-71375
15th 6 p. m.	**Musical Soiree** by Kaikey Roy & Bulbul Chowdhury at Kala Mandir	Invitation

33rd WORLD TABLE TENNIS CHAMPIONSHIP
EDENGARDENS, 6th—16th FEB. '75

Exhibitions :

Academy of Fine Arts Cathedral Road, Cal-16. Birla Academy of Art & Culture 108/109 Southern Avenue, Calcutta-29. Permanent Galleries. Open daily, except Monday From 3 p.m & 4 p.m. respectively.

Nehru Children's Museum, Chowringhee—Opens daily between 12 p. m. to 8 p. m. except Mondays. Admission 50 p. per adult and 25 p. per child.

Exhibition (1 p. m. to 8 p. m.)

Exhibition of paintings by Sri Jamini Roy at 18, Ballygange Place East up to 3rd Feb. (10 a.m.— 8 p.m.)

Festival fair Swadeshi mela at Park Circus Maidan.

Festival & Fair

Daily : Organised by Banga Sanskriti Sammelan at Calcutta Maidan Ticket : 0.25 p.

Calcutta Race Meet

Calcutta Race Meet at 1,00 p m. on 1st, 8th & 15th Feb. Admission Rs. 30/-, Rs, 10/-.

List of Bank Holidays

All Sundays.

City Tour by Luxury Bus.

Full day guided tour by W. B. Tourist Bureau, 3/2, B. B. D. Bag from 8 a.m. to 5-30 p.m. except Mondays Rs. 10/- only.

Half day sightseeing tours every day. Rs. 6/- Per ticket (Except Monday)

City Tour by Luxury Bus :—by I.T.D.C. from Govt. of India Tourist Office, 4, Shakespeare Sarani, Calcutta-16.

Tour No. 1

0800 hrs to 1230 hrs. Daily Fare Rs. 6/-

Tour No. 2

1330 hrs. to 1715 hrs, Daily except Mondays Fare Rs. 6/-

Combined Tours No. 1 & 2 Fare Rs. 10/-

Booking—I. T. D. C. Transport Unit, C/o. Govt. of India Tourist Office, 4, Shakespear Sarani, Calcutta-16.

Tours in and Around Calcutta.

Cars & Guides, on the approved list of the Department of Tourism, Govt. of India, are available at the following rates.

Tourist Car :—1.05 per km. Rs. 9/- per hour ;

Limousine Non A.C.—1.55 per km. Rs. 15/- per hour ;

Limousine A. C.—1.80 per km. Rs. 17/- per hour

Higher of the two rates is chargeable and charges are from garage. Available from Govt. of West Bengal Tourist Bureau or I. T. D. C.

Guide—Upto 4 Tourists Half-day Rs. 18.00, Full day Rs. 25.00. Language fee Rs. 15/- extra

The Services of trained guides can be obtained from the Govt. of India Tourist Office. Tel : 44-1402/44-3521

We welcome you to Calcutta and offer our services to make your stay enjoyable. We can assist you in the following ways :-

(1) Furnish you travel information and help draw up itineraries.

(2) Supply you with shopping Guide, lists of approved Travel Agents, Car Operators, Hoteliers and provide you with Trained Guides.

(3) Issue a Tourist Introduction Card/ All India Liquor Permit. (For foreign Tourists.)

WISHER

Issued by :

GOVT. OF INDIA TOURIST OFFICE
4, SHAKESPEARE SARANI,
CALCUTTA-16.
Tel : 44-3521/44-1402
Gram : INDTOUR

Working Hours :
Weekdays : 9 a.m. to 6 p.m.
2nd Saturdays & Holidays :
9 a.m. to 1 p.m.
Telex No. Tourist 021—7461

TOURIST BUREAU,
GOVT. OF WEST BENGAL,
3/2, B. B. D. BAG (Dalhousie Square East), Calcutta.
Tel : 23-8271 Gram : Traveltips

Working Hours :
Weekdays : 7 a.m. to 6 p.m.
Holidays : 7 a.m. to 1 p.m.

Printed by :—Central Calcutta Press, Calcutta-1. Phone : 23-1619

DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA
92, A. P. C. ROAD
CALCUTTA-9

Reprint from Ind. Jour. Physiol & Allied Sc., 1967, Vol. XXI. No. 2 from page 33—36

STUDY ON HEART RATE, BLOOD PRESSURE, BLOOD COAGULATION TIME AND OXYGEN CONSUMPTION BEFORE AND DURING GRADED EXERCISE

SUSIL RANJAN MAITRA, SATIPATI CHATTERJEE* AND SUNIL DAS**

(Department of Physiology, University College of Science, Calcutta)

Le Blank (1) suggested that the pulse rate during exercise and at the recovery period in human subjects, can be taken as a parameter for measuring the fatigue and work performance. Berggren and Christensen(2) have also suggested that for the short period of exercise, pulse rate can be taken as an index of metabolic rate. Tuttle (3) has stated that the effects of exercise on blood pressure and heart rate depend on the type of work performed. Brouha *et al* (4) noted that systolic blood pressure is influenced by work load not by environment.

The study on heart rate, blood pressure, and blood coagulation time have been studied already during exercise (4, 5 & 6). But the resparameters have not yet been studied with 100, 600 and 1200 kgm/min work loads in our country.

To collect such informations, experiments on human beings living in different countries with different climatic conditions and nutritional habits, should be undertaken, and data available from such experiments will give a better understanding about the biological values. With this objective in view, we are collecting data on the people of Eastern Region of India, whose nutritional habits and climatic condition are variable not only in relation to people outside India, but also of other parts of India.

So the study on blood coagulation time, blood pressure, heart rate and oxygen consumption have been undertaken to understand the stress going on during minimal, submaximal and maximal work loads, by noting the changes in respective function.

METHODS AND MATERIALS

20 male students of the University College of Science, Calcutta University, under the age, height and weight groups of 20-25 years, 160-177 cm and 44-50 kg respectively were selected for the present study. The exercise was performed by the subjects riding on a magnetic friction type bicycle ergometer (after Prof. E. A. Muller, Max-Planck Institute for Work Physiology) at room temperature 28°C-29°C controlled by air cooler. The procedure of half-an-hour's rest before starting work to bring the body's condition to the level of rest was followed here. The work loads given to the subjects with fixed time for five minutes were respectively 100 kgm min (minimal), 600 kgm min (submaximal) and 1200 kgm min (maximal). The classification is based on the oxygen consumption per minute(7). Samples of ten ml. of blood were withdrawn from the antecubital vein at each interval as follows:

(a) 5-10 minutes before the exercise (which is taken as the control value),

(b) within 90 seconds just after the end of the exercise.

*Assistant Research Officer, I.C.M.R.
**Research Assistant, I.C.M.R.

STUDY ON HEART RATE

The measurements of blood coagulation time and blood pressure were made in 16 and 10 subjects respectively. The heart rate was noted at every minute of exercise by feeling the carotid pulse and sometimes by electrocardiography. The blood pressure had been noted by Auscultatory method during the fourth minute of graded work. The data on heart rate and blood pressure presented in table 1 were noted simultaneously at the fourth minute of working condition.

The whole blood clotting time method of Lee and White (8) was employed to study the blood coagulation time before and just after the exercise.

Oxygen consumption was measured by collecting the gas samples through Gasometer and then analysing the samples by Scholander Gas Analysis Apparatus (9).

Results

The results presented in table 1 show the different changes during exercise. The average pre exercise values of heart rate, blood pressure and whole blood coagluation time are 77.40/min, 115.0/74.2 mm Hg and 438.25 seconds respectively. With the increase of the intensity of the work loads, the heart rate and systolic blood pressure are gradually increased from 77.40/min and 115.00 mm to 94.70/min and 120.6 mm, Hg 152.60/min. and 151.9 mm and 192.80/min and 180.00 mm Hg respectively during graded exercise. The diastolic blood pressure does not change so much during exercise. The average pre exercise value of the diastolic blood pressure is 74.2 mm Hg which rises to 78.5, 88.6 and 90.2 mm Hg during graded exercise.

TABLE 1

Average' standard deviation & standard error of heart rate, blood pressure, blood coagulation time and oxygen consumption under resting condition and three different work loads.

Name of the parameters	No. of volunteers experimented upon	Pre-exercise values	WORK LOAD IN KGM/MIN. 100	600	1200
Heart Rate (per min.)	20	77.40 S.D ±6.54 S.E. ±1.46	94.70 S.D. ±7.32 S.E. ±1.63	152.60 S.D. ±5.44 S.E. ±1.21	192.80 S.D. ±7.05 S.E. ±1.57
Blood pressure (mm. Hg.)	10	115.0 74.2 S.D. ±3.43 4.26 S.E. ±1.08 1.34	120.6 78.5 S.D. ±3.13 4.64 S.E. ±0.99 1.47	151.9 88.6 S.D. ±7.63 2.67 S.E. ±2.41 0.84	180.0 90.2 S.D. ±5.41 2.39 S.E. ±1.71 0.75
Blood coagulation time in sec. (Lee & White method)	16	438.25 S.D. ±121.44 S.E. ±30.36	447.00 S.D. ±117.53 S.E. ±29.38	368.00 S.D. ±108.66 S.E. ±27.16	354.75 S.D. ±111.23 S.E. ±27.81
Oxygen consumption in litre/min (STPD)	20	0.210 S.D. ±0.018 S.E. ±0.004	0.574 S.D. ±0.035 S.E. ±0.008	1.451 S.D. ±0.033 S.E. ±0.007	2.136 S.D. ±0.157 S.E. ±0.035

The average pre-exercise value of whole blood coagulation time (Lee and White method) in seconds is 438.25, which at the end of 100 kgm/min is 447.00 seconds. But after five minutes of work with 600 kgm/min and 1200 kgm/min. the whole blood coagulation time decreased from the pre exercise value into 368.00 and 354.75 seconds respectively (vide table 1). Iatridis *et al* (6) obsevred that the whole blood coagulation time of pre exercise state by the Lee & White method was 16.5 minutes.

The average oxygen consumption in litres/min (STPD) increases from 0.210 (pre exercise value) to 0.574 (100 kgm/min), 1.451 (600 kgm/min), and 2.136 (1200 kgm/min.)

Discussion

During exercise the demand of oxygen by the muscular tissues is increased. Supply of oxygen to the tissues can be enhanced by increasing either blood flow per unit of muscle, or arteriovenous difference of blood. The blood flow is increased perhaps by increasing both the frequency and stroke volume of the heart. It may be noted (table 1) that with the increase of work load oxygen consumption increases. It is already well established that oxygen consumption has got linear relationship with work load.

To maintain the blood flow, the blood pressure rises during exercise. The rise of pressure is mainly due to increased output, as total peripheral resistance perhaps decreases by vasodilatation in the muscular vessels, though vasoconstriction occurs in the splanchnic bed and in the skin (10). The changes in systolic and diastolic blood pressure (vide table 1) are agreeable with the findings of Bock *et al* (11) and Brouha *et al* (4) during exercise. But from the table 1 it is noted that the rate of change of blood pressure and heart rate is not proportional to the intensity of the work loads. During muscular activity the acid base balance is altered (12) and the chemoreceptors may play important role in increasing the blood pressure. The secretion of adrenal gland during muscular work is increased, as suggested by Hartman, Waite and McCordok (13). Vendsalu (5) said that the vasodilation following muscular activity was normally compensated for, by the homeostatic mechanism controlling blood pressure. The compensatory vasoconstriction in other areas (Loven's reflex) would also imply an increased activity of adrenergic nerve, and liberation of noradrenaline, into the circulating blood. It has also been observed by Vendsalu (5) that adrenaline, noradrenaline concentration in plasma of human beings and blood pressure gradually increase during graded exercise.

Whole blood coagulation time decreases during submaximal and maximal exercise i. e. muscular exercise hastens the blood coagulation mechanism. In terms of the proportionality of change in the coagulation time, as evident from tabl 1, th change is highest in submaximal exercise compared to that in minimal and maximal exercise. It is thought that there is a maximum limit of change possible, and with submaximal work major portion of the limit of chang is happening leaving only a small remainder which is attained with maximal work. Iatridis *et al* (6) have observed shorting of the blood coagulation time. Cannon and Gray (14) said that the increase coagulability was in no way related to blood pressure or blood sugar changes but was due to the action of epinephrine on the liver causing it to discharge some factor in coagulation. Tocantins and O'Neill (15) showed that prothombic activity of plasma is increased when epinephrine is injected.

Biggs *et al* (16) showed that severe (not mild) muscular exercise like epinephrine injections caused the appearance of fibrinolysin activity in tests on diluted plasma. They concluded that such fibrinolysis was another component of the initial phase of Selye's alarm reaction.

Muscular exercise through demand of oxygen by the muscular tissues produces stress condition in the body. It may be, therefore, assumed that liberation of adrenaline during exercise causes rise of blood pressure (5, and dcrease of blood coagulation time (14, 15 & 16) which corroborate also our findings. So it may be assumed that the changes in heart rate, blood pressure and coagulation time may be related with the liberation of adrenaline in plasma following graded exercise, which is under study. It may be suggested, also that though the degree of change of oxygen consumption has got linear relationship with minimal, submaximal and maximal work loads, yet the changes of heart rate, blood pressure and coagulation time are not proportional with the intensity of the work load.

References

1. Le Blanck, J. A. (1957). *J. Appl. Physiol., 10,* 275-280.
2. Berggren, G. and E. H. Christensen. (1950). *J. Arbeitsphysiologie, 10,* 255-260.
3. Tuttle, W. W. and S. M. Horvath (1957). *J. Appl. Physiol., 10,* 294.
4. Brouha, L., P. E. Jr., R. De Lanne and M. E. Maxfield (1960). *J. Appl. Physiol., 1*,* 133.
5. Vendsalu, A. (1960). *Acta Physiol. Scand., 49,* Suppl. 173.
6. Iatridis, Strrios G., and John H. Ferguson (1963). *J. Appl. Physiol., 18(2),* 337.344.
7. Brouha, L. (1960). *'Physiology in Industry'* Pergamon Press, p.4.
8. Wintrobe, M. M. (1958). *Clinical Hematology.* ed. 4th p. 286. Lea & Febiger. Philadelphia.
9. Scholander, P. F. (1947). *J. Biol. Chem., 167,* 235.
10. Wright, S. (1961). *Applied Physiology,* ed. 10th p. 205.
11. Bock, A. V., C. Varcaulaert, D. B. Dill, A. Folling and L. M. Hurxthal (1928). *J. Physiol., 66,* 136.
12. De Lanne, R., J. R. Barnes and L. Brouha (1959). *J. Appl. Physiol., 14*(5), 804-808.
13. Hartman, Waite and McCordock (1922). *Am. J. Physiol., 62,* 225.
14. Cannon, W. B. and H. Gray (1914). *Am. J. Physiol., 30,* 232.
15. Tocantins, L. M. and J. F. O'Neill (1941). *Proc. Soc. Exper. Biol. & Med., 07,* 477.
16. Biggs, R., R. G. Macfarlane and J. Pilling (1947). *Lancet, 252,* 402.
17. Vosburgh, C. H. and A. N. Richards (1903). *Am J. Physiol., 9,* 35.

Reprinted from " The proceedings of the Symposium on HUMAN ADAPTABILITY TO ENVIRONMENTS AND PHYSICAL FITNESS ", ed. M. S. MALHOTRA, Defence Institute of Physiology and Allied Sciences, Madras-3, India. 1966.

DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA
92, A. P. C. ROAD
CALCUTTA-9

Study on Protein Concentration in Plasma and Corpuscular Changes of Blood in Man with Minimal, Submaximal and Maximal Work Loads

S. R. MAITRA, S. CHATTERJEE* AND S. DAS**

Department of Physiology, University College of Science, Calcutta.

Experiments have been carried out on 30 male students. It has been noted that the haemoconcentration of haemoglobin, R. B. C. and plasma protein concentration and leucocytosis have taken place with minimal, submaximal and maximal work loads. In the initial stage starting from rest to the minimal work the change is very little, with the onset of submaximal work from the minimal the change is rather greater, but with the onset of maximal work from submaximal the rate of change is not proportional to the change occurred during submaximal work from the minimal. The increase of lymphocyte is noted to be maximal among white blood corpuscular changes.

During the process of recovery the protein content, haemoglobin and R.B.C. come back almost to resting level but neutrophilia, and to a lesser extent, eosinopenia and lymphopenia persist.

Corpuscular content in peripheral blood and protein content in plasma have been studied during muscular exercise (Dill, Edwards & Talbolt, 1930 ; De Lanne et al, 1958, 1960). Haemoconcentration during exercise was observed firstly by Zuntz and his associates (1895). Chalamers et al (1942) have suggested that exercise may cause the blood to become more concentrated and this in turn will affect the concentration of all substances in the blood. But gradual changes, however, in concentration of blood composition, starting from rest phase to minimal, submaximal and maximal work, have not been studied thoroughly. Moreover, the biological variations, if there be any, in people of different regions of the world due to graded exercise are not clear.

The purpose of the investigation is to have an idea of degree of change of (a) haemoconcentration of R. B. C., Hb and protein content of plasma, and (b) leucocytosis, caused by muscular activity with the fixed task of the minimal, submaximal and maximal work loads.

METHODS AND MATERIALS

The experiments have been performed on 30 male students of the University College of Science, Calcutta University, under the age,

* Assistant Research Officer, I. C. M. R.
** Research Assistant, I. C. M. R.

height and weight groups between 16 and 30 years, from 151.25 cm to 180.12 cm and from 52.22 kg to 81.36 kg respectively. The exercise is performed by the 30 subjects, who used to come to the laboratory after a light breakfast by riding a magnetic friction type bicycle ergometer (after Prof. E. A. Muller, Max-Planck Institute for Work Physiology) at room temperature 28°C–29°C controlled by air cooler. The procedure of half-an-hour's rest before starting work to bring the body's condition to the level of rest is being followed here. The work loads given to the subjects with fixed time for five minutes were 100 kgm/min (minimal), 600 kgm/min (submaximal) and 1200 kgm/min (maximal). The classification is based on the oxygen consumption per minute (Brouha, 1960). Ten ml of blood were withdrawn from the antecubital vein at each interval as follows :

(a) 5–10 minutes before the exercise (which is taken as the control value),

(b) within 90 seconds just after the end of the exercise,

(c) one hour after the completion of the work with the subject at rest,

for the following estimation :—

(a) Total plasma protein concentration

(b) Total count of red blood cells per cubic millimeter

(c) Packed cell volume

(d) Haemoglobin concentration

(e) Specific gravity of blood and plasma

(f) Total and differential count of W.B.C.

The total plasma protein concentration has been determined by microkjeldahl method (Keys, 1940). The specific gravity of blood and plasma has been determined by copper sulfate method (Philips et al, 1950). The number of red blood cells per cubic millimeter is estimated from the number counted in 25 squares on each side of the Neubauer chambers. Haemoglobin is measured colorimetrically as acid hematin and expressed in gram per cent. Haematocrits are obtained in duplicate samples centrifuged for 30 minutes at 3000 r.p.m. and mean corpuscular volume and haemoglobin concentration are calculated from the haematocrit values (De Lanne et al, 1960). Total count of W.B.C. per cubic millimeter was calculated from the average of cells in five squares of two Neubauer chambers. Differential counts were made by counting 200 cells in three longitudinal columns in each of two smears stained with Leishman stain

TABLE 1

Average, standard deviation & standard error of haemoglobin, total no. of R. B. C., packed cell volume, mean corpuscular volume, mean corpuscular haemoglobin concentration etc. under resting condition & three different work loads.

Name of the Parameter	No. of volunteers experimented upon	Pre-exercise value	Work Load in kgm/min (Just after the end of work)		
			100	600	1200
Haemoglobin (gm. per 100c. c. of blood)	30	14·86 S.D. ±0.85 S.E. ±0.16	14·97 S.D. ±0·87 S.E. ±0·16	16.21 S.D. ±0·76 S.E. ±0·14	16·62 S.D. ±0·77 S.E. ±0.14
Total number of R.B.C. per cubic millimeter	30	4·870 S.D. ±0·117 S.E. ±0·021	4·895 S.D. ±0·115 S.E. ±0·021	5.336 S.D. ±0.106 S.E. ±0·019	5 418 S.D. ±0·120 S E. ±0·021
Packed cell volume%	30	43·84 S.D. ±1·74 S.E. ±0·32	43·93 S.D. ±1·73 S.E. ±0·32	46·89 S.D. ±1·81 S.E. ±0·33	47·74 S.D. ±1·63 S.E. ±0·30
Mean corpuscular volume (cubic u)	30	89·98 S.D. ±1·78 S.E ±0·32	89·68 S.D. ±1·98 S.E. ±0·36	88·12 S.D. ±1·952 S.E. ±0·35	88·04 S.D. ±2·18 S.E. ±0·399
Mean corpuscular haemoglobin conc.%	30	33·89 S.D. ±0·92 S.E. ±0·16	34·04 S.D. ±0·90 S.E. ±0·16	34·46 S.D. ±0·86 S.E. ±0·15	34·73 S.D. ±0·79 S.E. ±0·14
Total plasma protein conc. (micro-Kjeldal (gm%)	30	6·62 S.D. ±0·32 S.E. ±0·05	6.68 S.D. ±0·31 S.E. ±0·05	7.38 S.D. ±0·26 S.E. ±0·04	7·74 S.D. ±0·30 S.E. ±0·05
Specific gravity of blood	30	1·054 S.D. ±0·0011 S.E. +0·0002	1·055 S.D. ±0·0010 S.E. ±0·0002	1·057 S.D. ±0·0011 S.E. ±0·0002	1·058 S.D. ±0·0011 S.E. ±0·0002
Specific gravity of plasma	30	1·027 S.D. ±0·0007 S.E. ±0·0001	1·027 S.D, ±0·0007 S.E. ±0·0001	1·029 S.D. ±0·0008 S.E. ±0·0001	1·030 S.D. ±0·0008 S.E. ±0·0001

RESULTS :

Haemoconcentration of R. B. C., Hb and Plasma protein

During graded exercise it has been noted that there is a gradual rise of concentration of haemoglobin, total plasma protein and total count of R.B.C. (Vide Table 1) and percentage of packed cell volume, mean corpuscular haemoglobin,concentration and specific gravity of blood and plasma. (Vide Fig. 1 and Fig. 2). These increments are not proportional with the intensity of the work loads. It

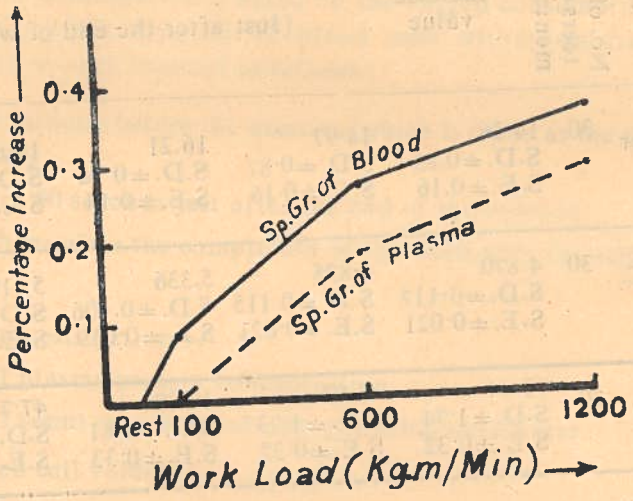


FIGURE 1

Showing average percentage increase of specific gravity of blood & plasma from rest to the definite period of work for 5 minutes (minimal, sub-maximal & maximal).

has been noted that after one hour of cessation of the exercise R.B.C., Hb and protein concentration come back almost to their resting level.

Haemoglobin

The concentration of haemoglobin is increased from 14.86 gm/100 ml of blood (pre-exercise value) to 14.97, 16.21 and 16.62 respectively during minimal, submaximal and maximal exercise (vide Table 1) and at the recovery the values under three different work loads are as follows :

14.81 ± 0.88 (minimal), 14.92 ± 0.85 (submaximal) and
14.99 ± 0.86 (maximal).

R.B.C.

The total count of R.B.C./Cu. mm is increased from 4.870 (preexercise value) to 4.895, 5.336 and 5.418 respectively during graded

exercise (vide Table 1) and at the recovery the values under three different work loads are as follows :

4.856 ± 0.125 (minimal), 4.884 ± 0.129 (submaximal) and 4.905 ± 0.132 (maximal).

Total plasma protein concentration : The total plasma protein concentration is increased from 6.62 gm% to 6.68, 7.38 and 7.74 gm% res-

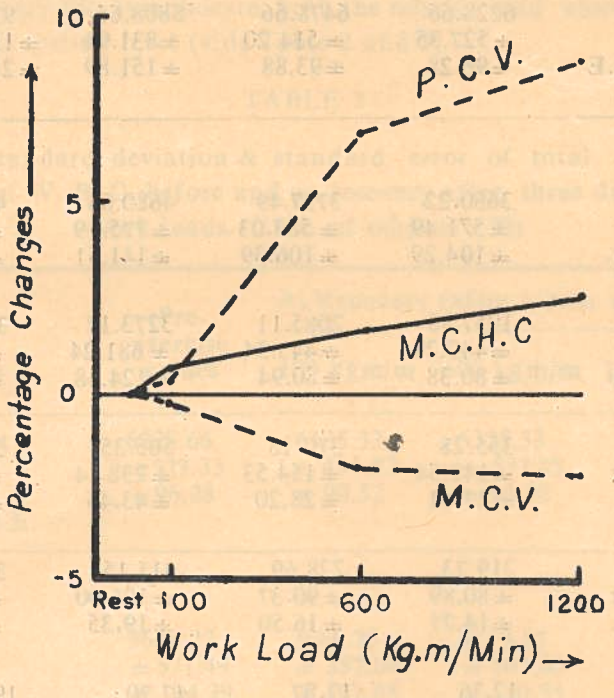


FIGURE 2.

Showing average percentage changes of packed cell volume, mean corpuscular haemoglobin concentration & mean corpuscular volume from rest to the definite period of work for 5 minutes (minimal, sub-maximal & maximal).

pectively during graded exercise (vide Table 1) and at the recovery the values under three different work loads are as follows :

6.617 ± 0.337 (minimal), 6.708 ± 0.275 (submaximal) and 6.736 ± 0.291 (maximal).

Leucocytes : It is also clear (vide Fig. 3) that there is a gradual rise of white blood corpuscle from the rest values to the minimal work and then to submaximal work and finally to maximal work which is the highest. Total count of W.B.C. increases with the rise in the intensity of the exercise. The rise in the percentage of lymphocyte is the highest among all the leucocytes. It has been also observed that

TABLE 2

Average standard deviation & standard error & absolute count of W.B.C. before and during three different work loads.
(No. of subjets : 30)

Name of the parameters	Pre-exercise values	Just after the end of work		
		100 kgm/m	600 kgm/m	1200kgm/m
Total count of W.B.C per cubic mm. S.D., S.E	6228.66 ±527.35 ±96.28	6478.66 ±514.20 ±93.88	8808.66 ±831.94 ±151.89	9705.33 ±1158.34 ±211.48
Absolute Count :				
(a) Neutrophil per cubic mm. S.D.,S.E.	3680.22 ±571.49 ±104.29	3777.49 ±583.03 ±106.39	4680.66 ±775.49 ±141.51	4975.76 ±805.54 ±147.00
(b) Lymphocyte per cubic mm. S.D.,S.E	1957.88 ±440.28 ±80.38	2085.11 ±443.34 ±80.94	3273.12 ±681.24 ±124.38	3811.05 ±760.00 ±138.76
(c) Eosinophil per cubic mm. S.D.,S.E.	355.28 ±148.54 ±27.11	370.18 ±154.53 ±28.20	505.35 ±238.14 ±43.46	553.12 ±260.04 ±47.45
(d) Monocyte per cubic mm. S.D.,S.E.	219.73 ±80.89 ±14.77	228.69 ±90.37 ±16.50	311.15 ±106.00 ±19.35	345.68 ±129.27 ±23.60
(e) Basophil per cubic mm. S.D.,S.E.	12.36 ±23.58 ±14.77	12.87 ±24.47 ±4.47	17.70 ±34.11 ±6.23	19.70 ±38.54 ±7.04

at the recovery there is a neutrophilia and to a lesser extent eosinopenia and lymphopenia (Fig. 4).

Neutrophil: The average pre-exercise values of both the relative and absolute counts of neutrophil are 59.10±7.67 and 3680·22 ± 571.49 respectively. During exercise the relative count decreases, but the absolute count does not decrease as the total count of W.B C. increases. At the recovery the absolute count of neutrophil is increased for the increase of relative count (vide Table 2 & 3).

Lymphocyte: The average pre-exercise values of both the relative and absolute count of lymphocyte are 31.53 ± 6.62 and 1957.88±440.28

respectively. During exercise both the relative count and absolute count increase. But at the recovery both the relative and absolute counts go below the resting value (Table 2 & 3).

Eosinophil: The average pre-exercise values of both the relative and absolute counts of eosinophil are 5.67 ± 2.24 and 355.28 ± 148.54 respectively. The relative count during exercise almost does not change but the absolute count increases as the total count of W.B.C. increases. At the recovery like lymphocyte, both the relative and absolute counts go below the resting level (vide Table 2 and 3).

TABLE 3

Average, standard deviation & standard error of total & absolute count of W. B. C. before and at recovery after three different work loads. (No. of subjects : 30)

Name of the Parameters	Pre-exercise values	At Recovery (after 1 hour work done)		
		100 kgm/m	600 kgm/m	1200 kgm/m
Total count of W. B. C. per cubic mm. S.D.,S.E.	6228.66 ± 527.35 ± 96.28	6185.33 ± 495.82 ± 90.52	6325.33 ± 537.85 ± 98.20	6396.66 ± 550.35 ± 100.48
Absolute Count :				
a) Neutrophil per cubic mm. S.D.,S.E.	3680.22 ± 571.49 ± 104.29	3666.75 ± 557.04 ± 101.65	4119.87 ± 605.80 ± 110.55	4327.68 ± 611.65 ± 111.61
b) Lymphocyte per cubic mm. S.D.,S.E.	1957.8 ± 440.28 ± 80.38	1937.73 ± 432.16 ± 78.90	1710.44 ± 424.22 ± 77.45	1615.30 ± 418.33 ± 76.38
c) Eosinophil per cubic mm. S.D.,S.E.	355.28 ± 148.54 ± 27.11	353.51 ± 154.34 ± 28.16	270.92 ± 136.11 ± 24.84	222.96 ± 109.04 ± 19.90
d) Monocyte per cubic mm. S.D.,S.E.	219.73 ± 80.89 ± 14.77	222.09 ± 78.11 ± 14.26	217.67 ± 79.22 ± 14.46	203.55 ± 73.04 ± 13.34
e) Basophil per cubic mm. S.D.,S.E.	12.36 ± 23.58 ± 14.77	12.35 ± 23.65 ± 4.32	12.61 ± 24.06 ± 4.39	12.83 ± 24.54 ± 4.48

Monocyte : The average pre-exercise values of both the relative and absolute counts of monocyte are 3.50 ± 1.21 and 219.73 ± 80.89. The relative count of monocyte during exercise does not change so much. With the increase of total count of W.B.C. the absolute count increases during exercise (vide Table 2 & 3).

DISCUSSION

The resting equilibria of the subjects change due to different work loads put on them. Haemoconcentration and leucocytosis happen during graded exercise. The rate of change from rest to submaximal work (600 kgm/min) is more than later stages of work, i.e. from sub-maximal (600 kgm/min) to maximal (1200 kgm/min). It is as if

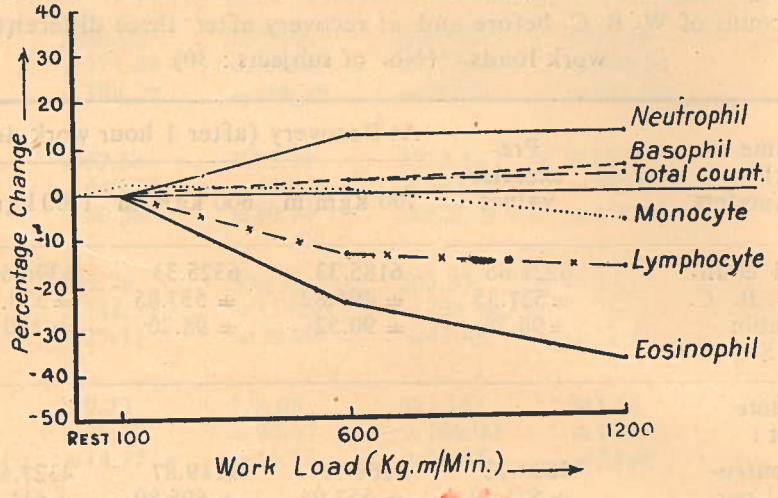


FIGURE 3

Fig-3 The average percentage increase of different white blood corpuscles from rest to the definite period of work for 5 minutes (minimal, sub-maximal & maximal.)

there is a maximal limit of change possible which is gradually attained with maximal work. With submaximal work major portion of the limit of change is happening leaving only a small remainder which is attained with maximal work.

Haemoconcentration

David (1961) has stated that various mechanisms are considered to be responsible for shifts in haematocrits values. Haemoconcentration produced by epinephrine has been attributed to splenic contraction (Barker, 1960), that in exercise to loss of water into the active muscle (De Lanne, 1960) and that in hypothermic condition to loculation of

plasma rich blood in parts of the vascular bed (Williams, 1960). In the present investigations the percentage change of Hb, total plasma protein concentration, specific gravity of blood and plasma are different. So it is thought that the haemoconcentration during short period of

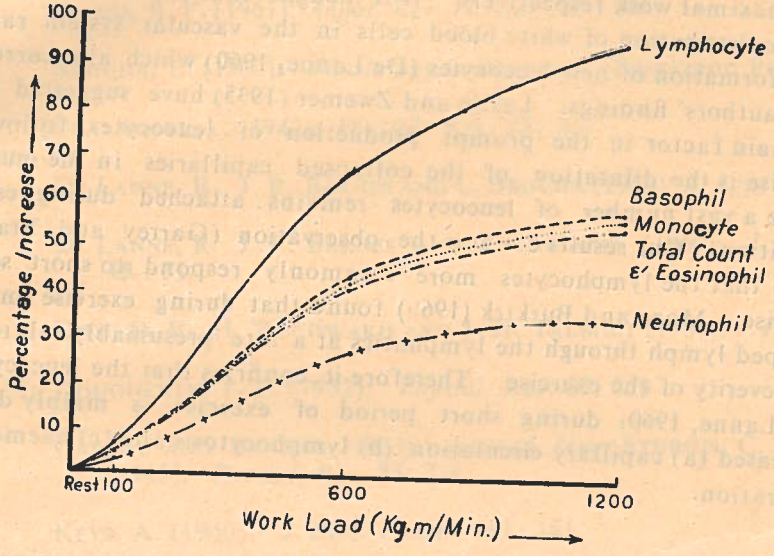


FIGURE 4 3

Fig 4 Neutrophilia & to a lesser extent eosinopenia & lymphopenia at recovery, after one hour stoppage of exercise of three different work loads.

exercise may not be transference of the water only from the vascular bed. It is noted from the Fig. 3 that the increase of lymphocyte is maximum, and the flow of lymph is increased during exercise (Sturgis, 1943). One of the really important functions of the lymph is to remove excess protein and return it to the blood stream. The result of this action is to increase plasma proteins (Wasserman and Mayerson, 1951).

The increase of specific gravity of plasma, total plasma protein concentration and the decrease of mean corpuscular volume indicate that the haemoconcentration is primarily due to transport of water.

One hour after the stoppage of the exercise, it is noted that the total count of R.B.C., Hb and plasma protein concentration come back almost to the resting level. As the erythropoitic centre is not being stimulated during the short period of exercise (De Lanne, 1960) it is possible that haemoconcentration is primarily due to loss of water into the muscle cells, and then by addition of lymph protein and R B.C. from the reserved source and ultimately stagnancy of water in the inactive area such as splanchnic bed.

Leucocytosis

In all experiments there is a rise of total count of leucocytes after 5 minutes of exercise from the rest values to the minimal, submaximal and maximal work respectively. It is thought that the increase is due to a redistribution of white blood cells in the vascular system rather than formation of new leucocytes (De Lanne, 1960) which also corroborates authors' findings. Laslie and Zwemer (1935) have suggested that the main factor in the prompt production of leucocytes following exercise is the dilatation of the collapsed capillaries in the muscles where a vast number of leucocytes remains attached during resting condition. Our results confirm the observation (Garrey and Bragan, 1935) that the lymphocytes more commonly respond to short severe exercise. Moor and Burkirk (196') found that during exercise muscle pumped lymph through the lymphatics at a rate presumably related to the severity of the exercise. Therefore it confirms that the leucocytosis (De Lanne, 1960) during short period of exercise is mainly due to increased (a) capillary circulation, (b) lymphocytosis and (c) haemoconcentration.

At the recovery, the neutrophilia and to a lesser extent eosinopenia and lymphopenia may be explained as due to the stress of the physical exercise which helps in the liberation of epinephrine (Aado Vendsalu 1960).The epinephrine (Wrights, 1961) causes the eosinopenia and it is also suggested that it stimulates the secretion of ACTH which can cause elymphocytolysis (Dougherty, 1952) resulting in neutrophilia, eosinopenia and lymphopenia.

It is evident that the physical exercise in different intensities not only brings the changes in heart rate, O_2 consumption and lactic acid conc. of blood, but also in different constituents of blood including corpuscles. This investigation shows also that changes in constituents in blood are not related to transfer of water only from blood to the muscle, and the increase of haemoconcentration is more during submaximal work from rest than of that during maximal work from submaximal. In order to explain how far these differential changes are related with endocrine factors, the study on endocrine relation along with present study may be worked out. How far these changes are to be related with the people of different regions of India may be studied more thoroughly. The shift in the dynamic equilibrium or homeostasis due to different grades of work will give more intimate knowledge about the men at work.

REFERENCES

AADO VENDSALU (1960): *Acta Physiol. Scand.* **49**, Suppl. 173,

BARKER, C. H. AND J. N. REMINGTON (1960): *Am. J. Physiol,* **198** : 906.

DAVID, B. F. (1961): *Annal. Rev. Physiol.* **23** : 296.

BROUHA, L. (1960): *Physiology in Industry.* Pergamon Press. p. 4.

CHALAMERS, L. (1942): *Physiol. Rev.* **22** : 33.

DE LANNE, R., J. R. BARNES AND L. BROUHA (1958): *J. App. Physiol.* **13**: 97.

DE LANNE, R., J. R. BARNES AND L. BROUHA (1960): *J. App. Physiol.* **15** : 31.

DILL, D. B., H. T. EDWARD AND J. H. TALBOLT (1930): *J. Physiol.* **69**: 267

DOUGHERTY, T. F. (1952): *Physiol. Rev.* **32**: 379

GARREY AND BRAGAN (1933): *Quoted from* STURGIS, C. AND F. BETHEL (1943). *Physiol. Rev.* **23**: 279.

KEYS, A. (1940): *J. Biol. Chem.* **132** : 181.

LASLIE and ZWEMER (1935) : *Quoted from* STURGIS,C.and F. BETHEL (1943). *Physiol. Rev.* **23** : 279

MOORE and BUSKIRK (1960): *Quoted from* JOHNSON et al (1961). *J. App. Physiol.* **16(5)** : 807.

PHILLIPS, R. A., D. D. VANSLKYE, P. B. HAMILTON, V. P. DOLE, EMERSON, KENDAL JR and ARCHIBALD, R M: (1950): *J. Biol. Chem.* **183** : 305.

WRIGHT, SAMSON (1961): *Applied Physiology.* 10th ed. p. 482.

STURGIS, C and F. BETHEL (1943): *Physiol. Rev.* **23** : 279.

WASSERMAN, K. and H. S. MAYERSON (1951): *Am. J. Physiol* **165** : 15.

WILLIAMS, F. L. and S. RODBARD (1960): *Am. J. Physiol.* **198** : 169.

ZUNIZ et al (1895): *Quoted from* DILL, D. B. et al (1930): *J. Physiol.* **69** : 267.

DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA
92, A. P. C. ROAD
CALCUTTA-9

Reprint from Ind. Jour. Physiol and Allied Sc. 1967,
Vol. XXI No. 3, from Page 96—100

POSSIBLE RELATIONSHIP BETWEEN THE AMPLITUDE OF THE 'T' WAVE IN ECG AND THE LACTIC ACID CONC. IN BLOOD OF GRADED WORK

PRATIMA CHATTERJEE & S. R. MAITRA

(*Department of Physiology, University College of Science, Calcutta-9*)

During exercise, transient alterations in the electrocardiographic contour may be caused by changes in blood chemistry. Chief among these chemical changes, affecting the electrocardiogram are acidosis, alkalosis, hypoglycemia, variations in sodium, potassium and calcium and changes of some of the hormone levels of the blood. Acidosis is apt to increase the height of the 'T' wave (1)

With the application of the graded quantitative physical work load, there are increased voltage activities of different components of the electrocardiogram (2) and also increase amount of lactic acid concentration in blood (3).

Gartler, Hoff and Human (4) found on dog's heart after acidification of the blood with either lactic acid or h drocholoride T and R amplitudes progressively increased.

The object of this study is therefore to find out any possible relationship between the amplitude of 'T' wave in ECG and the lactic acid concentration in blood under different grades of work load.

METHODS AND MATERIALS

The experiments have been performed on ten male students under the age group ranging from 20-30 year at room temperature of 30 to 32°C. The work load given to the subjects with fixed time for 5 minutes was divided into three intensities, such as (i) 300 Kgm/min, (ii) 600 Kgm/min and (iii) 900 Kgm/min.

The exercise was performed by magnetic friction type of bicycle ergometer.

Before the start of the exercise, subjects were allowed to take some rest. Two electrodes were placed over manubrium and xiphoid proces for recording ECG (5). Blood was drawn at the following intervals :

(i) 5 to 10 minutes before the exercise.

(ii) Within 2 to 3 minutes just after the end of the exrcise.

EGG for 'T' wave was also recorded by M-X lead (5) of the above mentioned time period. The lactic acid was determined by the method of Barker and Summerson (6) modifed by Strom (7).

Animal preparation and recording :

For experimental verification, one male rabbit of 1 Kg. body weight was used, taking rabbit as a biologically equivalent animal with man as regards internal physiological meachanism are concerned.

Before taking records two small elctrodes were placed on manubrium and xiphoid process respectively. Hair was clipped off from these areas previously. The animal was placed in a closed wooden box with the head and mouth kept free. Before the injection of lactic acid normal EGG record was taken. The lactic acid in different concentration e.g. 2 mg., 4 mg., 6 mg., 8 mg. and lastly 100 mg/Kg body weight was injected intravenously through the marginal ear vein and records were taken for each dose given.

RESULTS

Table 1 shows the average amplitude (mv) of 'T' wave and lactic acid concentration (mg/100 ml) just after 2 minutes at the end of three different work loads.

TABLE 1

	Before work	300 Kgm/min		600 Kgm/min		900 Kgm/min	
			% increase		% increase		% increase
Amplitude of 'T' (mv)	0.44	0.60	(37.3)	0.74	(66.6)	0.96	(118.8)
±	±	±		±		±	
±S. D.	0.075	0.091		0.127		0.127	
Lactic acid (mg/100 cc)	12.7	21.09	(65.7)	45.06	(271.2)	84.81	(587.0)
±	±	±		±		±	
±S. D.	2.3	4.8		3.0		10.0	

N.B.—Figures in parenthesis indicate percentage change from control.

The average resting values of 'T' wave and lactic acid conc. are within the normal range i.e. 0.44 mv and 12.7 mg% respectively (vide Table 1).

In Fig. 1, maximum amplitude of 'T' wave has been shown at the 2nd minute of recovery period and it was also observed that this amplitude is greater than that of during work period.

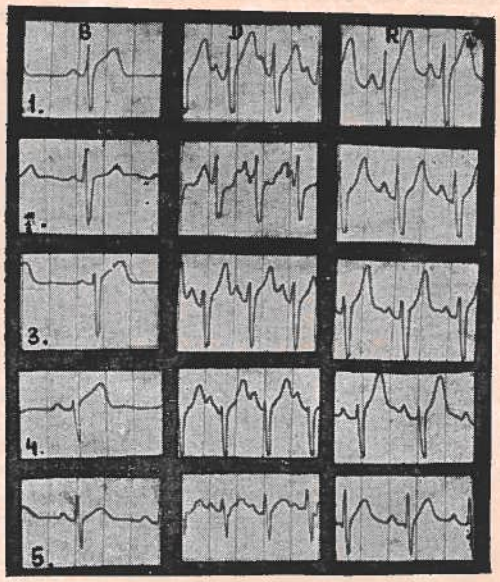


Fig. 1 Maximum amplitude of 'T' wave at 2nd minute of recovery (R) on five normal subjects (1, 2, 3, 4, 5). B before work. D during 5 minutes of work.

In Fig. 2, the effect of lactic acid (in different doses) injection upon the ani-animal's body has been shown. A gradual increase of the amplitude of the 'T' wave was noted when lactic acid in concentrations 2 mg., 4 mg., 6 mg., and 8 mg. per Kg. body weight respectively, had been injected. But following injection of a large dose of lactic acid (100 mg kg), irregularities in the ECG tracings were noted.

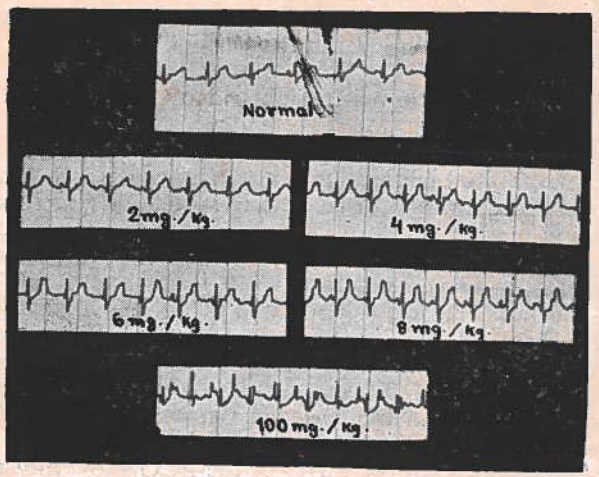


Fig. 2 The gradual increased amplitude of 'T' wave of rabbit's heart after the injection of lactic acid in different doses.

In Fig. 3, a relation between the percentage increase of lactic acid in blood and the percentage increase in the amplitude of 'T' wave evidently noted just after 2 minutes of three grades of work loads.

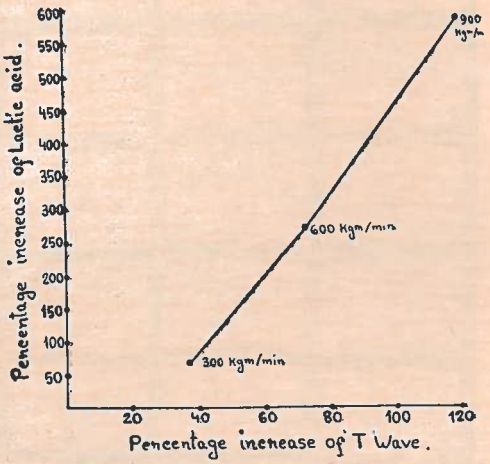


Fig. 3 Showing relationship between percentage increase of blood lactic acid and the percentage increase of 'T' wave of the 2nd minute of recovery.

DISCUSSION

It was observed in this study that after 2 minutes of graded exercise, the amplitude of 'T' wave rises simultaneously with the increase of lactic acid conc. in blood.

Normally, when lactic acid is poured out from the muscles, the acidity of blood is prevented from rising too high by virtue of the bicarbonate it contains according to the following reaction (8) :

Sodium bicarbonate + lactic acid $\rightleftarrows$ Sodium lactate + carbonic acid

But during exercise, there is enough lactic acid production in blood and this may not be neutralized by the sufficient amount of bicarbonate (8) as a result of which, this enhanced amount of lactic acid is suggested to increase the acidity of blood. During recovery from exercise, some of the lactic acid disappearing from the blood is used directly as fuel by most of the body tissues (9). In the case of heart muscle in heart lung preparation, it has been found that the venous blood leaving the heart muscle is poorer in lactic acid than the arterial blood entering it. The heart muscle does not use its accumulation mechanism at all readily so that its glycogen stores are not depleted during activity and the lactic acid which it absorbs from the blood stream must be burnt directly by the muscle (9). Thus, lactic acid has an influence on the heart muscle. Moreover, lactic acid concentration in blood reaches maximum level within 2 to 6 minutes after the end of the work (10). All the waves of the ECG show the maximum amplitude during work period and after the end of work those decline gradually with the recovery period. But'T' wave attains maximum amplitude not during work

period rather just after 2 to 3 minutes of the recovery period. This suggests that there may be a possible relationship between the amplitude of 'T' wave and the lactic acid conc. in blood.

The animal experiment verify the possible relationship between these two.

Summary and Conclusion

Studies were carried on 10 normal healthy male subjects before and just after the end of three different work loads; e.g. 300 Kgm/min., 600 Kgm/min. and 900 Kgm/min. It was observed that after 2 minutes of graded exercise, the amplitude of 'T' wave rises simultaneously with the increase of lactic acid conc. in blood. For verification, animal experiment was also carried by injecting lactic acid in different doses (2 mg., 4 mg., 6 mg., and 8 mg. per Kg. body weight); whereas, with a dose of 100 mg Kg body weight, irregular records were obtained.

If it does not appear premature, it may be concluded that there may be a possible relationship between the lactic acid conc. in blood and the amplitude of 'T' wave in ECG.

Acknowledgement

The authors offer their sincere thanks to Dr. P. K. Dey, M.Sc., D. Phil. and Dr. Chandidas Dey, for their kind co-operation in this study.

References

1) Katz, L. N. (1949), *Electrocardiolography*, Lea & Febiger, Philadelphia, p. 215.
2) Maitra, S. R. and P. Sen Gupta (1962), *Ind. Jour. Physiol. And Allied Sci.*, **16** : 144.
3) Maitra, S. R. and P. SenGupta (1964), *Ind. Physiol. And Allied Sci.*, **18**, 73.
4) Gartler, M. M., H. E. Hoff and D. G. Humm (1946), *Am. J. Physiol.*, **146** : 478.
5) Gedds, L. A., M. Parttidge and H. E. Hoff (1960), *J. Appl. Physiol.* **15** : 311.
6) Barker, S. B. and W. H. Summerson (1941), *J. Biol. Chem.*, **138** : 535.
7) Strom, G. (1949), *Acta Physiol. Scand.*, **17** : 440.
8) Eggleton, M. G. (1936), *Muscular Exercise*, Kegan Paul, Trench, Rrubner & Co. Ltd., London, p. 104.
9) Eggleton, M. B. (1936), *Muscular Exercise*, Kegan Paul, Trench, Trubner & Co. Ltd., London, p. 152.
10) Karpovich, P. V. (1959), *Physiology of Muscular Activity*, 5th ed. W. B. Saunders Comp. Philadelphia, p. 161.

DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA
92, A. P. C. ROAD
CALCUTTA-9

[Reprinted from *Ind. Jour. Physiol. and Allied Sci.*, Vol. XVI, No. 4, October, 1962]

STUDIES OF ELECTROCARDIOGRAPHIC CHANGES DURING DIFFERENT GRADES OF WORK

S. R. Maitra and Pratima Sengupta*

(Department of Physiology, University College of Science, Calcutta)

The electrocardiographic method of studying the cardiac function is of importance to find out the distinction between physiological response of the body during work and rest.

The functional arrangement in heart is expected to correlate with the amount of blood pumped out. By changing its rate and amplitude it can supply the increased amount of blood needed. Increase in amplitude is expected to be due to increase in strength of stimulus to heart and increase in rate may vary the time sequence in the electrocardiographic record. The garded work requires graded increase in blood supply to working muscle which must be done by corresponding increase in working of the heart both in amplitude and rate. How this response in heart due to graded work can be made out from electrocardiographic record is the object of this paper.

Studies on the electrocardiographic changes during exercise have long been undertaken by a number of workers in order to find a correlation of the electrocardiographic changes of the heart subjected to varying degrees of stress and strain, as it is evident that electrocardiograph at rest often fails to give any decisive and objective proofs.

Material and Methods

Subjects were young healthy male students, some were collected from our Physiology Department and others were taken from outside the science college. They were divided into two groups according to their age:

Group A—contains 10 subjects, age ranging between 20 to 30 (except one, who is 45).

Group B—contains 8 subjects, age ranging between 10 to 20.

Subjects were allowed to do different grades of work for a definite period of time. The first work load was usually 300 kgm./minute and then it was increased by 600 and 900 kgm./minute. Work under each load was performed for 5 minutes and electrocardiographic changes were recorded every time. Here, the physical work was the pedalling a bicycle ergometer. The use of the bicycle

---

* Research Assistant, Department of Physiology, University of Calcutta.

ergometer has many advantages. Physically, it allows the objective determination of the size of the load and physiologically enables studies of different circulatory parameters during work including EKG training.

Before the start of work subjects were allowed to take some rest in a recumbent position for about 20 to 30 minutes. Then two electrodes were taped over the manubrium and xiphoid process. The lead, here used, was called M-X lead (1). The standard lead and even the chest leads encompass large muscle masses and contraction of these muscles during work produce electromyographic potentials which cause large artifacts in the EKG. Because of this fundamental difficulty the M-x lead was used which would permit recording the EKG while large muscle masses were contracting.

Before work started subjects were allowed to get on the cycle and electrocardiographic changes were recorded before work, during work and after work.

Results

Subjects, ages, heights and weights are given in the table 1.

Table 1

Subjects	Age (yrs.)	Height (cms.)	Weight (kg.)
Group A:			
1	23	170·2	47·7
2	21	180·34	63·6
3	23	170·2	48·6
4	30	167·6	51·3
5	45	165·1	51·8
6	20	180·34	52·7
7	22	167·6	43·6
8	24	167·6	55·4
9	26	162·6	55·9
10	30	167·6	52·7
Group B:			
1	17	175·3	53·1
2	17	162·6	49·0
3	18	170·2	53·6
4	18	162·6	46·3
5	17	167·6	53·1
6	13	160·02	43·6
7	14	160·02	41·3
8	17	165·1	47·2

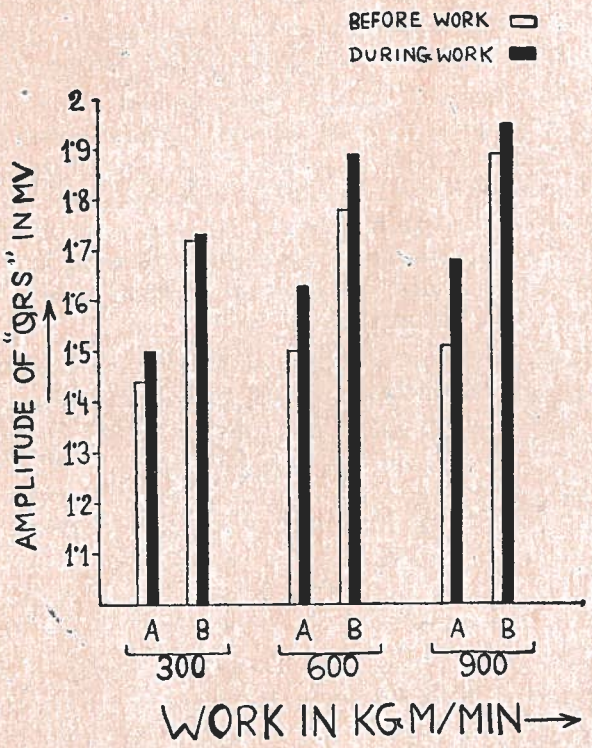

BEFORE WORK
DURING WORK
AMPLITUDE OF "QRS" IN MV
2
1·9
1·8
1·7
1·6
1·5
1·4
1·3
1·2
1·1
A B
A B
A B
300
600
900
WORK IN KGM/MIN

FIG. 1.

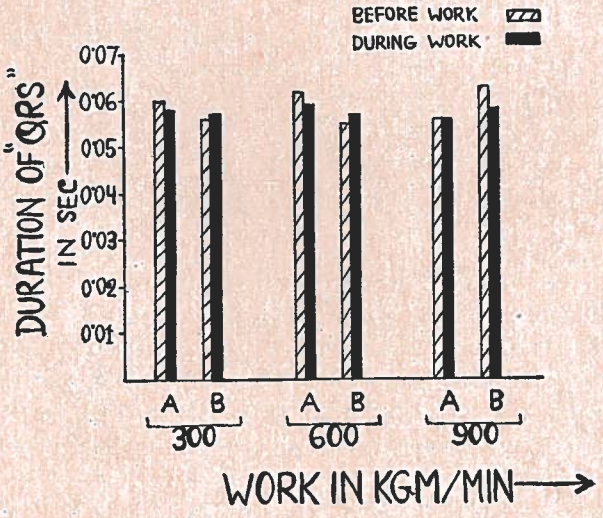

BEFORE WORK
DURING WORK
DURATION OF "QRS" IN SEC
0·07
0·06
0·05
0·04
0·03
0·02
0·01
A B
A B
A B
300
600
900
WORK IN KGM/MIN

FIG. 2.

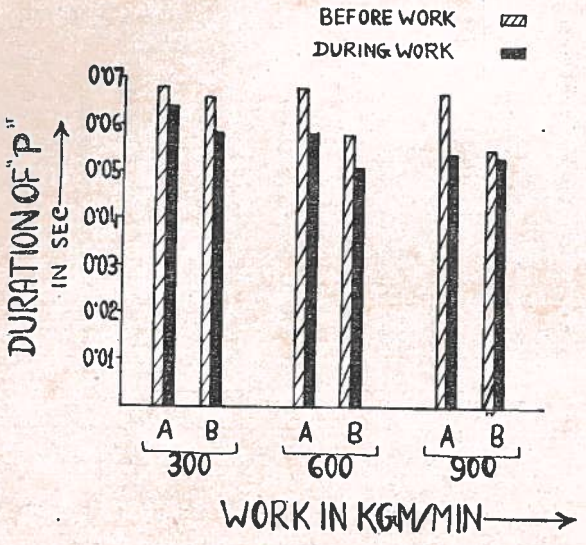

BEFORE WORK
DURING WORK
DURATION OF "P" IN SEC
0·07
0·06
0·05
0·04
0·03
0·02
0·01
A B
300
A B
600
A B
900
WORK IN KGM/MIN

FIG. 3.

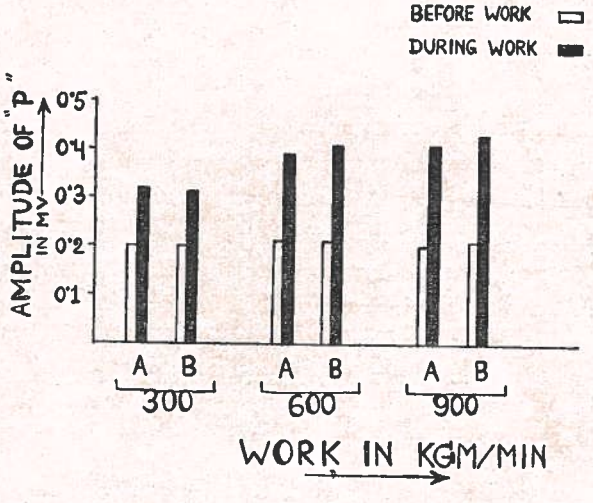

BEFORE WORK
DURING WORK
AMPLITUDE OF "P" IN MV
0·5
0·4
0·3
0·2
0·1
A B
300
A B
600
A B
900
WORK IN KGM/MIN

FIG. 4.

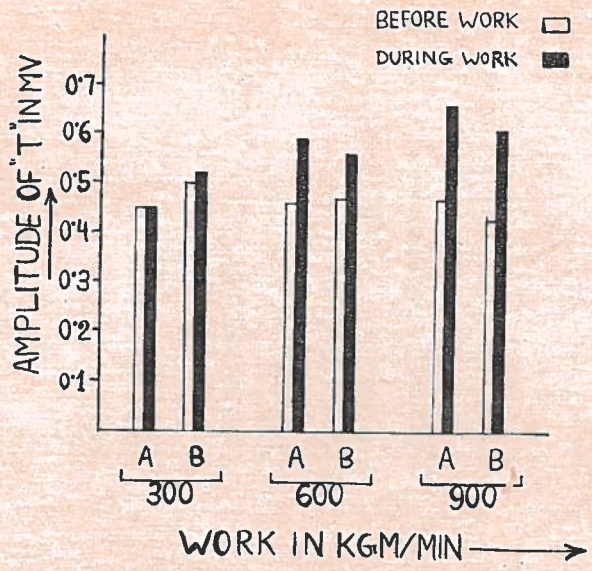

BEFORE WORK
DURING WORK
AMPLITUDE OF "T" IN MV
0·7
0·6
0·5
0·4
0·3
0·2
0·1
A B
A B
A B
300
600
900
WORK IN KGM/MIN

FIG. 5.

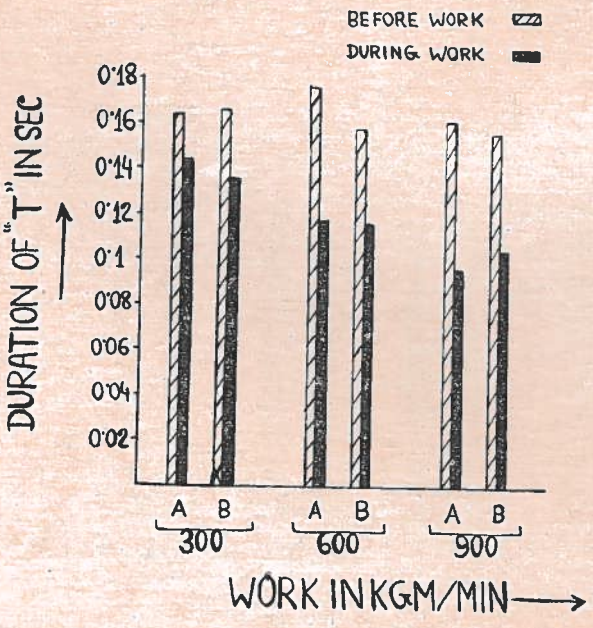

BEFORE WORK
DURING WORK
DURATION OF "T" IN SEC
0·18
0·16
0·14
0·12
0·1
0·08
0·06
0·04
0·02
A B
A B
A B
300
600
900
WORK IN KGM/MIN

FIG. 6.

TABLE 2

Mean amplitude (mV) of 'P', 'QRS' and 'T' waves in subjects on different grades of work.

		300 kgm./min.		600 kgm./min.		900 kgm./min.	
		Before work	During work	Before work	During work	Before work	During work
Amplitude of 'P' wave in mV.							
Group A	...	0·20	0·32	0·21	0·39	0·20	0·41
Group B	...	0·20	0·31	0·21	0·41	0·21	0·43
Amplitude of 'QRS' complex in mV.							
Group A	...	1·44	1·50	1·50	1·63	1·51	1·68
Group B	...	1·72	1·73	1·78	1·89	1·89	1·95
Amplitude of 'T' wave in mv.							
Group A	...	0·45	0·45	0·46	0·59	0·47	0·66
Group B	...	0·50	0·52	0·47	0·56	0·43	0·61

TABLE 3

Mean duration (sec.) of 'P', 'QRS' and 'T' waves in subjects on different grades of work.

		300 kgm./min.		600 kgm./min.		900 kgm./min.	
		Before work	During work	Before work	During work	Before work	During work
Duration of 'P' wave.							
Group A	...	0·068	0·064	0·068	0·058	0·067	0·054
Group B	...	0·066	0·058	0·058	0·051	0·055	0·053
Duration of 'QRS' complex.							
Group A	...	0·06	0·058	0·062	0·059	0·056	0·056
Group B	...	0·056	0·057	0·055	0·057	0·063	0·058
Duration of 'T' wave.							
Group A	...	0·164	0·144	0·176	0·117	0·161	0·096
Group B	...	0·166	0·135	0·158	0·116	0·156	0·105

DISCUSSION

The first author to publish EKG changes in the S-T and T interval in connection with physical work, seems to be the pioneer in electrocardiography, Einthoven (1908) (2). He described the increase in the height of the P and T waves and a depression of the P-R segment and a negative T in lead III which became positive.

In 1956 Klepzig, Muller and Reindell (3) published an investigation with EKG recording during work done on a bicycle ergometer and where the standard leads were registered. In their opinion, the method was too complicated in comparison with EKG recording only after exercise. Simonson and Keys (1956) (4) discussed Master's normal controls, and concluded that deviations in S-T depression upto 1 mm. represented random variations in a normal population and could not be considered abnormal. These investigations deal mainly with the value of Master's two step test compared with that of a treadmill in the diagnosis of coronary diseases.

In a modified Master's two-step test with ECG recording also during work, Yu and Soffer (1952) (5) emphasised among other facts, the value of the Q-T/T-Q quotient as a sign of the myocardial function during work.

It is suggested from the results that there is an increased amplitude (in mV) (Fig. 1, 4, 5)and also diminished duration (in sec.) (Fig. 2, 3, 6) of 'P', 'QRS' and 'T' waves with different grades of work. As the work lead is increased there is also gradual increase in voltage activity of heart with increasing heart rate. Therefore, there is definite relation with changes in the electrical activity of the heart with the different grades of work and there is also a definite qualitative change on the ECG of heart both in auricle and in ventricle due to the different types of work load given.

During recovery period the reversion of electrical activity of 'P', 'QRS' and 'T' to normal phase depends upon the degree of work load applied. At 300 kgm./min. the reversion of electrical activity of 'P', 'QRS', 'T' to normal state requires 20-30 minutes, but at a comparatively high load of work the reversion requires much longer time than lower grade of work. Whether they are related reflexly from the working muscle or it is due to the higher 0_2 consumption arrangement of the heart muscles is not clear.

In comparison between Group A to Group B (Fig. 1) it is found that in Group B there is comparatively higher voltage developed in heart during different grades of work than Group A. It may be that due to the growing period of life the voltage activity of heart increases.

During cycling the upper part of the body is not making any appreciable change in its posture and the ECG recordings are made on the subjects on the sitting posture on the cycle during rest, work and recovery. The electrical axis of the heart changes in different postures of the body. But as there is no appreciable variation in posture and moreover the results of the EKG records show similar pattern with each grade of work with Bicycle ergometer, the question of axis variation has not been taken into consideration.

SUMMARY

1. A new method of studying the cardiac and other physiological response during exercise has been described.

2. It utilises the effect of a definite amount of work load on electrocardiograph and by this method the exertion has been limited to a definite amount and it has been standardized to the subject's age, sex, height and weight.

ACKNOWLEDGEMENT

The authors express their sincere thanks to Dr. P. K. Dey, Dr. B. N. Koley and Dr. A. K. Maiti for taking interest in this investigation.

REFERENCES

1. Gedds, L. A., Parttidge, M. and Hoff, H. E. ((1960). *J. App. Physiol.*, **15**, 311.
2. Einthoven, W., Weiteres über das Electrokardiogram, (1908). *Arch. f. d. ges. Physiol.*, **122**, 517. (Quoted from 'Studies on Electrocardiographic Changes during Exercise Tests' by Lars Sandberg).
3. Klepzig, H., Muller, D. and Reindell, H. (1956). *Ztschr f. Kreislaufforsch.*, **45**, 741. (Quoted from 'Studies on Electrocardiographic Changes during Exercise Tests' by Lars Sandberg).
4. Simonson, E. and Keys, A. (1956). *Am. Heart J.*, **52**, 83. (Quoted from 'Studies on Electrocardiographic Changes during Exercise Tests' by Lars Sandberg).
5. Yu, P. N. G. and Soffer, A. (1952). *Circulation*, **6**, 183. (Quoted from 'Studies on Electrocardiographic Changes during Exercise Tests' by Lars Sandberg).

TABLE : 1

Average, Standard deviation & Standard error of rest phase (pre-exercise) values(The experiments have been performed under the age,height & weight groups between 16 to 30 years,between 151.25 Cm.to 180.12 Cm.& between 52.22 Kg.to 81.36 Kg.respectively).

Name of the parameters	No. of volunteers experimented upon	Average	Standard deviation	Standard error
1. Heart rate (per min.)	20	77.40	± 6.54	± 1.46
2. Blood pressure (mm.Hg)	10	115.0/74.2	± 3.43/4.26	± 1.08/1.34
3. Ventilation (per min.)	20	6.66	± 0.49	± 0.11
4. O_2 Consumption (litres)	20	0.262	± 0.018	± 0.004
5. O_2 Pulse (ml) per min.	20	3.38	± 0.19	± 0.04
6. Lactic acid(mg.per 100 c.c. of blood)	20	10.18	± 1.96	± 0.44
7. Haemoglobin(gm.per 100 c.c. of blood)	30	14.86	± 0.85	± 0.16
8. Total count of R.B.C.per Cu.mm	30	4.870	± 0.117	± 0.021
9. Packed cell volume	30	43.84	± 1.74	± 0.32
10. Mean corpuscular volume(Cubicu)	30	89.98	± 1.780	± 0.325
11. Mean corpuscular haemoglobin conc.	30	33.893	± 0.921	± 0.168
12. Total plasma protein conc. (microkjeldal)(gm.%)	30	6.629	± 0.320	± 0.058
13. E.S.R.(mm) per hour	16	6.99	± 2.75	± 0.69
14. Specific gravity of blood	30	1.054	± 0.0011	± 0.0002
15. Specific gravity of plasma	30	1.027	± 0.00079	± 0.00014
16. Total count of W.B.C.per Cu.mm.	30	6228.66	± 527.35	± 96.28
17. Absolute count(per Cu.mm) of:	30			
a) Neutrophil	"	3680.22	± 571.49	± 104.29
b) Lymphocyte	"	1957.88	± 440.28	± 27.11
c) Eosinophil	"	355.28	± 148.54	± 27.11
d) Monocyte	"	219.73	± 80.89	± 14.77
e) Basophil	"	12.36	± 23.58	± 4.31
18. Relative count: percentage of:	30			
a) Neutrophil	"	59.10	± 7.67	± 1.40
b) Lymphocyte	"	31.53	± 6.62	± 1.20
c) Eosinophil	"	5.67	± 2.24	± 0.40
d) Monocyte	"	3.50	± 1.21	± 0.22
e) Basophil	"	0.20	± 0.37	± 0.06
19. Sodium (mEq) /L	20	142.10	± 2.08	± 0.46
20. Potassium (mEq) /L	20	4.18	± 0.15	± 0.034
21. Calcium (mEq) /L	20	4.95	± 0.066	± 0.015

DEPARTMENT OF PHYSIOLOGY
UNIVERSITY OF CALCUTTA
92, A. P. C. ROAD
CALCUTTA 9

TABLE : 2

Average, Standard deviation & Standard error of heart rate, blood pressure, ventilation, O_2 consumption, O_2 pulse & lactic acid under resting condition & three different work loads.

Name of the Parameters	Pre-exercise values	WORK LOAD IN KGM/MIN		
		100	600	1200
Heart Rate (per min.)	77.40 S.D.±6.54 S.E.±1.46	94.70 S.D.±7.32 S.E.±1.63	152.60 S.D.±5.44 S.E.±1.21	192.80 S.D.±7.05 S.E.±1.57
Blood Pressure (mm.Hg.)	115.0/74.2 S.D.±3.43/4.26 S.E.±1.08/1.34	120.6/78.5 S.D.±3.13/4.64 S.E.±0.99/1.47	151.9/88.6 S.D.±7.63/2.67 S.E.±2.41/0.84	180.0/90.2 S.D.±5.41/2.39 S.E.±1.71/0.75
Ventilation (per min.)	6.66 S.D.±0.49 S.E.±0.11	16.28 S.D.±1.29 S.E.±0.29	36.78 S.D.±2.79 S.E.±0.62	58.34 S.D.±6.06 S.E.±1.35
O_2 Consumption/min. (litres)	0.262 S.D.±0.018 S.E.±0.004	0.574 S.D.±0.035 S.E.±0.008	1.451 S.D.±0.033 S.E.±0.007	2.136 S.D.±0.157 S.E.±0.035
O_2 Pulse (ml) per min.	3.384 S.D.±0.197 S.E.±0.044	6.054 S.D.±0.556 S.E.±0.124	9.482 S.D.±0.427 S.E.±0.096	11.026 S.D.±0.916 S.E.±0.205
Lactic Acid (mg.per 100 c.c.)	10.18 S.D.±1.96 S.E.±0.44	15.37 S.D.±2.90 S.E.±0.65	50.02 S.D.±5.01 S.E.±1.12	95.81 S.D.±7.19 S.E.±1.61

TABLE : 3

...g., Standard deviation & Standard error of haemoglobin, total no.of R.B.C., Packed ... volume, mean corpuscular volume, mean corpuscular haemoglobin concentration etc. under resting condition & three different work loads.

Name of the Parameters	Pre-exercise value	WORK LOAD IN KGM/MIN.		
		100	600	1200
Haemoglobin (gm.per 100 c.c.of blood)	14.86 S.D.±0.85 S.E.±0.16	14.97 S.D.±0.87 S.E.±0.16	16.21 S.D.±0.76 S.E.±0.14	16.62 S.D.±0.77 S.E.±0.14
Total number of R.B.C.per cubic millimeter	4.870 S.D.±0.117 S.E.±0.021	4.895 S.D.±0.115 S.E.±0.021	5.336 S.D.±0.106 S.E.±0.019	5.418 S.D.±0.120 S.E.±0.021
Packed cell volume %	43.84 S.D.±1.74 S.E.±0.32	43.93 S.D.±1.73 S.E.±0.32	46.89 S.D.±1.81 S.E.±0.33	47.74 S.D.±1.63 S.E.±0.30
Mean corpuscular volume (cubic u)	89.98 S.D.±1.78 S.E.±0.32	89.68 S.D.±1.98 S.E.±0.36	88.12 S.D.±1.952 S.E.±0.35	88.04 S.D.±2.18 S.E.±0.399
Mean corpuscular haemoglobin conc.%	33.89 S.D.±0.92 S.E.±0.16	34.04 S.D.±0.90 S.E.±0.16	34.46 S.D.±0.86 S.E.±0.15	34.73 S.D.±0.79 S.E.±0.14
Total plasma protein conc.(micro-Kjeldal) (gm.%)	6.62 S.D.±0.32 S.E.±0.05	6.68 S.D.±0.31 S.E.±0.05	7.38 S.D.±0.26 S.E.±0.04	7.74 S.D.±0.30 S.E.±0.05
Total plasma protein conc.(from sp.gr.of plasma)	7.15 S.D.±0.27 S.E.±0.05	7.21 S.D.±0.24 S.E.±0.04	7.95 S.D.±0.32 S.E.±0.05	8.31 S.D.±0.31 S.E.±0.05
E.S.R./hour (mm)	6.99 S.D.±2.75 S.E.±0.69	6.96 S.D.±2.77 S.E.±0.69	6.03 S.D.±2.56 S.E.±0.64	5.24 S.D.±1.98 S.E.±0.49
Specific gravity of blood	1.054 S.D.±0.0011 S.E.±0.0002	1.055 S.D.±0.0010 S.E.±0.0002	1.057 S.D.±0.0011 S.E.±0.0002	1.058 S.D.±0.0011 S.E.±0.0002
Specific gravity of plasma	1.027 S.D.±0.0007 S.E.±0.0001	1.027 S.D.±0.0007 S.E.±0.0001	1.029 S.D.±0.0008 S.E.±0.0001	1.030 S.D.±0.0008 S.E.±0.0001

TABLE : 4

Average,Standard deviation & Standard error of total, Absolute & Relative count of W.B.C.before, during & at recovery after three different work loads.

Name of the Parameters	Pre-exercise values	Just after the end of work			Recovery (after 1 hour work done)		
		100 Kgm/m	600 Kgm/m	1200 Kgm/m	100 Kgm/m	600 Kgm/m	1200 Kgm/m
Total Count of W.B.C.per cubic mm.	6228.66 S.D. ± 527.35 S.E. ± 96.28	6478.66 S.D. ± 514.20 S.E. ± 93.88	8808.66 S.D. ± 831.94 S.E. ± 151.89	9705.33 S.D. ± 1158.34 S.E. ± 211.48	6185.33 S.D. ± 495.82 S.E. ± 90.52	6325.33 S.D. ± 537.85 S.E. ± 98.20	6396.66 S.D. ± 550.35 S.E. ± 100.48
Absolute Count : a) Neutrophil per cubic mm.	3680.22 S.D. ± 571.49 S.E. ± 104.29	3777.49 S.D. ± 583.03 S.E. ± 106.39	4680.63 S.D. ± 775.49 S.E. ± 141.51	4975.76 S.D. ± 805.54 S.E. ± 147.00	3666.75 S.D ± 557.04 S.E. ± 101.65	4119.87 S.D. ± 605.80 S.E. ± 110.55	4327.63 S.D. ± 611.35 S.E. ± 111.61
b) Lymphocyte per cubic mm.	1957.88 S.D. ± 440.28 S.E. ± 80.38	2085.11 S.D. ± 443.34 S.E. ± 80.94	3275.12 S.D. ± 681.24 S.E. ± 124.38	3811.05 S.D. ± 760.00 S.E. ± 138.76	1937.73 S.D. ± 432.16 S.E. ± 78.90	1710.44 S.D. ± 424.22 S.E. ± 77.45	1615.30 S.D. ± 418.33 S.E. ± 76.38
c) Eosinophil per cubic mm.	355.28 S.D. ± 148.54 S.E. ± 27.11	370.18 S.D. ± 154.53 S.E. ± 28.20	505.35 S.D. ± 238.14 S.E. ± 43.46	553.12 S.D. ± 260.04 S.E. ± 47.45	353.51 S.D. ± 154.34 S.E. ± 28.16	270.92 S.D. ± 136.11 S.E. ± 24.84	222.96 S.D. ± 109.04 S.E. ± 19.90
d) Monocyte per cubic mm.	219.73 S.D. ± 80.89 S.E. ± 14.77	228.69 S.D. ± 90.37 S.E. ± 16.50	311.15 S.D. ± 106.00 S.E. ± 19.35	345.68 S.D. ± 129.27 S.E. ± 23.60	222.09 S.D. ± 78.11 S.E. ± 14.26	217.67 S.D. ± 79.22 S.E. ± 14.46	203.55 S.D. ± 73.04 S.E. ± 13.34
e) Basophil per cubic mm.	12.36 S.D. ± 23.58 S.E. ± 14.77	12.87 S.D. ± 24.47 S.E. ± 4.47	17.70 S.D. ± 34.11 S.E. ± 6.23	19.70 S.D. ± 38.54 S.E. ± 7.04	12.35 S.D. ± 23.65 S.E. ± 4.32	12.61 S.D. ± 24.06 S.E. ± 4.39	12.83 S.D. ± 24.54 S.E. ± 4.48

Contd.....

TABLE : 4 (Contd.)

Name of the Parameters	Pre-exercise values	Just after the end of work			Recovery (after 1 hour work done)		
		100 Kgm/m	600 Kgm/m	1200 Kgm/m	100 Kgm/m	600 Kgm/m	1200 Kgm/m
Relative Count:							
a) % of Neutrophil	59.10 S.D. ± 7.67 S.E. ± 1.40	58.43 S.D. ± 7.64 S.E. ± 1.39	53.43 S.D. ± 7.61 S.E. ± 1.38	51.40 S.D. ± 6.97 S.E. ± 1.27	59.30 S.D. ± 7.65 S.E. ± 1.39	65.13 S.D. ± 7.59 S.E. ± 1.38	67.87 S.D. ± 7.31 S.E. ± 1.33
b) % of Lymphocyte	31.53 S.D. ± 6.62 S.E. ± 1.20	32.23 S.D. ± 6.53 S.E. ± 1.19	37.17 S.D. ± 6.69 S.E. ± 1.22	39.27 S.D. ± 6.06 S.E. ± 1.10	31.37 S.D. ± 6.63 S.E. ± 1.21	27.10 S.D. ± 6.54 S.E. ± 1.19	25.30 S.D. ± 6.30 S.E. ± 1.15
c) % of Eosinophil	5.67 S.D. ± 2.24 S.E. ± 0.40	5.67 S.D. ± 2.24 S.E. ± 0.40	5.67 S.D. ± 2.24 S.E. ± 0.40	5.57 S.D. ± 2.11 S.E. ± 0.38	5.63 S.D. ± 2.28 S.E. ± 0.41	4.20 S.D. ± 2.00 S.E. ± 0.36	3.43 S.D. ± 1.54 S.E. ± 0.28
d) % of Monocyte	3.50 S.D. ± 1.21 S.E. ± 0.22	3.50 S.D. ± 1.31 S.E. ± 0.24	3.53 S.D. ± 1.15 S.E. ± 0.21	3.53 S.D. ± 1.21 S.E. ± 0.22	3.57 S.D. ± 1.18 S.E. ± 0.21	3.37 S.D. ± 1.19 S.E. ± 0.21	3.13 S.D. ± 1.09 S.E. ± 0.20
e) % of Basophil	0.20 S.D. ± 0.37 S.E. ± 0.06	0.20 S.D. ± 0.37 S.E. ± 0.06	0.20 S.D. ± 0.37 S.E. ± 0.06	0.20 S.D. ± 0.37 S.E. ± 0.06	0.20 S.D. ± 0.37 S.E. ± 0.06	0.17 S.D. ± 0.34 S.E. ± 0.06	0.17 S.D. ± 0.34 S.E. ± 0.06

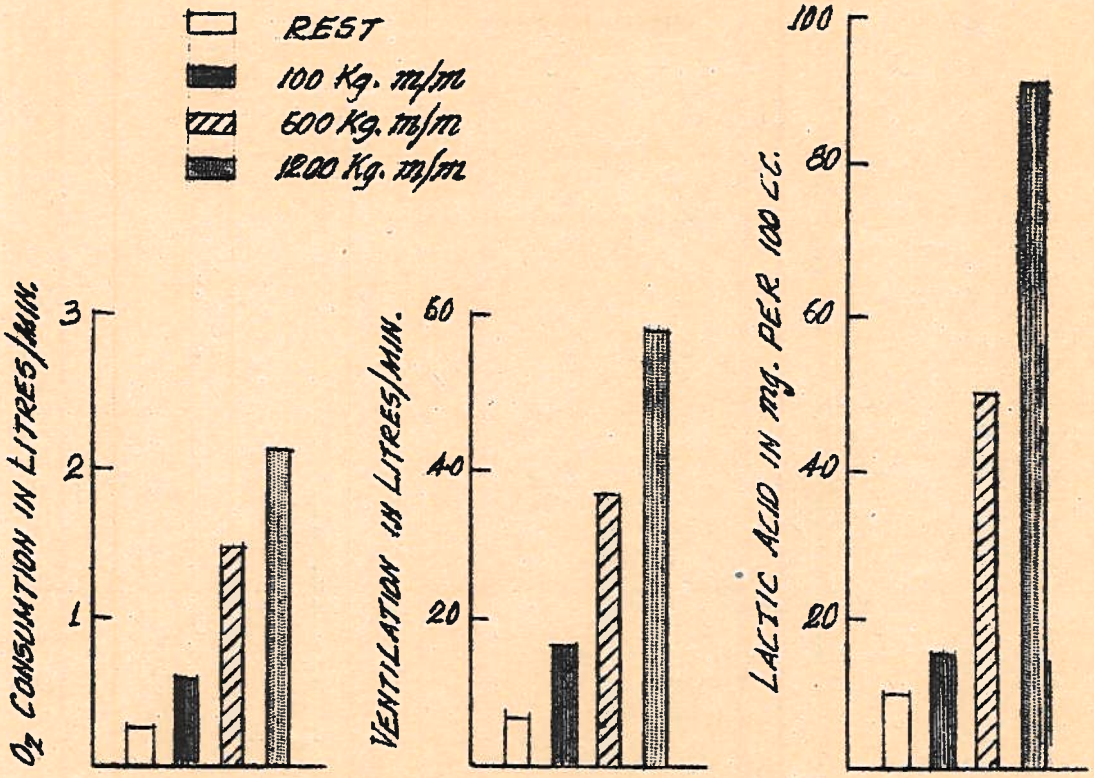
TABLE : 6

Average, Standard deviation and Standard error of Sodium, Potassium and Calcium under resting condition and their percentage increase under different intensities of work load.

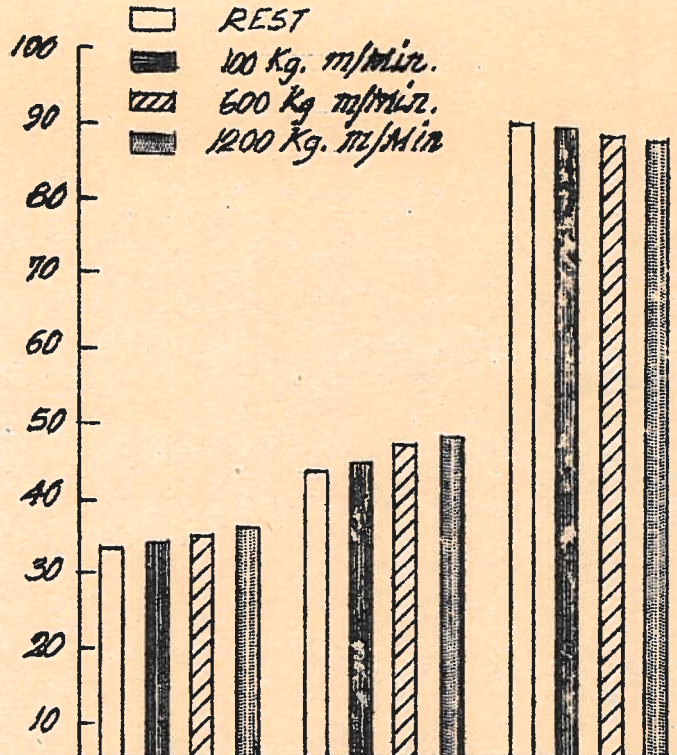
Percentage increase from the pre-exercise value under different work intensities.

Name of the Parameters	Resting values	Work loads in Kgm.				
		100	300	600	900	1200
Sodium/L (mEq)	142.01 S.D.±2.08 S.E.±0.46	Nil	0.68 S.D.±0.56 S.E.±0.13	2.61 S.D.±0.81 S.E.±0.18	3.12 S.D.±0.61 S.E.±0.14	4.76 S.D.±1.05 S.E.±0.23
Potassium/L (mEq)	4.18 S.D.±0.15 S.E.±0.03	Nil	1.98 S.D.±1.21 S.E.±0.27	7.01 S.D.±2.89 S.E.±0.65	7.65 S.D.±3.14 S.E.±0.70	15.04 S.D.±4.27 S.E.±0.95
Calcium/L (mEq)	4.95 S.D.±0.06 S.E.±0.01	Nil	1.59 S.D.±1.43 S.E.±0.32	4.97 S.D.±2.62 S.E.±0.58	4.62 S.D.±1.74 S.E.±0.39	10.22 S.D.±3.94 S.E.±0.88

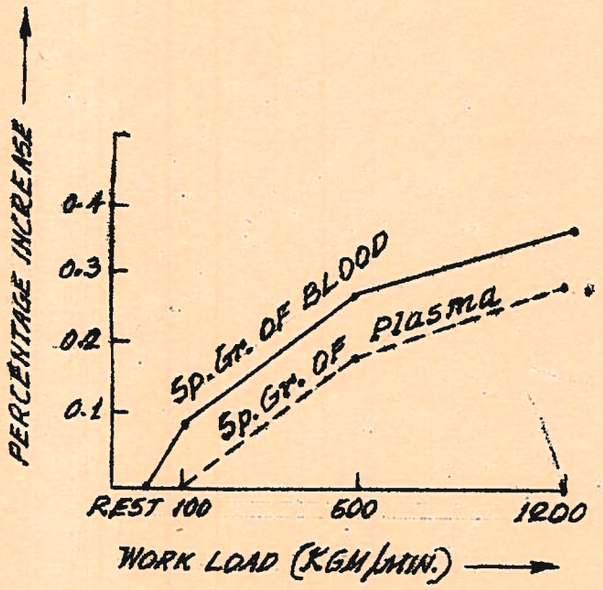
Average changes of oxygen consumption, ventilation and lactic acid from rest to the definite period of work for 5 minutes (minimal, submaximal and maximal)



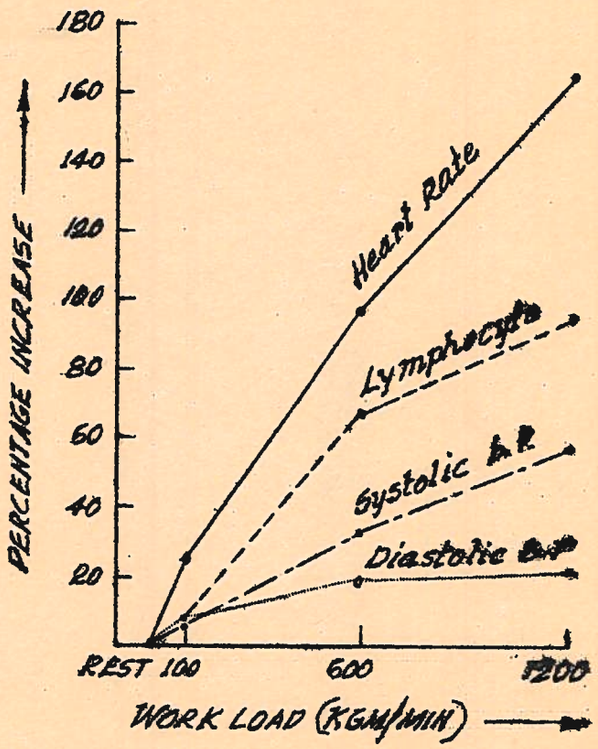
Average changes of mean corpuscular haemoglobin concentration, packed cell volume and mean corpuscular volume from rest to the definite period of work for 5 minutes (minimal, submaximal and maximal)



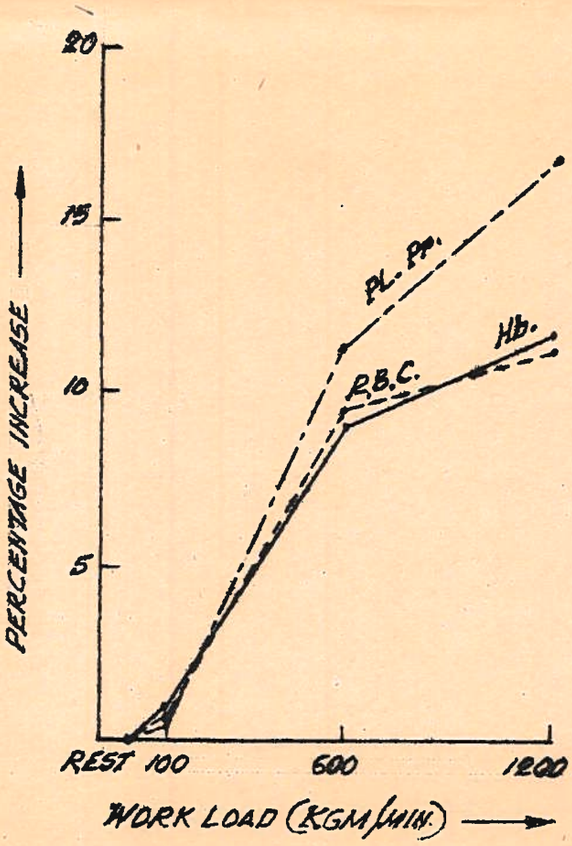
Showing average percentage increase of specific gravity of blood and plasma from rest to minimal, submaximal and maximal work loads.



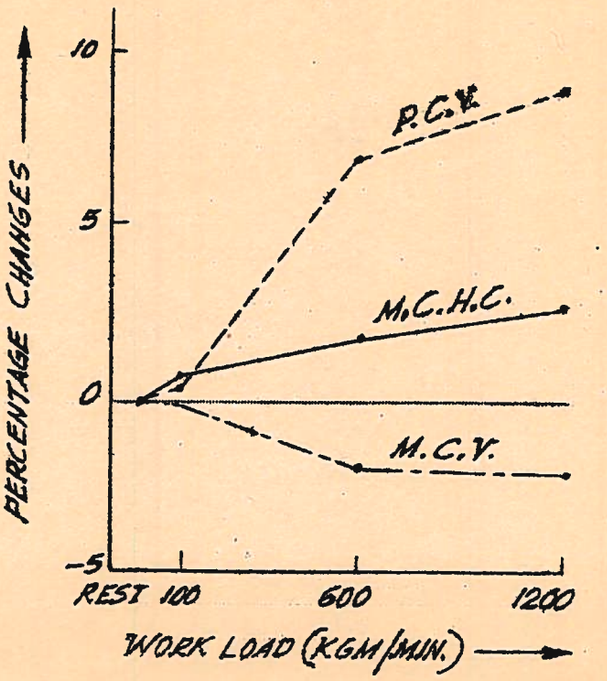
Showing the relationship among the percentage increase of heart rate, lymphocyte and blood pressure from rest to minimal, submaximal and maximal work loads.



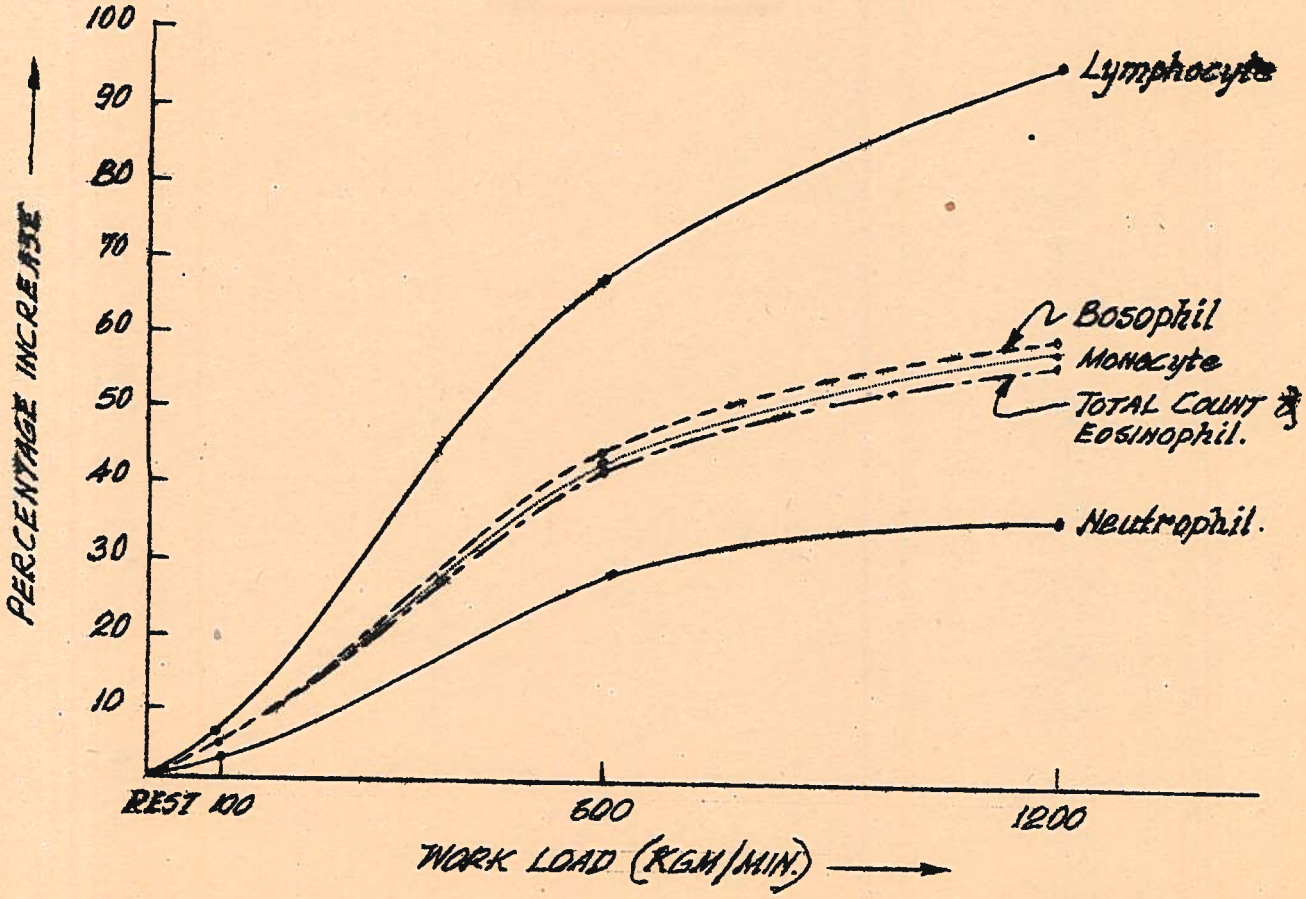
Showing average percentage increase of haemoglobin, R.B.C. and plasma protein with minimal, submaximal and maximal work loads.



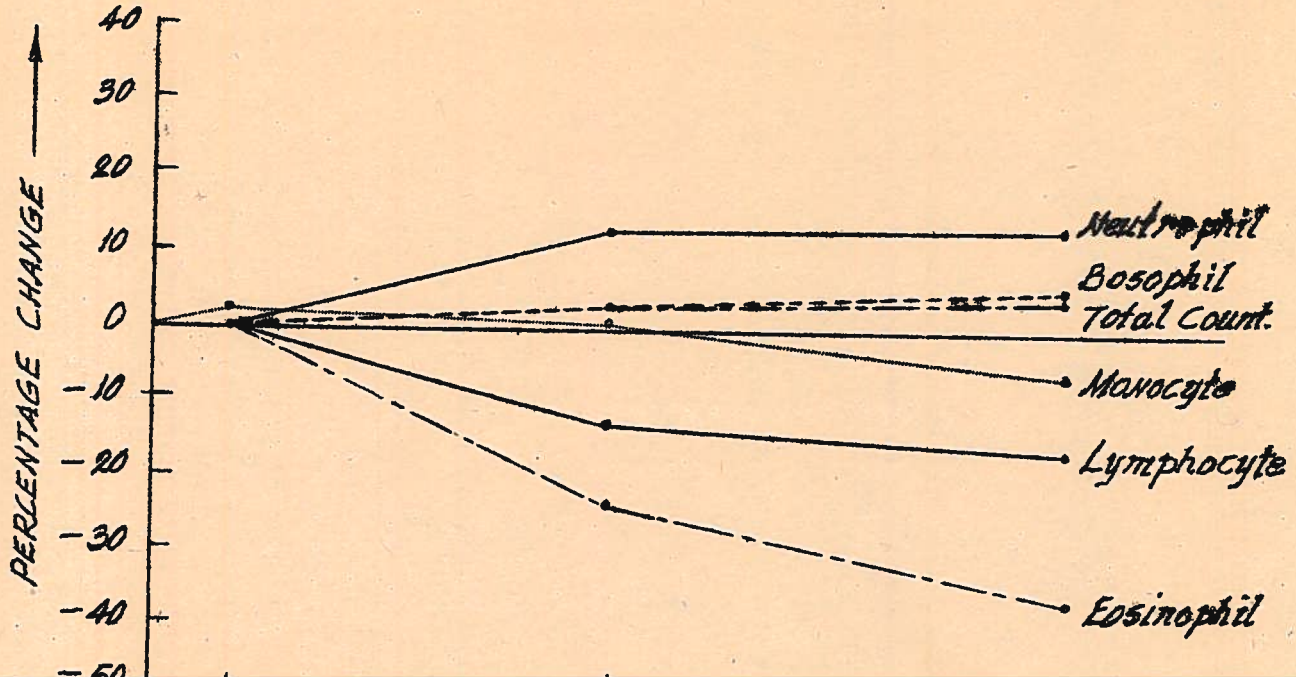
Showing average percentage changes of packed cell volume, mean corpuscular haemoglobin concentration and mean corpuscular volume from rest to minimal, submaximal and maximal work loads.

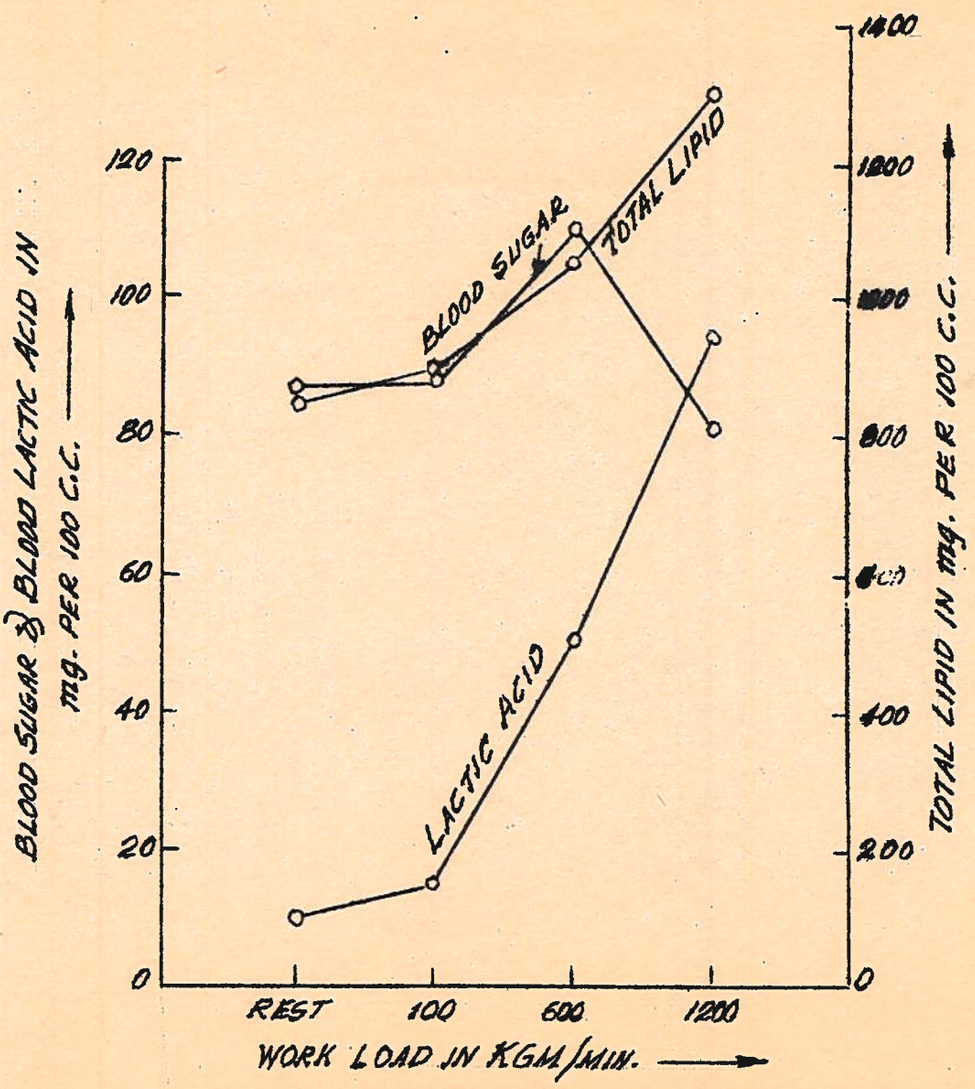


Showing the average percentage increase of different white blood corpuscles from rest to minimal, submaximal and maximal work loads.



Showing neutrophilia and to a lesser extent eosinopenia and lymphopenia at recovery (after one hour stoppage of exercise) of three different work loads.





Average changes of total serum lipid, blood sugar and lactic acid concentration during minimal, submaximal and maximal exercise.