CARDIODYNAMIC AND HAEMODYNAMIC ASPECTS OF THE "RELAXATION RESPONSE" IN ADULT NIGERIANS

By

GABRIEL ADEKUNLE ADELEYE

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ABSTRACT

Experiments were carried out on 120 volunteer, unanaesthetized and intact subjects who were trained to achieve the "Relaxation Response", a behavioral stimulus situation developed as a "transcendent function" aimed at defusing real and imagined tensions pent-up within the body system as a "general adaptation syndrome" and defined by its proponents as an equivalent of the "trophotropic - endophylatic" reaction described in cat by Hess (1943). 20 subjects (16.6%) failed to achieve the response.

Measurements were made before, during and after relaxation of the following Parameters:

Electroencephalogram (EEG), Impedance Pneumogram (IP), Transthoracic Electrical Impedance (TEI), Blood Pressure (BP), Heart Rate (HR), Electrocardiogram (ECG),

To ascertain the visceroactive mode of the "Relaxation Response Technique" RRT), the Duration and the Frequency of practice were patterned to bring out the chronic and acute effects of the stimulus situation in order to facilitate the interpretation of the cardiodynamic and the haemodynamic Data obtained.

Most hypertensives, for example, are clinically diagnosed as essential, yet a number begin as labile in which the elevated arterial pressure is consequent upon increased cardiac output (Lund-Johasen, 1967) and the cardiovascular response pattern resembles that of exercise (Brod, 1963). In contrast, essential

hypertension is maintained by increase in peripheral resistance with about normal cardiac output (Eich et al, 1966, Pickering 1968). The former may be neurogenically mediated but its repeated occurence induces a non-neural mechanism (Folkow 1971 and Guyton et al, 1970). Therefore, one must not lose sight of the fact that visceral response patterns associated with certain behavioral manoeuvrings develop from a long-term (chronic) exposure to a given change in the environment (the technique). In fact, such long-term effects can perhaps be viewed as mere repeated application of short-term (acute) exposures and are thus best approached with well-defined short-term models. This is why the 20-minute time limit imposed by the hybridized Meditational technique (the RRT) is quite appropriate. Not only is it more easily repeated with the least possible side effect, but it also enables one to hypothesize what response patterns are due to neural or to endocrine mediation purely on account of the latency and duration of the responses.

So far, the most outstanding claims have been confirmed through the application of RRT. Also the best parameters as indicative of RRT were shown to be EEG and Impedance Pneumogram. New parameters promoting a better understanding of cardiodynamic response patterns were deduced during RRT and the following points were clarified.

(1) Stroke Volume changed little in acute RRT application

(2) It was reduced significantly ($P < 0.05$) following chronic application of RRT.

(3) Blood pressure showed a permanent change (fall) after four sessions of RRT. The fall is the resultant of the reciprocal relationship between cardiac output (fall in acute and chronic) and the total peripheral resistance (increase).

(4) Heart rate changed considerably in acute RRT application. Even after much practice, Heart rate reduced to a greater extent than (sv) stroke volume.

(5) These physiological responses exhibited a circadian rythm.

(6) There was no significant difference between the response of female and male subjects.

(7) Age had no effect on the response

(8) The iliosacral angle determined how fast and to what extent a response can be elicited. At an angle of 120° the subject falls asleep and concentrates less (due to strain) than at an angle of 90° whereas the optimum angle lies between 105° and 120°.

(9) The efficiency of the heart during exercise improved with RRT.

(10) Pregnant women quite easily responded to the Relaxation Response Technique.

From these findings, it is concluded that the RRT is capable of improving the cardiovascular functions consistently in sedentary as well as in working subjects within a week of sincere practices.

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G. A. Adeleye.

Certification Page

We certify that this work was carried out by Mr. G. A. Adeleye in the Department of Human Physiology, Ahmadu Bello University, Zaria, and Department of Physiology, University of Ibadan, Nigeria.

1) ______________________
(Supervisor)

O. M. G. Murphy, M.A., B.Sc., M.B,B.Ch., D.C.H., M.R.C.V.S.
Acting Head of Department,
Department of Human Physiology,
Ahmadu Bello University,
ZARIA. NIGERIA.

2) ______________________
(Supervisor)

R. A. Elegbe, M.D.,
Lecturer in the Department of Physiology, University of Ibadan,
IBADAN. NIGERIA.

Dedicated

To Lovette, my wife

and to Adebimpe, my daughter whose very existence inspired in me enough sense of responsibility to persevere in this continuum of struggle - a struggle in which the human race is profoundly implicated.

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CHAPTER 1

INTRODUCTION

By being recklessly adventurous, unscrupulously ambitious, nervously time-pressured, and irredeemably avaricious, Man has created for himself a chaotic situation which is becoming increasingly resistant to almost all the conventional methods of management. This technological age, a product of his ingenuity, is characterised by rapid and astronomical changes unprecedented in scale or in complexity or in novelty. The attendant environmental disorder maximizes every moment towards infinity. In fact, the capacity of man to adjust to the impact of all these (his handiwork) is so severely tested that his organs have to work near their limits to cope. The juggernaut is survival while the cost is tension. This though is a paradox, in as much as tension trigers off a physiological discordance which, if allowed, is capable of accelerating life towards extinction. Chronic, excessive strain and tension are summed up in the word stress.

Stress is being incorporated into the list of a few ill-defined and generally overused medical terminologies, meaning different things to different people; yet it has long been the subject of psychological speculations. In as much as these speculations form the starting point of my present investigation, an attempt is made here to delve into the meaning of stress.

Synoptically, stress is a function of an inexorable tendency to cope with the demands of a topsy-turvy environment. The three main components into which it can be resolved are: Emotional Stress, Environmental Stress and Physiological Stress. The emotional stress consists of all the deep-seated negative feelings like disappointment, frustration, grief, hatred, and fear; Environmental stress consists of exposure to physical discomforts like cold, heat, and strong illumination; and Physiological stress consists of an outpouring of steroid hormones from adrenal gland, just as elaborated upon by Hans Selye (1975) who believed in their vital significance to survival and considered them as sensitive indices of stress. These three components interact in certain ways to derange the normal autonomic functions.

It is a stimulus situation of a chronic type which established its influence through a barrage of impulses bombarding not only the intermediolateral horn of the spinal cord but also the reticular system, the hypothalamus sub-collicular area, the amygdala (through the amgdalofugal projection on the hypothalamus) and the cerebral cortex. That is why it is little surprising the synapses and the n neuronal links function at random.

That environmental events provoke certain behavioural adjustments capable of eliciting overt autonomic changes hardly requires documentation but much of the foundation for hypothesis derives from anecdotal and correlational observations. Stress is not quantifiable and so, this fact renders teleological the various attempts to implicate stress while explaining some (if not all) of the maladies untraceable to either functional or organic origins. The problem of how to quantify stress, per se, is now side-tracked by extrapolating from the measurable physiological consequences. Scarcely needing over-emphasis is the fact that man reacts instinctively by activating the "Emergency Reaction Pathway" popularized by Walter Cannon (1914, 1929, 1966). Interest has been aroused over the last half of this decade as regards the possibility of managing and controlling the visceral derangement through a mechanism which probably reverses the "Emergency Reaction" response. In this direction, Medicine has begun to make in-roads, moving from mere psychological speculations to a more systematic physiological observations.

This work is designed to exploit a behavioural practice to subdue the physiological effects of stress. Pre-requisite to investigating behavioural effects on the viscera, experimental paradigms in which controlled stimuli reliably elicit specific visceral response patterns must be established to provide models with which one can attempt to specify the effective component of the stimulus situation (the behavioural practice) and explore how its manipulation alters the response pattern. Given this general working premise, one can then categorize such paradigms into those in which the stimuli are initially neutral but which eventually acquire the capacity to elicit such response as a function of behavioural training.

Implicit in this formulation is that the behaviours and the accompanying responses are under specifiable stimulus control and the subject be intact and unanaethetized.

By way of illustration, one category of experimental paradigm includes the effects of basic stimulus situation like exercise, postural (orthostatic) change, nociceptive stimulation as well as more complex stimulus situations reflexly eliciting such integrated behavioural patterns as defence, feeding and sexual activity. The second category has been more the domain of psychophysiologists and it involves the various learning (conditioned) situations which transform neutral stimuli into visceroactive ones by associating them with stimuli that reflexly affect the visceral functions. This present investigation belongs to the latter category and so, attempts is made here to classify the various learning situations.

One is the classical conditioning in which some largely neutral stimulus (the conditioned stimulus) is systematically paired with another (the unconditioned stimulus) that reflexly affects the viscera. After a sufficient number of conditioned-unconditioned stimuli pairing, the conditioned stimulus alone can acquire the capacity to effect the same reflex (conditioned response). Another is the instrumental or operant conditioning which is similar in basic principle, differing only by the fact that the subject is less passively involved; he has some control over the situation on account of his behaviour which leads either to a reward or a punishment. The Biofeedback is yet another learning situation. In it the subject is allowed a recognition and a feedback of his success in controlling a specific physiological variable. Usually through an electrophysiological instrumentation, possibly audio-visual (external feedback), the subject is presented some information concerning his unconscious self. Thereby he learns to influence them by the use of mentally, emotionally and physically visualized efforts.

Of the three examples, Biofeedback comes closest to solving the autonomic derangement touched off by stress; but unfortunately the drawbacks are too many. For example, no more than one physiologic function can be fed back upon and thus changed. It is essential also to follow the progress of the physiologic changes carefully step by step so that a reward or a punishment may be made in the appropriate direction and not only is this cumbersome but also it warrants the use of costly equipments which may not be in general circulation.

There is an age old learning situation devised, developed and executed in the East (rapidly spreading in the West) that enables the practitioners to achieve the "impossible" of the physiological investigations of the yesteryears. A device founded on the basic philosophy that

> every change in the physiological state is accompanied by an appropriate change in the mental-emotional state conscious or unconscious and conversely, every change in the mental-emotional state conscious or unconscious is accompanied by an appropriate change in the physiological state, when coupled with VOLITION, which is of indeterminate origin, makes theoretically possible the self regulation of all body function,

enunciated at a symposium in 1971 at De Anaz College in Cupetino, California by Green, who concluded that "the problem apparently is to learn to control the unconscious, at least". The ancient meditational techniques developed are Zen Buddhism, Yoga, autogenic training, sentic cycles, Hypnosis, contention, ditention, Progressive Relaxation and Transcendental Meditation (TM). Of all these, the latter (probably, because of its relative simplicity) had been thoroughly investigated, and a sizeable literature has evolved t treating the claims made. Among the physiological changes reported are a wakeful hypometabolic state, a decreased oxygen consumption, carbon dioxide elimination, respiratory rate, minute ventilation with no change in respiratory quotient, arterial blood pH decreasing slighly while blood lactate markedly decreased, and an increase in skin resistance. It was also reported that the electroencephalogram records shows an occasional theta-wave activity.

As divergent as the ancient techniques are, Benson, et al., (1974) hypothesized a marriage of principle, having isolated the effective techniques in his paradigm cantioned the "Relaxation Response Technique" which he claimed is an equivalent of the "Trophotropic response" first described in the cat by Hess (1957). He claims the technique achieves the opposite of the synergistically associated mechanisms involved during the 'fight-or-flight' reaction described by Cannon (1922); Gutman, et al., (1971).

In all these techniques, there is agreement as regards oxygen consumption, carbon dioxide elimination, Heart Rate, Respiratory rate, minute ventilation and skin resistance. Systolic, diastolic, and mean arterial blood pressure changes are either inconclusive or not measured at all or unchanged. Muscle tonus, not yet measured in Transcendental Meditation, decreases in other Relaxation Techniques (Jacobson, Luthe, 1969). These inconsistencies are reported by Bagchi and Wenger, 1957); Wenger and Bagchi, 1961; Anand, et al., (1961).

The Review by Wallace (1974) considered the feasibility studies in to the physiological influences of TM. This inspired the author to attempt an investigation into the dynamics of the cardiovascular system. In carrying out this work, the author has deviated from previous experimenters by not using Trained Meditators. The psychophysiologic technique described by Benson (1974) was however utilized. This was considered inevitable in view of the fact that:

(1) Some of the equipments used especially for the pulmonary investigations tend to encroach on the subjects' conveniences. Even in fact Wenger and Bagchi (1961) reported that investigators have difficulty in taking measurements in a way that did not interfere with the subjects' contemplative or concentrative efforts.

(2) Traditional Meditators were often used, this has restricted the general applicability of the earlier

methods. Also Wenger and Bagchi (1961) reported that investigators expressed difficulty in obtaining expert Practitioners of meditation.

(3) Workers used non-meditators as control in their experimental models. Whereas, if the diversity of our genetic constitution and the concommitant idiosyncracies were considered, it would hardly be imaginable how objective conclusions can be drawn from a situation where an individual acts as a control for another in a test meant to elaborate on innate tendencies.

(4) In instances where meditators were not found, traditional Tutors of Meditational Techniques were invited to train subjects. This connotes the impression of complexity rather than the simplicity which the paradigm requires.

(5) Age, sex, geographical environment, race, diet and occupation are some of the variables capable of interfering with the results, yet the pioneer workers often ignored them.

(6) Granted that the technique elicits measurable autonomic changes, hardly was it ever mentioned if the result was significant enough for the detection by simple bedside diagnostic equipments or whether they were so small that only the sensitive scientific laboratory equipments can be used.

The Experimental Design

(1) Investigation was carried out in three main phases:

A. Pilot Phase:

The aims of which are

(i) to verify the claims made

(ii) to select which of them is best indicative of the relaxation response.

B. Exploratory Phase:

The aims of which are:

(i) to investigate new parameters

(ii) to find out the effect of RRT at first trial

(iii) to find if any improvement can be achieved with trial frequency

(iv) to find out the minimum trial required for a significant physiological response pattern

(v) to establish how long-lasting are the effects (if any)

(vi) to find out the effect on work capacity.

C. Concluding Phase:

The aims of which are:

(i) to hypothesize and

(ii) to classify the mechanism involved in the provocation of the responses.

(2) Experimental subjects

Two categories of volunteers were used

(a) Normotensive (male and female) adult Nigerian

(b) Pregnant Nigerian women,

(3) Three principal sets of observations were made

(a) Pre-relaxation

(b) During-relaxation

(c) Post-relaxation,

a fourth consisted (for comparison) of observation made during sleep.

(4) The observations made during a short-term practice of 20-minutes were compared with the long-term practice.

(5) The cardiovascular system and Respiratory system were investigated in different sets of individuals.

(6) Two rooms were used: The first contained nothing but the volunteer and the second contained the recording equipment.

CHAPTER 2

LITERATURE REVIEW

The History of the Relaxation Response Technique

Techniques have existed for centuries, usually within a religious context, which allow an individual to experience the relaxation response. A fourteenth-century Christian treatise entitled The Cloud of Unknowing discussed how to attain an altered state of consciousness required to attain alleged union with God (Progoff, 1969). The anonymous author stated that this goal could not be reached in the ordinary levels of human consciousness, but rather by use of "lower" levels. These levels were reached by eliminating all distractions and physical activity, and all worldly things including all thoughts.

In beating down thoughts, it was considered that the use of single syllable words such as 'good' or 'love' should be repeated and kept in the mind to be used as a weapon such that if any thought should press upon the mind this word only shall be repeated as a response. Thus there will be moments when

> every created thing may suddenly and completely be forgotten. But immediately after each stirring, because of the corruption of the flesh, it (the soul) drops down again to some thought or some deed.

In order to achieve the above, Progoff himself suggested "....do not by another means work in it with your mind or with your imagination.

Another Christian work, The Third Spiritual Alphabet, Osuna, (1931), dealt with an altered state of consciousness. To achieve this it was necessary to blind oneself to all that was not God, to be deaf and dumb to the entire world and quit all obstacle, by keeping the eyes bent on the ground. The method can be operated either a short, self-composed prayer, repeated over and over, or simply saying "no" to thoughts when they occur. This exercise should be performed for one hour in the morning and evening and should be taught by a qualified teacher. Such an exercise it was considered would help in all endeavours, making one more efficient in his task and the task more enjoyable. It was suggested that all men, especially the busy, secular as well as religious, should be taught this meditation for it is a refuge to which one can retreat when faced with stressful situations.

Benson (1974) described the methods used by fifteenth-century Christian mystics, Saints John and Terese, to achieve the mystical state. This included ignoring distractions, usually by repetitive prayer.

Christian meditation and mysticism were well developed within the Byzantine church and known as Hesychasm (Norwich and Sitwell, 1966). This method of repetitive prayer was described in the fourteenth century as Mount Athos in Greece by Gregory of Sinai according to Norwich and Sitwell (1966) and is called "The Prayer of the Heart" or "The Prayer of Jesus", which dates back to the beginning of the Christian era. The prayer itself was called secret meditation and was transmitted from older to younger monks through instructor. The method of prayer recommended by these monks (French, 1968) was:

> Sit down alone and in silence. Lower your head, shut your eyes, breath out gently, and imagine yourself looking into your own heart. Carry your mind, i.e., your thoughts, from your head to heart. As you breath out, say 'Lord Jesus Christ, have mercy on me'. Say it moving your lips gently, or simply say it in your mind. Try to put all other thoughts aside. Be calm, be patient and repeat the process very frequently (Ross 1965).

Saddhatissa (1971), in his presentation of Buddism for western readers, outlines methods similar to Eliade's (1958). Saddhatissa (1971) mentioned two types of Buddhist meditation - Samatha, the development of calm and concentration and vispassana, the development of insight. The practice recommends that the meditator focuses his attention at the lip of his nostril and quietly "watches" the breath flowing in and out while numerals are counted up to (and to above) ten, and then repeated the count to aid his concentration.

According to mahayana Faith, the technique as expounded by Ashvagosha (1961) in his book 'The Awakening of Faith' consists of five stages

> As to the practice of checking vain thoughts, It should be done in a quiet place and In a proper spirit ... for all kind of ideas as soon as thought of must also be put away. As all existence originally came to be without any idea of its own; Any thought arising therefore must be from being absolutely passive. Nor must one follow the mind in its excursions.

to this he added "proper posture".

In the practice of sufism, a system of Mohammedan mysticism, transcendent experiences are attained through all the four elements. Mohammed who lived in the sixth century found Mohammedanism whereas sufism has been in existence since the second century, and it is interesting to note its similarities to Christianity and Buddhism. Dhikr, a special method of worship in sufism, is explained by Al-Ghazali in a passage that has been summarized by Macdonald and cited in a Moslem Seeker After God as follows:

Meditation is achieved in Dhikr, a special form of worship in sufism as follows:

> let me the worshipper reduce his heart to a state in which the existence of anything and its non-existence are the same to him. Then let him sit alone in some corner, limiting his religious duties to what is absolutely necessary, and not occupying himself either with reciting the Koran or considering its meaning with a book of religious traditions, or with anything of the sort. And let him see to it that nothing save God most high enters his mind. Then as he sits in solitude, let him not cease saying continuously with his tongue "Allah, Allah", keeping his thought on it. At last he will reach a state when the motion of his tongue will cease and it will seem as though the word flowed from it.

> Let him persevere until all trace of motion is removed from his tongue and he finds his heart persevering in the thought. Let him still persevere until the form of the word, its letters and shapes is removed from his heart and there remains the idea alone, as though clinging to his heart inseparable from it.

Taoism one of the influential philosophical systems in the history of China dates back to the sixth century B.C., with the writing of Lao Tzu, which embodies all of Taoist philosophy, on which Chuang Tzu elaborated upon two hundred years later (Benson, 1974). To practice Taoism according to Chuang (1963) is "To regard the fundamental as the essence, to regard things as coarse, to regard accumulation as deficiency and to dwell quietly alone with the spiritual and the intellect" Through tranquility of the mind one achieves accord with nature and hence with Tao, the Yoga breathing technique was assimilated but rather than the Indian philosophy of attaining spiritual transcendence, the concern of Taoist was the indefinite prolongation of life and the material body. Eliade (1958) described one Taoist technique of inner breaking as choosing a quiet room loosening the hair, unfastering the cloths, and lying down in the right position. After harmonizing his breaths, the practitioner holds his breath until doing so becomes intolerable. During this time he must "darken the heart (the organ of thought) so it does not think" the procedure should then be repeated.

Similar meditative practices may be found in practically every culture. Shamanism, for example, is a form of mysticism in which a chant or song intoned by a shaman or holy man, brings on trances. Shamanism is practices in North and South America, Indonesia, Africa, Siberia and Japan.

In Judaism similar practices leading to this altered state of consciousness date back to the time of the second temple in the second century B.C. and were found in one of the earliest forms of Jewish mysticism, Merkabalism (Scholem, 1967) is a practice of meditation in which the subject sat with his head between his knees, whispered hymns and songs, and repeated a name of a magic seal. In the thirteenth century A.D., the works of Rabbi Abulafia were published and his ideas became a major part of Jewish Kabbalistic mysticism (Scholem, 1967). Rabbi Abulafia felt that the normal life of the soul was kept within limits by our sensory perceptions and emotions, and since these perceptions and emotions were concerned with the finite, the soul's life was finite. Man therefore needed a higher form of perception, which instead of blocking the soul's deeper regions, opened them up. Rabbi Abulafia considered that an "absolute" object upon which to mediate was required. He found this in the Hebrew alphabets from which he developed a mystical system of contemplating the letters of God's name. Bokser (1962) described Rabbi Abulafia's prayer:

> ... immersed in prayer and meditation, uttering the divine name with special modulations of the voice and with special gestures, he induced in himself a state of ecstasy in which he believed the soul had shed its material bonds, and, unimpeded, returned to its divine source.

The purpose of this prayer and methodical meditation was to experience a new state of consciousness, described as harmonious movement of pure thought, which had severed all relation to the senses. This was considered by Scholem (1967) as comparable to music and yoga. He further felt that Rabbi Abulafia's

> ... teachings represent but a Judaized version of that ancient spiritual technique which has found its classical expression in the practices of the Indian mystics who follow the system known as Yoga. To cite only one instance out of many, an important part in Abulafia's system is played by the technique of breathing; now this technique has found its highest development in the Indian Yoga, where it is commonly regarded as the most important instrument of mental discipline. Again, Abulafia lays down certain rules of body posture, certain corresponding combinations of consonants and vowels, and certain forms of recitation, and in particular some passages of his book "The Light of the Intellect" give the impression of a Judaized treatise on Yoga. The similarity even extends to some aspects of the doctrine of ecstatic vision, as preceded and brought about by these practices.

The basic elements which elicit the relaxation response in certain practices of Christianity and Judaism were also found in Islamic mysticism or Sufism (Trimingham, 1971). Sufism developed as a reaction against the external rationalization of Islam and made use of intuitive and emotional faculties which were claimed to be dormant until they were utilized through training under the guidance of a teacher. The method of employing these faculties is known as Dhikr. It is a means of excluding distractions and of drawing nearer to God by the constant repetition of His name, either silently or aloud, and by rhythmic breathing. Music, musical poems, and dance are also employed in the ritual of Dhikr, for it was noticed that they could help induce state of ecstasy. Originally, Dhikr was only practiced by the members of the society who made a deliberate choice to redirect their lives to God as the preliminary step in the surrender of the will. Upon initiation to the order, the initiative received the weird, a secret, holy sound. The old Masters felt that the true encounter with God could not be attained by all, for most men were born deaf to mystical sensitivity. By the twelfth century, however, this attitude had changed. It was realized that this ecstasy could be induced in the ordinary man in a relatively short time by rhythmic exercise involving posture, control of breath, coordinated movements, and oral repetitions (Trimingham, 1971).

In the Western world, the relaxation response elicited by religious practices was not part of the routine practice of religions, but rather was within the mystical tradition. In the East, however, meditation which elicited the relaxation response was developed much earlier and became a major element in religion and in everyday life. Writings from Indian scriptures, the Upanishads, dated sixth century B.C., note that individuals might attain

> ... a unified state with the Brahman (the Deity) by means of restraint of breath, withdrawal of senses, meditation, concentration, contemplation and absorption (Organ, 1970).

There are a multitude of Eastern religions and ways of life, including Zen and Yoga with their many variants, which can elicit the relaxation response. They employ mental and physical methods including the repetition of a word or sound, the exclusion of meaningful thoughts, a quiet environment, and a comfortable position, and they stress the importance of a trained teacher. One of the meditative practices of Zen Buddhism called Zazen, employs a yoga-like technique of the coupling of respiration and counting to ten - i.e., one on inhaling, two on exhaling, and so on, to ten. With time, one stops counting and simply "follows the breath" (Johnson, 1931, 1971) in a quiet environment, in a horizontal position, and with closed eyes (Luthe, 1969). Exercise 1 focuses on the feeling of heaviness in the limbs, and Exercise 2 on the cultivation of the sensation of warmth in the limbs, Exercise 3 deals with cardiac regulation, while Exercise 4 consists of passive concentration on breathing. In Exercise 5, the subject cultivates the sensation of warmth in his upper abdomen, and Exercise 6 is the cultivation of feelings of coolness in the forehead. Exercise 1 through 4 most effectively elicit the trophotropic response, while Exercise 5 and 6 were reported to have different effects (Luthe, 1969). The subject's attitude toward the exercise must not be intense and compulsive, but rather of a quiet, "let it happen", nature. This was referred to as passive concentration and was deemed absolutely essential (Luthe, 1972).

Progressive relaxation is a technique which seeks to achieve increased discriminative control over skeletal muscle until a subject is able to induce very low levels of tonus in the major muscle groups. The technique was devised by Jacobson, 1930 when he considered that anxiety and muscular relaxation produced opposite physiologic states, and therefore could not exist together. Progressive relaxation is practiced in a supine position in a quiet room; a passive attitude is essential because mental imagination induces slight, measurable tensions in muscles, especially those of the eyes and face. The subject is taught to recognize even slight contractions of his muscles so that he can avoid them and achieve the deepest degree of relaxation possible.

Hypnosis is an artificially induced state characterized by increased suggestibility (Gorton, 1949). A subject is judged to be in the hypnotic state if he manifests a high level of response to test suggestions such as muscle rigidity, amnesia, hallucination, anaesthesia, and post-hypnotic suggestion which are used in standard scales such as that of Weitzenhoffer and Hilgard (1959). The hypnotic induction procedure usually includes suggestion (autosuggestion for self-hypnosis) of relaxation and drowsiness, closed eyes, and a recumbent or semisupine position (Barber, 1971). Following the induction procedure, an appropriate suggestion for the desired mental or physical behaviour is given.

So far it has not been possible to find a unique physiologic index which defines the hypnotic state, Barber (1971). Physiologic states vary the same way during hypnosis as they do during waking behaviour. Suggested states of arousal or relaxation were accompanied by either increased or decreased metabolic rate, heart rate, blood pressure, skin conductance, and respiratory rate corresponding to the changes seen when these states were induced by non-hypnotic means (Barber, 1971). He further considered if the control state is the same as the suggested state, then of course, no change in physiologic parameters would be seen. Whitehorn, et al., 1958, reported that the control oxygen consumption value of 217 ml/min. was not significantly changed by hypnosis. Subjects were however in this experiment trained to relax before control readings were taken. Hypnotic suggestion therefore to relax produced no further change.

Sentic cycles is another psychophysiologic technique, devised by Clynes (1970). A sentic "cycle" is composed of eight sentic states. A sentic "state" is a self-induced emotional experience. The sequence of states as used by Clynes is as indicated: no emotion, anger, hate, grief, love, sex, joy, reverence. A subject practices a cycle by thinking the state e.g., anger - and responding with finger pressure on a key (which transduces the pressure for recording) as he sits and listens to a tape recording. The recording indicate which sentic state is present and when the subject should press the key.

Shiomi (1969) stated that Burrow had described two kinds of attention: contention and ditention. Contention requires the subject to "... focus on the object of its environment". It is concentration on one thing exclusively. Ditention is described as "ordinary" wakefulness, in which state the subject's interest shifts from object to object. The state of contention is induced by relaxing the muscles, closing the eyes, and resting them on a point imagined to be the centre of a curtain of darkness infront of the subject.

Yoga has been an important part of Indian culture for thousands of years. It is claimed to be the culmination of the efforts of ancient Hindu thinkers to "give man the fullest possible control over his mind" (Hoenig, 1968). Yoga consists of meditation practices and physical techniques usually performed in a quiet environment, and it has many variant forms. Yoga began as Raja Yoga, which sought "union with the absolute" by meditation. Later, there was an emphasis on physical methods in attempt to achieve an altered state of consciousness. This form is termed Hatha Yoga. It has developed into a physical culture and is claimed to prevent and cure certain diseases. Essential to the practice of Hatha Yoga are appropriate posture and control of respiration (Ramamurthi, 1967). The most common posture is called Lotus (seated on the ground with legs crossed). This posture helps the spine stay erect without strain and is claimed to enhance concentration. The respiratory training promotes control of duration of inspiration and expiration, and the pause between breaths, so that one eventually achieves voluntary control of respiration. Bagchi and Wenger, in studies of Yoga practitioners, reported that Yoga could produce a 70% increase in skin resistance, decreased heart rate, and EEG alpha wave activity. These observations led them to suggest that Yoga is "deep relaxation of a certain aspect of the autonomic nervous system without drowsiness of sleep".

Transcendental Meditation is currently a widely practiced form of Yoga. The technique, as taught by Maharishi Mahesh Yogi, comes from the Vedic tradition of India. Instruction is given individually, and the technique is allegedly easily learned at the first instruction session. It is said to require no physical or mental control. The individual is taught a systematic method of repeating a word or sound the mantra, without attempting to concentrate specifically on it. It involves little change in life style, other than meditation period of 15 to 20 minutes twice a day when the practitioners sit in a comfortable position with closed eyes.

Zen is similar to Yoga, from which it developed, and is associated with the Budhist religion (Organ, 1970). In Zen meditation, the subject is said to achieve a "controlled psychophysiologic decrease of the cerebral excitatory state" by a crossed-leg posture, closed eyes, regulation of respiration, and concentration on the Koan (an alogical problem - e.g., What is the sound of one hand clapping?), or by prayer and chanting. Respiration is adjusted by taking several slow deep breaths, then inspiring briefly and forcelessly, and expiring long and forcefully, with subsequent natural breathing. Any sensory perceptions or mental images are allowed to appear and leave passively. A quiet, comfortable environment is essential. Benson (1974), quoting Sugi and Akutsy, remarked that experienced Zen meditators elicit the relaxation response more efficiently than novices.

Relaxation Response: Its definition

Hess (1943) produced the changes usually associated with the "Fight-or-Flight" response by stimulating the hypothalamic area. Hess (1957) observed a response diametrically opposite the above response. The first response he termed "ergotropic" and the second he called "trophotropic" response. The former corresponds to the "Emergency Reaction", "Fight-or-Flight" response, or the "Defence Reaction (Hess and Brugger, 1957; Abraham, et al., 1964). The "trophotropic" Zone is located in the anterior hypothalamus. The response is claimed to be mediated by the parasympathetic nervous system and an electrical stimulation of the zone result in hypo or, a-dynamia of skeletal musculature, decreased blood pressure, decreased respiratory rate and myosis. Hess stated

> Let us repeat at this point that we are actually dealing with a protective mechanism against overstress belonging to the trophototropic-endophylactic system and promoting restorative processes. We emphasise that these dynamic effects are opposed to ergotropic reactions which are oriented towards increased oxidative metabolism and utilization of energy.

Whereas the ergotropic zone, extending from the anterior midbrain towards the hypothalamus, when electrically stimulated consistently produced cycloplegia, increased blood pressure, increased respiratory rate, and heightened motor excitability claimed to be mediated via the sympathetic nervous system.

Although, at times, one of these response may be emphasized, Hess stressed that there were no foci that correspond to individual isolated responses such as in the cortical motor zone. Rather, in the diencephalon we are dealing with a collective representation which include responses of the autonomic system as they make their appearance in the form of synergistically associated mechanism. The similarity between this and the "Relaxation Response" is striking in as much as it also appears to be an integrated hypothalamic response which results in generalized decreased sympathetic nervous response and probably an escalated parasympathetic activity. Benson, et al. (1974), having found out this striking similarity concluded that the tropotropic response in man can be provoked by the Relaxation Response a-dynamia of skeletal musculature, decreased blood pressure, decreased respiratory rate and myosis. Hess stated

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A basic teaching of many meditational organization is that of a little meditation is good, a lot would even be better. This encourages the followers to meditate for a long time. This practice unfortunately lowers the hallucinatory threshold in people already predisposed to such problem.

CARDIOVASCULAR SYSTEM IN RESPONSE TO PSYCHOPHYSIOLOGICAL TECHNIQUES

Anecdotal and Correlational Observations

It should be stressed that these anecdotal and correlational observations could be good only from the vantage of speculations. Where a precise relationship is required between behaviour and cardiovascular responses, they may be grossly inadequate. It is for such a reason that this review would be made strictly synoptic except where a literature contributes significantly to the historical inception of this field.

Graham (1945) observed a high blood pressure in humans exposed to combat. A similar observation was made by Ruskin, et al. (1948) in humans after a natural blast disaster. Chronic occupational stress as experienced by some air traffic controllers was claimed by

Cobb and Rose (1973) to have precipitated sustained alterations in cardiovascular function. Analogously, animal studies indicate considerable cardiovascular responses to psychosocial stimulus situation. Henry, et al. (1967) reported an induced prolonged systolic hypertension in mice exposed to over-crowding and chronic territorial conflict. Imposition of stressful behavioural tasks, like the continuous 72-hour period of shock - avoidance schedules to which Forsyth (1969) subjected some Rhesus Monkeys, produced a blood pressure rise. Also a contemporary shock-avoidance conditioning performed by Benson, et al. (1969) induced an arterial hypertension.

Based on such studies, environmental or behavioural factors have been imputed with various degrees of importance in the aetiology of cardiovascular pathology as contained in the review of Gutman and Benson (1971). Lown, et al. (1973) suggested that acute emotional episodes can precipitate ventricular fibrillation and sudden death and they speculated as regards how the threshold for repetitive ventricular response can be lowered by incessant psychophysiologic embarrassment.

Systematic Investigation

It is only in recent years that systematic experimental efforts are being focussed on controlled laboratory models with the aim of examining the degree to which (i) the cardiovascular changes are produced with psychophysiological manipulations, (ii) the critical psychophysiological variables can be specified and (iii) these findings can be related to the central neutral control of the cardiovascular system. It is also pertinent to emphasize the visceral responses in learning situations in as much as the major thrust in visceral psychophysiology literature has been in this area.

Basic cardiovascular response patterns are manifest in models which permit the stimulus situation to elicit reflexly a specific change. Chosen in this discussion to represent possible examples of the Primary stimulus situation capable of invoking basic response patterns are exercise, postural change, and noxious stimulation. They are the elemental components of more complex behavioural situations like defence; offence, feeding, sexual activity and learning.

Learning Behavioural Models

It seems firmly established that most, if not all, behaviours have cardiovascular concomitants, which represent adjustment in cardiac output and its distribution to meet the metabolic demands of those behaviours. However, what has generated the current interest in this area is not that behavioural-cardiovascular interactions occur but rather that cardiovascular responses, normal or pathological, can occur in anticipation of behavioural demands and that the repeated occurrence of certain behavioural demands may be capable of producing transient or sustained cardiovascular pathology.

It is important to stress here that any training situation generates an appropriate ensemble of learned responses of which cardiovascular adjustments are but one component. The unfortunate thing about the learning situations investigated is that few had allowed analysis with respect to basic response patterns, the literature being largely directed toward demonstrating and characterizing learning with a variety of training conditions and procedures. It is primarily the more recent literature that has begun to deal with mechanism.

Beyond describing learned cardiovascular change and its mechanisms, the other major thrust of the literature involes the role of behaviour in the aetiology and the treatment of cardiovascular pathology. This area of investigation has included diverse approaches, many still preliminary, and the major questions are yet to be answered. The development of effective experimental models and the efforts of such investigators as Forsyth (1969, 1974) and Herd, et al. (1969, 1974) to develop animal models of hypertension are quite promising. Not only do such models allow parametric exploration of the conditions under which pathological responses develop, they may also provide a rigorous means of determining the relative neural and non-neural contributions at various stages of development of the pathology and of determining what occurs in the transition from neural to non-neural maintenance of pathological responses.

Another interesting direction is the hypothesis that pathology develops less from intense repeated metabolic demands than from adjustments made repeatedly without metabolic demand. This situation can occur in the case of learned or anticipatory cardiovascular adjustments. The cardiovascular exercise pattern has been observed frequently in instrumental conditioning paradigms in both dogs and human (Brod, 1963; Forsyth, 1971; Anderson and Tosheff, 1973; Lawler, Obrist and Lawler, 1975; Obrist, et al., 1974) this response can occur in the absence of muscular activity or can exceed the demands of oxygen consumption. Barger, et al. (1966) have reported that dogs trained on a treadmill elevate their cardiac output in preparation for running with little or no change in oxygen consumption as indicated by a decreased arteriovenous oxygen difference. Analogously, in humans it has been reported that during certain behavioural situations oxygen consumption either does not change in association with elevated cardiac output (Brodd, 1963) or increases disproportionately to what would be expected on the basis of the cardiac index (Hickman, et al. 1948; Stead, et al., 1945). It is of interest that such discrepancies between anticipating cardiovascular adjustments and metabolic demand occur most often in behavioural situations in which the organism is given an opportunity to avoid the stressful stimuli by an overt behavioural act (Brod, 1963). Perhaps, this fact contributes to the greater effectiveness of instrumental conditioning paradigms in producing pathology.

Meditational Techniques

For thousands of years philosophers have held that is is possible for man to attain "higher" level of consciousness through meditation techniques. The term "meditation" is difficult for some people to grasp because it may connote exotic Eastern cults or Christian monks who spend most of their waking hours in monastry cells contemplating God. As Ornstein (1973) pointed out in his book "The Psychology of Consciousness"

> impersonal, objective scientific approach, with its exclusive emphasis on logica and analysis makes it difficult for most of us even to conceive of a psychology which could be based on the existence of another, intuitive gestal mode of thought.

Yogi (1969) described this as turning the attention inwards towards the subtlest levels of thought until the mind transcends the experience of the subtlest state of the thought. This expands the conscious mind and at the same time brings it into contact with the creative intelligence that gives rise to every thought. This state is achieved without suggestion, mental control or physical manipulation.

Transcendental Meditation and Autonomic Nervous System

Activation of the sympathetic nervous system produces an increase in the heart rate and respiratory rate, increase in blood pressure, constriction of blood vessels and increased metabolic activity in general. The activation of the parasympathetic system produce effects diametrically opposite. Changes in these responses had been reported in various studies of TM. Allison (1964; 1970) observed a decrease in the rate of respiration during TM. This was confirmed by Wallace (1970) and Wallace, et al., (1971, 1972) who also found a 17% decrease in oxygen consumption, a slight slowing of the respiratory and heart rates as well as a decrease in the ventilatory activity of the lungs. A decrease in the volume of air breathed in each breath as well as per minute was recorded during TM by Corey (1975). Although Wallace, et al., (1971), in an earlier study did not observe any change in blood pressure during TM, subsequently Wallace and Benson (1972) found decrease in blood pressure in 22 hypertensive patients after they had practised TM for a few weeks. A decrease in the metabolic rate was reported in the preliminary observations of Corey (1975), Denray and Singh (1974) during TM. Thus, TM produces physiological changes which are similar to those in other forms of meditation.

Lander, et al. (1972) found a 32% increase in the flow of blood to the forearm in TM, while Riechert (1967) reported an increase of 300%. Most of these increases may be accounted for by an opening of small bloos vessels in the skin due to the reduction of activity of sympathetic nervous system. This inference is further supported by an increase in the resistance of the skin to the flow of a weak electrical current applied from outside - the Galvanic skin response (GSR). A dry skin shows increased resistance while a wet one offers less resistance. Resistance is normally kept high by the secretion of seat and blood flowing through the small vessels. Wallace, et al. (1971) observed an increase in the skin resistance during TM which was confirmed by Orme-Johnson (1973), who also found that there were spontaneous fluctuations in the skin resistance, which were decreased during TM. The responses, apart from being smooth, also showed a much faster habituation to stress in the form of loud noises in TM meditators. Since increased anxiety has been found to decrease skin resistance, the above observations have been taken to mean that TM induces a relaxed state with a more stable autonomic nervous system and a decrease in the anxiety level.

Corey (1975) observed about 25% increase in specific airway conductance (the capacity of air to enter the lung tissues) at the end of a 20-minute period of TM. Possibly, this was due to the relaxation of smooth muscles in their passage. TM has been used to give relief to patients with asthma, Wallace (1971).

A better heat dissipation has been reported in meditators by McDonagh and Zgenos (1975) who found that the body temperature returned to normal more quickly after severe exercise, compared to non-meditators.

The evidence obtained so far during TM thus point to a reduced activity of the sympathetic nervous system in general and to the fact that the parasympathetic system is more dominant.

Biochemical Changes in TM

A decrease in the lactate content of the blood from 11.4 mg to 8 mg/100 ml. was noticed during TM and for some time after it (Wallace, et al., 1971). The lactate in the blood is normally produced during the activity of muscles under conditions of inadequate supply of oxygen, owing to the incomplete breakdown of glucose. It has been suggested that this is due to an increase in blood flow and improved oxygen supply to the muscles, but this has yet to be proved. In fact, it may be interpreted in other ways, too. Normally, during rest, most of the blood is directed to the skin area. Even if, however, there is no change in the rate of production of the lactate, and if the same amount is now diluted by the increase rate of blood flow, its concentration may decrease per unit volume. The decrease in sympathetic activity may further produce a decrease in metabolic activity of the muscles as observed by Wallace, et al. (1971) which in turn may lead to the formation of less lactate. The observation of Wallace (1971) who found no change in the blood flow in the finger in TM does point to a possible substance in blood flow to the muscles, but does not provide a conclusive evidence. Some patients with anxiety neurosis show an increase in blood lactate levels under "Stress"; also, an infusion of lactate in some normal persons can produce anxiety symptoms Wallace (1971). Hence, it has been infered that in TM there is decreased anxiety. This has been further supported by psychological studies since blood lactate is higher in some persons suffering from hypertension than in normal persons, overactivity of the sympathetic nervous system is indicated in them. Decrease in blood lactate during TM may, therefore result from relaxation rather than the other way round.

Claims about other physiological changes from TM have also been made. These are improved performance of athletes, increase in reaction time and improved perceptual discrimination. It has also been claimed that there is increase in weight of underweight and decrease in weight of the overweight and no change in weight of normal-weight persons, Orme-Johnson (1972).

In cases of insomnia, it has been claimed that there is a reduction in the time required to fall asleep. Miskiman (1975), on the other hand, found that meditators recovered quicker from the effects of sleep deprivation for 48 hours as measured by the duration of compensatory dreaming.

The body function show an extreme degree of flexibility in adapting to the needs of an individual. There is a hypometabolic or keyed up physiological state produced by stress, on the one hand, and there is the "wakeful hypometabolic" physiological state described by Wallace, et al. (1971) as resulting from TM, on the other.

Transcendental Meditation and Electroencephalography

Scientists working on brain functions and consciousness have established certain criteria of (EEG) electroencephalogram changes and body functions which enable the identification and differentiation of waking, sleeping, dreaming and meditative states. For this purpose, electrical potentials of the brain were recorded on an electroencephalograph machine and tape recorder, and in several instances their mean square amplitude (intensity) and spectral analysis (study of the intensity of the waves at different frequencies) were done with the help of a computer.

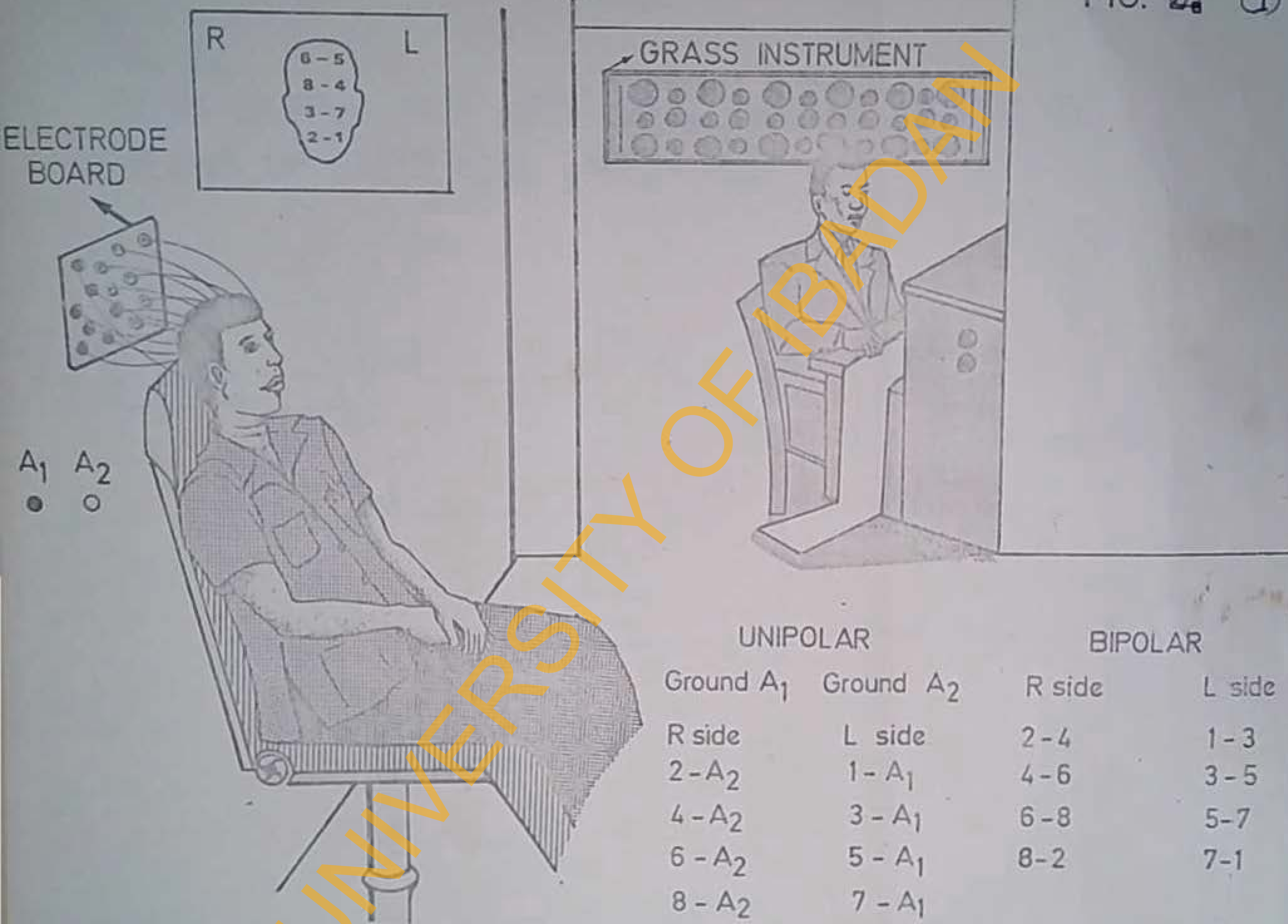
The electrical activity of the brain, as seen on the EEG records, show four broad patterns - alpha, beta, theta and delta waves. The alpha waves have a frequency of 8 to 13 cycles per second (CPS) and are found in normal persons when they are in a restful or relaxed state. Many researchers have found an intensification of the alpha activity during meditation. Anand, et al. and Singh at the New Delhi (1960 and 1961), had observed an increase in the amplitude of alpha activity and its modulation during meditation. This activity persisted and was not blockable, even when different types of sensory stimulation were used. The presence of alpha activity during Yogi or Zen meditation has been reported by several other workers (Wenger and Bagchi, 1959; Hirai, 1960; Kasamatsu and Hirai, 1966). During the Nada Yoga meditation (employing vocal or instrumental music), an increase in amplitude of alpha activity was obtained by replayed music, making the individual extremely attentive to its presence. Changes in other functions of the body indicative of a relaxed state were also reported during meditation. Measurements of physiological variables and brain waves indicate that TM is a unique physiological state different from sleeping and waking - a state of alertness along with restfulness.

Wallace, Benson and Wilson (1971) in their studies on meditation observed increased intensity of the 8 to 9 cycles per second alpha waves in the central and frontal regions of the brains of their subjects during Transcendental Meditation. In 5 out of 33 subjects, this was accompanied by trains of 5 to 7 CPS theta waves in the frontal region of the brain. In three other subjects who reported feeling drowsy at the beginning of TM, flattering of alpha and the presence of low voltage mixed frequency waves with a prominence of 2 to 7 CPS waves were noted. This pattern was replaced with regular alpha activity by the end of meditation. Obviously, these latter subjects had drifted to the sleep state during the slow wave EEG activity (delta and theta waves). These persons possibly felt relaxed because of a short nap which they went through while trying to practise TM. In the unpublished studies of Chhina and others (1969) on 25 subjects of TM, most of whom were personally initiated into TM by Yogi, eight went to sleep and showed prominent delta activity. In nine, an increase in the intensity of alpha activity was observed, while the remaining eight displayed no change in their EEGs with TM. It is possible that either the latter persons may not have been following the instructions properly or that some persons are unable to practise TM.

Another worker, Banquet (1972), from his studies of computerised spectral analysis of EEG in 10 subjects during TM, found that there was a constant tendency of the waves to shift from alpha to slow frequencies which were mostly theta and mixed frequency waves, but also sometimes included low and medium voltage delta waves. There were swift shifts from one frequency to another with a brief sequence of alpha, theta, delta and return to alpha waves. The amplitude of alpha activity increased at the end of meditation. Beta and theta waves were prominent in deep meditation. Alpha waves extended from the parieto-occipital (rear) to the central and frontal areas and frontal beta diffused towards the posterior region. Banquet found periods of uniformity of frequency and amplitude from all leads in deep meditation. In addition, beta spindles of 23 CPS were observed in some subjects. Banquet also reported that the amplitude of alpha rhythm increased and it spread to the frontal region of the brain in the beginning of TM. In the second phase, theta waves diffused to the posterior regions in the form of short theta periods or longer rhythm theta trains. In the third stage, rhythmic amplitude modulated beta waves appeared over the whole scalp. He also observed the synchronisation of electrical waves of the two hemispheres of the brain as well as those from the frontal and posterior poles. A click sound stimulus during TM blocked the theta waves for one to three seconds only, but caused arousal in non-meditators, as seen by the appearance of beta waves. Banquet and Saillan (1974) found an increase in the level of wakefulness and a reduction in the level of activation at the end of TM. These observations find support from some other workers also. Tabecis (1974), however, on a careful analysis, found no appreciable change in the EEGs of meditators, as compared to non-meditator subjects.

These observations suggest that not all individuals practising TM may show identical responses of brain activity. Furthermore, even within the period of about 20 minutes which subjects spend in TM, the state of mental activity varies considerably. At least three phases are indicated by the observations of Banquet (1973). Wallace and others (1971) reported the variability of the effects at least in eight subjects out of 36. These persons showed light sleep in a part of the TM session. Chhina, et al. (1968) saw individuals who went to sleep during TM, and there were those who showed no change at all, apart from some who showed increased amplitude of alpha waves. Most of the persons in the last category had been practising meditation for a longer period than the others. The beta "spindles" found by Banquet (1973) were not reported by Wallace, et al. (1971) and other observers.

FIG. 2 (1)

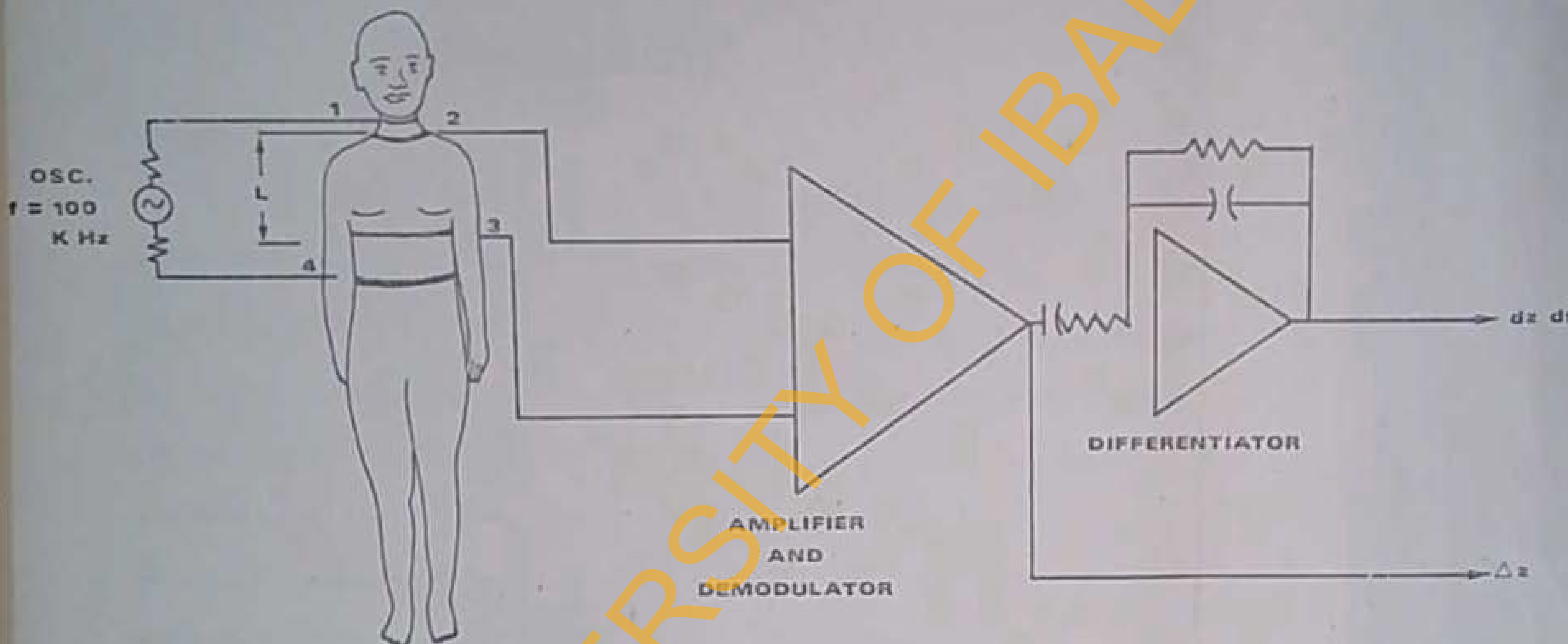


UNIPOLAR		BIPOLAR	
Ground A_1	Ground A_2	R side	L side
R side	L side	2 - 4	1 - 3
2 - A_2	1 - A_1	4 - 6	3 - 5
4 - A_2	3 - A_1	6 - 8	5 - 7
6 - A_2	5 - A_1	8 - 2	7 - 1
8 - A_2	7 - A_1		

THE SUBJECT UNDER RRT AND THE EXPERIMENTER IN THE ADJACENT ROOM WATCHING THE EEG RECORDS TO KNOW WHEN TO OPERATE THE GRASS EQUIPMENTS THAT MEASURES THE VISCERAL RESPONSES ACCOMPANYING THE RRT.

FIG. 2

BASIC SYSTEM FOR MEASURING CARDIAC OUTPUT BY MEANS OF ELECTRICAL IMPEDANCE.



CHAPTER 3

MATERIALS AND METHODS

Approach

In measuring the visceral responses to the prescribed psychophysiologic technique it was important to tamper as little as possible with the subjects' convenience which he needs for the required concentration; and so, this fact has been made a guide in the choice of equipments. The subjects were picked somewhat randomly but the randomness of the sample was limited to the educated community because of language barrier. Volunteers were welcome from all works of life. These included students, clergymen, bankers, chiefs, lecturers and soldiers.

The volunteers were medically checked to make sure there is no disease that might complicate the responses obtained. Cardiopulmonary Diseases like arteriosklerosis, cardiac failure, hypertension (particularly of organic origin), asthma, emphysema etc. were carefully screened. This exercise was carried out by medically qualified people.

Age, diet, social status, marital status, geographical environment, occupation and race were noted while selecting the subjects. Medical history for every subject was compiled. (Horizontal) Longitudinal and (vertical) latitudinal methods of investigation were strictly observed throughout the work to be able to compile, compare, and contrast the effects of acute and chronic practices of the prescribed technique.

Each subject acts as his own control in the pre-meditational, post-meditational and sleep periods. No professional meditator was invited (because I did not know any), and no expert instructor was required in the Relaxation Response Technique as recommended by Benson, et al. (1974). The subjects meditated in one compartment while the records were obtained in another.

The experiment on each subject lasted a total period of about one hour twenty minutes. The period was divided into three segments Pre-, Post- and Relaxation intervals. Pre and Post Relaxation periods were used in taking control readings for each subject. The first ten minutes of these control periods were spent with a REACTION - TIME DEVICE (RTD) constructed by Dr. Oliver Murphy of the Ahmadu Bello University, Human Physiology Department. This game-like exercise helped to steady the subjects mentally, emotionally and physically. A number (3) has been pre-programmed to remain fixed on the digital display component of the device as soon as one of the twin buttons on a connecting panel was pressed. This also electronically operated a period timer-read-out on the control panel to record the time it has taken the subject to react to the appearance of number 3 on the screen. The second ten minutes were spent on physical relaxation and the last ten minutes was spent in taking control readings.

Readings were also obtained in subjects exercising on an ergometric bicycle before and after control periods, that is the beginning and the end of Relaxation period. A chair was constructed such that the iliosacral angle of the subjects sitting in it was greater than 105° but less than 120°.

Electrodes were attached for the various parameters (See Figure 1) and the subject was left alone in the relaxation compartment where he practices the RRT while the experimentor was constantly watching the recording panels of the instrument assembly in the adjacent room.

Materials

The very nature of the work made it imperative that we used two sets of apparatus (1) To detect the period of transcendental meditation and (2) to detect the psychovisceral responses to transcendental meditation. The third apparatus was that measuring the amount of exercise in terms of work done.

Apparatus Indicating the RRT Period

(1) The electroencephalograph Polygraph Data recording system (Grass Instrument Co. Model 7??) whose electrical signals drove four pens of a polygraph recorder (Grass Instrument Co.) equipped with Electric Chart Drive and electrode selector panel. The skin electrodes of silver/silver

chloride were inserted in the occipital, Temporal, Parietal and frontal aspects of the scalp. Bipola and monopolar recordings were made and the ground electrode was placed over an ear lobe.

For this investigation fresh sterilized needless of silver/silver chloride were inserted into the scalp. The impedance of a needle electrode is inversely proportional to the area of contact and is similar to that of a large resistor in parallel with a capacitor; thus there may be attenuation of the signal at low frequencies (Zablow and Goldenshon, 1969).

Any pattern of electrode combination (montages)* was set up using the electrode-switching unit with master selector. A calibration signal, usually 100 UV was simultaneously recorded on all the channels and the gains adjusted so that all the pens gave a deflection of 1 cm. The paper speed was usually 30 mm/sec. with the master gain control adjusted so that pen excursions fluctuate between 0.5 and 2 cm unless a high voltage is anticipated in which case the gain is reduced to prevent distortion due to mechanical restriction of the pen deflections.

After the subject was connected to the electrode board which is connected to the EEG amplifiers, and after the machine was calibrated, the subject was instructed to practice the RRT. The tracing was concurrently scrutinized to observe changes in the

* See Figure 1.

alpha rhythm.

(2) Geddes and Hoff (1956; 1957; 1959; 1961) designed, developed and built the physiograph whose three basic components are the transducer, the processor and the reproducer, a combination of which is called an information data-channel or more simply a channel.

The transducer or pick-up converts the information to a signal which is more easily processed than the original. The processor then received the transduced signal and operate on it. The operation may consist of amplification, attenuation, extraction of the square root or the longarithm or some other mathematical procedure to produce a signal acceptable to the reproducer, a device which converts the signal to a form suitable for reception by the human senses.

The physiograph contains many such channels for measurements of Blood pressure, respiration, heart sounds, bioelectric events (ECG, EMG and EEG). The basic physiograph amplifier is technically known as a direct-coupled amplifier with two knobs for sensitivity and centering controls. The recorder is a rugged d'Arsonval type of moving coil recording pen. It is merely a large galvanometer having enough energy to drive an ink-writing stylus.

One of the six channels of a Narco Biosystems multi-channelled physiograph equipped with appropriate transducers and pre-amplifers was made to record the impedance pneumograph, the ampliture of which indicated the degree of meditation.

Measurement of Impedance Pneumograph (IP)

Plate Electrodes were affixed at the optimum location. With the IP Gain control duly counter clockwise, amplifier Record-Calibrate (R-C) switch was raised. After a period of warm-up, the IPGC was returned clockwise slowly until a tracing of adequate amplitude was recorded. The R-C switch was placed at "calibrate" and then depressed momentarily to introduce an impedance change of 5 ohms into the circuit for standardization purposes. Then it was switched back to "Record" to measure Z equivalent to the lung gas volume. Electrocardiogram recording were obtained directly from the IP amplifier.

Apparatus Indicating the Visceral Responses

The subject should be intact and undisturbed and this fact prompted the use of a non-invasive and easily adaptable method of measuring cardiac output. It has been proved useful in earlier work aimed at comparing this method with the conventional Fick principle and dye dilution (Geddes and Baker, 1968; Hill, et al., 1967; Kubicek, et al., 1967, 1968; Smith, et al., 1970). Electrical Impedance has been used for measuring volume and flow of fluid in many tissues and for determining respiratory ventilation. Kubicek, et al.

(1968) have adapted impedance measurements to the investigation of cardiac function; these studies have indicated that upon passage of a sinusoidal current across the chest, there are impedance changes which are synchronous with the cardiac cycle. The peak value of the first derivative of the impedance wave front has a linear relationship to the peak flow in the ascending aorta as measured with an electro-magnetic flowmeter in the dog; the peak value of the second derivative of the wave form was related to the 1st derivative suggesting that the former might be an index of blood acceleration in the aorta. From such experiments, a partly empirical formula for stroke volume was derived, based on impedance measurements.

Measurement of Impedance Cardiogram

For this investigation an IFM/IMPEDANCE CARDIOGRAPH (instrumentation for medicine Model, 400) was used. It is a four-electrode impedance system developed to monitor left ventricular output (Kubicek, et al., 1967 and 1968). Two band electrodes (3M tape) were placed around the subjects' neck (with at least 3 cm separation), around thorax 1 cm below the xiphisternal junction and the 4th around the abdomen. A sinusoidal constant current (4 mA or less) in the frequency range of 20-100 kH_z was applied to the outer two electrodes (1 & 4). Potential changes reflecting impedance changes (Z) accompanying cardiac activity were recorded between the two inner electrodes (2 & 3). An electronic differentiator was used to obtain the derivative of the impedance change Z.

The equation used to calculate cardiac output is based upon the assumption that the thorax is equivalent electrically to a homogenous cylinder of blood the resistance of which is given by the simple expression $R = {}^{L}/_{A}$ manipulated to give $dv = L^2/Z^2 \, dZ$ if it is assumed that the diameter of the cylinder increases uniformly with ejection of blood where P is the resistivity of blood, L is the length of cylinder, A is the cross-sectional area, dv is the volume (ml) of blood ejected/per heart beat (stroke volume), L (cm) is the distance between electrodes 2 & 3, Z_o is the basal Transthoracic impedance (ohms), dz is impedance change of the cylinder (thorax) if quantity ejected was effective in producing the impedance change (i.e. there is no run-off from the thorax). In fact, to estimate impedance change of Z wave-form i.e. dz/dt max and multiply this by the ejection time, T which transform the equation finally into

$$dv = P\frac{L^2}{Z_o} \, {}^{dz}/_{dt}\, m^T \quad \text{(Karnegis \& Kubicek)}$$

The impedance cardiography was coupled with a Devices recorder.

Indirect Measurement of Blood-Pressure

Various designs of surface electrodes are used depending on the sort of information being monitored. In all cases, Redux Paste or creme (503 ytube, part No. 651-1008 - 1) or Grass electrode cream or gel were used to reduce interference at electrode-skin junctions.

The physiograph (8-channel), air-pressure cuff were connected according to Hoff and Geddes (1968) and the blood pressure was taken according to the Joint Recommendations of the American Heart Association and the cardiac society of Great Britain and Ireland (1937), approved by the Association of Life Insurance Medical Directors of America and also according to James Bordley, et al. (1951). The method recommended by Geddess and Hoff, 1969, put into consideration all the facts translated from Krotkoff's original paper. In this investigation care was taken to follow the above procedures.

Oxygen-Consumption

Because of the intrusiveness of the O_2-consumption methods, not much emphasis was placed on this parameter except in Phase One of this investigation; the open-circuit method was used sparingly. The close-circuit method was carried out by using a spirometer and expirometer. Emphasis was placed on O_2-consumption during exercise by computing from the pulse rate using Astrand and Rymind normogram (1954).

For the Oxygen-consumption during RRT practice, a closed-circuit method was employed in strict compliance with the rules laid down by the introducers Regnault and Reiset (1948). The newly designed Godart Expirograph (Model Number: 16000) was used, to cross-check Benedict-Roth Spirometer recordings.

The Oxygen-consumption in response to cardiovascular methods during exercise was carried out using the open-circuit method according to Jongbloed, et al. (1957); Lukin (1963) and Webb, et al., (1970) and corrections made according to Stoker, et al. (1973).

Effect of RRT on Cardio-Vascular Response to Exercise

To find out the effect of RRT on the overall well-being of the subject one must not lose sight of stress testing as an adjunct to physical fitness.

Of all the stressors that may be faced by an individual exercise produces the greatest challenge to the function of the cardiovascular system and the field of exercise physiology comes alive when one can begin to apply knowledge through measurement of performance. Quite a number of cardiovascular tests are available to be employed in exercise physiology, from those that measure aerobic capacity to those that only estimate it. In the current investigations, the Astrand-Rhyming Test was adopted.

The dynamo ergometer (model KE-11 type 7110, medicor Budapest) whose output is measured with a voltmeter and ammeter the product (volts x amperes) read off on the tachometer giving output in watts. An accesory device coupled to the bike made it possible to regulate the resistance placed on the pedals. Thereby, subjects can work at various revolution per min. Since 1 Kcal per minute is equivalent to 70 watts and also to 427Kg meter per minute the work done is readily converted to Kg meters.

It has been found experimentally that the apparatus is 70% efficient, Murphy, 1976, meaning that the output in watts calculated from the meter reading is only 70% of the power applied to the pedals and so the answer above is multiplied by a factor of 10/7 to correct for the mechanical disadvantage.

An initial ECG recording is made for cardiac evaluation. Then the subject is allowed to warm-up (accommodation phase) to enable his heart to stabilize. Then, by varying the output and resistances he was made to do a known work during which his pulses will be measured and O_2-consumption estimated using the Astrand-Rhyming Normogram. This test was done pre and post BRT in acute and chronic practices.

PLATE 1

I was calibrating the multichannelled Physiograph, while at the background electrodes were being mounted on a volunteer

BELOW

Dr Oliver Murphy was checking the devices coupled with the impedance cardiogram (on his immediate left), while we, (myself & the Technician) were determining the extent to which the subject could stand the rigours of the experiment without any cardiovascular problem.

PLATE 2

PLATE 3

Using the Goddart expirograph, the pulmonary functions of the subject were being determined, pre-exercise.

BELOW
The multichannelled physiograph was being calibrated with the subject connected. This was the most important step before the experiment commenced.

PLATE 4

PLATE 5

How the subject was left alone in a separate room where he practised the RRT while we quietly discussed the findings pre-RRT.

PLATE 6

The RRT was in progress while we operated the Grass company EEG equipment to detect the wave-forms that showed the achievements of the RRT (see figure 2)

PLATE 7

As soon as the the EEG had signified the RRT achievement, we turned to measure the visceral changes that accompanied it.

BELOW

Simultaneously, the impedance cardiogram was obtained from the coupled accessory devices.

PLATE 8

CHAPTER 4

R E S U L T S

(PRESENTED ONLY IN TABULAR FORMS)

TABLE 1

DATA VERIFYING SOME OF THE BASIC CLAIMS MADE BY EARLIER INVESTIGATORS (Refer to page 44)

PARAMETER	TN	TRIAL	PRE	DRG	PST	UNIT	% Response
O_2- Consumption	$22^{-3^{\circ}+}$	X4	260-240	230-200	240-200	ml/min	12-17%
Heart Rate Changes	$40^{-6^{\circ}+}$	"	80-70	80-60	80-70	bpm	0-14%
CO_2-Elimination	$22^{-3^{\circ}+}$	"	220-210	180-160	224-198	ml/min	10-25%
Respiratory Rate	$40^{-6^{\circ}+}$	"	18-16	15-12	18-16	bpm	16-25%
Impedance (INSP)	$40^{-6^{\circ}+}$	"	10-6	18-16	10-6)	)ohm	80-150%
Pneumogram (EXP)		"	7-5	16-14	7-5)	)ohm	140-180%
Electroencephalogram	$20^{-10^{\circ}+}$	"	4-5	10-50	10-20	mv	400-900
			4-6	12-16	5-7	F/min	166-200%
			of 9-10cps wave forms				

$\overline{o}+$ = Number of Female

TN = Total Number

PRE = Pre-RRT

DRG = During RRT

PST = Post-RRT

INSP = Inspiration and

EXP = Expiration

TABLE 2

DATA SHOWING THE EFFECTS OF RRT ON VENTRICULAR STROKE VOLUME IN THE 1ST AND THE 8TH TRIALS

SAMPLE	TN	AGE IN YEARS	Wt(Kg)	$PRE_{1(ml)}$	$PST_{1(ml)}$	$C_1(ml)$	$R_1(ml)$	PRE_8	PST_8	$C_8(ml)$	$R_{8(ml)}$
P_gN_tF	3	18-27	67 ± 1.0	71 ± .8	70 ± .5	70 ± .6	61 ± .8	68 ± .8	68 ± .9	68 ± .8	61 ± .10
N_tM	30	15-30	62 ± 1.3	63 ± .7	62 ± .6	62 ± .6	61 ± .5	58 ± .6	57 ± .5	58 ± .6	54 ± .7
N_tF	25	15-30	54 ± .8	55 ±1.1	55 ± .9	55 ±1.0	54 ± .7	44 ± .7	43 ± .7	44 ± .7	41 ± .5

PRE_1 = Pre-RRT
PST_1 = Post-RRT
C_1 = Control
R_1 = RRT Value

in the 1st Trial

Subscript 8 refers to these values at the 8th Trial

TN = Total Number
P_gN_tF = Pregant Normotensive Female
N_tM = Normotensive Male
N_tF = Normotensive Female

TABLE 3

SHOWS RRT EFFECT ON HEART RATE DURING THE 1ST AND THE 8TH TRIALS

SAMPLE	PRE_1	PST_1	C_1	R_1	% diff.	PRE_8	PST_8	C_8	R_8	
P_gN_tF	78 ± 2.0	78 ± .6	78 ± .4	60 ± .6	23.08	72 ± .4	72 ± .4	72 ± .4	60 ± .5	16.67
N_tM	75 ± .8	75 ± .7	75 ± .7	60 ± 0.8	14.67	66 ± .7	66 ± .9	66 ± .8	59 ± .9	25.76
N_tF	66 ± .7	66 ± .8	66 ± .8	49 ±1.10	25.76	58 ±1.0	58 ±2.10	58 ±1.10	51 ±1.12	12.07

% diff. of the R_8 relative to C_1

P_gN_tF . 23.08

N_tM = 21.33

N_tF = 25.76

TABLE 4

SHOWS THE RRT EFFECT ON CARDIAC OUTPUT DURING THE FIRST AND THE EIGHTH TRIALS

SAMPLE	$C_{1(HR)}$	$R_{1(HR)}$	$C_{1(V)}$	$R_{1(V)}$	$C_{1(O)}$	$R_{1(CO)}$	$C_{8(HR)}$	$R_{8(HR)}$	$C_{8(V)}$	$R_{8(V)}$	$C_{8(CO)}$	$R_{8(CO)}$
P_gN_tF	78 ± .4	60 ± .6	70 ± .6	61 ± .8	5.5±012	3.7±24	72 ± .4	60 ± .9	68 ± .6	61 ±1.0	5.6±.016	3.7 ±.025
N_tM	75 ± .7	54 ± ..8	62 ± .6	61 ± .5	4.5±021	3.3±20	66 ± .8	59 ± .9	58 ± .6	54 ± .7	3.8±.024	3.2 ±.032
N_tF	66 ± .6	49 ± 1.0	55 ±1.0	54 ± .7	3.6±030	2.6±.35	58 ±1.0	51 ±1.2	44 ± .7	41 ± .5	2.6±.035	2.1 ±.030

HR = Heart Rate

V = Stroke Volume

C = Control values)
) the subscripts 1 & 8 indicate the Trials.
R = RRT values   )

TABLE 5

SHOWS EFFECTS OF RRT ON CARDIAC OUTPUT INDEX

SAMPLE	SA	$R_{1(COI)}$	$R_{8(COI)}$
P_tN_tF	1.63	3.37 +.007	2.3 + .014
N_tM	1.57	2.9 +.013	2.1 + .013
N_tF	1.48	2.4 +.020	1.76+ .023

TABLE 6

CARDIAC WORK INDEX

	C_1	R_1	C_1	R_1
P_gN_tF	326.82	202.40	294.68	182.46
N_tM	261.96	186.90	207.19	180.60
N_tF	208.01	156.01	147.01	113.86

SA = Surface Area

COI = Output Index

TABLE 7

EFFECT OF RRT ON BLOOD PRESSURE

	P_s		P_D		PP (P_s-P_D)	
P_gN_tF	$C_1$125±3.0	$R_1$124±2.6	$C_1$70±3.0	$R_1$70±1.9	$C_1$55±01	$R_1$54± 7
	$C_4$123.5±3.2	$R_4$116±3.1	$C_4$68±1.0	$R_4$64±1.6	$C_4$55.5±22	$R_4$52±17
	$C_8$124±2.3	$R_8$110±2.5	$C_8$68±1.2	$R_8$64± .8	$C_8$56±11	$R_8$46±17
N_tM	$C_1$127±2.3	$R_1$127±2.3	$C_1$72±1.1	$R_1$70±1.2	$C_1$55±12	$R_1$57±11
	$C_4$119±2.3	$R_4$118±2.1	$C_4$70±1.0	$R_4$70±1.0	$C_4$49±13	$R_4$48±11
	$C_8$119±1.5	$R_8$118±1.1	$C_8$70±1.1	$R_8$70±1.1	$C_8$49± 4	$R_8$48±01
N_tF	$C_1$120±2.2	$R_1$120±2.1	$C_1$70±.8	$R_1$70±.4	$C_1$50±16	$R_1$50±17
	$C_4$110±1.7	$R_4$110±1.4	$C_4$69±.6	$R_4$68±.5	$C_4$41±11	$R_4$42± 9
	$C_8$108±1.3	$R_8$108±1.1	$R_8$68.5±.5	$R_8$68±.4	$C_8$39.5±8	$R_8$40± 7

TABLE 8

EFFECT OF RRT ON MEAN ARTERIAL PRESSURE MAP

P_gN_tF	$C_1$88.33±09.17	$R_1$88±3.0
	$C_4$86.5 ±08	$R_4$81.33±03.3
	$C_8$86.67±03.7	$R_8$79.33±07.3
N_tM	$C_1$90.33±03	$R_1$89±02
	$C_4$86.33±02.3	$R_4$86±07.3
	$C_8$86.33±07.7	$R_8$86±05.3
N_tF	$C_1$86.67±.0	$R_1$86.67±05.3
	$C_4$82.67±05.7	$R_4$82.00±03.3
	$C_8$81.67±02	$R_8$81.33±1.0

Ps = Systolic pressure

P_D = Diastolic pressure

PP = Pulse pressure

MAP = Mean Arterial Pressure

TABLE 9

EFFECTS OF RRT ON THE LEFT VENTRICULAR STROKE WORK IN KILOPOND/BEAT

	C_1 SV	C_1 MAP	C_1 LVSW	R_1 SV	R_1 MAP	R_1 LVSW
P_gN_tF	70	88.33	8.4×10^{-2}±005	61	88.00	7.3×10^{-2}±003
N_tM	62	90.33	7.6×10^{-2}±001	61	89.00	7.4×10^{-2}±004
N_tF	55	86.67	6.5×10^{-2}±003	54	86.67	6.4×10^{-2}±001

	C_8 SV	C_8 MAP	C_8 LVSW	R_8 SV	R_8 MAP	R_8 LVSW
P_gN_tF	68	86.67	8.0×10^{-2}±007	61	79.33	6.6×10^{-2}±001
N_tM	58	86.33	6.8×10^{-2}±006	54	86.00	6.3×10^{-2}±007
N_tF	41	81.67	4.9×10^{-2}±001	44	81.00	4.8×10^{-2}±005

TABLE 10

LEFT VENTRICULAR SYSTOLIC WORK RATE IN KILOPOND/SEC

	C_1 LVSW	C_1 HR	C_1 LVSWR	R_1 LVSW	R_1 HR	R_1 LVSWR
P_gN_tF	8.4×10^{-2}	78	0.109±006	7.3×10^{-2}	60	0.073±004
N_tM	7.6×10^{-2}	75	0.095±005	7.4×10^{-2}	54	0.066±005
N_tF	6.5×10^{-2}	66	0.072±007	6.4×10^{-2}	49	0.052±007

	C_8 LVSW	C_8 HR	C_8 LVSWR	R_8 LVSW	R_8 HR	R_8 LVSWR
P_gN_tF	8.0×10^{-2}	72	0.096+007	6.6×10^{-2}	60	0.066+005
N_tM	6.8×10^{-2}	66	0.075+007	6.3×10^{-2}	59	0.062+007
N_tF	4.9×10^{-2}	58	0.048+006	4.8×10^{-2}	51	0.041+007

TABLE 11

RRT AND CLINICAL INDEX OF CARDIAC OXYGEN CONSUMPTION

	(C_1)			(R_1)		
	MAP(mmHg)	HR(bpm)	mVO_2(ml)	MAP(mmHg)	HR(bpm)	mVO_2(ml)
P_gN_tF	88.33	78	6889.74± 9.0	88	60	5280.00±20.00
N_tM	90.33	75	6774.75±20.0	89	54	4806.00±16.00
N_tF	86.67	66	5720.22±12.0	86.67	49	4246.83±17.00

	C_8			R_8		
	MAP	HR	$mV)_2$	MAP	HR	$mV)_2$
P_gN_tF	86.67	72	6240.24± 6.00	79.33	60	4759.80±10.00
N_tM	86.33	66	5697.78±10.00	86.00	59	5074.00±16.00
N_tF	81.67	58	4736.86±17.00	81.00	51	4131.00± 8.00

MAP = Mean Arterial Pressure

$mV)_2$ = Myocardial Oxygen Consumption.

TABLE 12

EFFECT OF BRT ON THE TOTAL PERIPHERAL RESISTANCE IN mmHg L^{-1} min (Hybrid Resistant Unit HRU)

	MAP		CO		TPR	
	C_1	R_1	C_1	R_1	C_1	R_1
P_gN_tF	88.33	88	5.5	3.7	16.06±1.06	23.78±1.08
N_tM	90.33	89	4.5	3.3	20.07±1.03	26.97±1.01
N_tF	86.67	86.67	3.6	3.0	24.08±1.01	28.89±1.11

	MAP		CO		TPR	
	C_8	C_8	C_8	R_8	C_8	R_8
P_gN_tF	86.67	79.33	5.6	3.7	15.48±1.01	21.44±1.05
N_tM	86.33	86.00	3.0	2.9	28.78±1.04	29.66±1.06
N_tF	81.00	81.00	2.6	2.1	31.41±1.03	38.57±1.02

TPR = Total Peripheral Resistance

MAP = Mean Arterial Pressure

CO = Cardiac Output

HRU = Hybrid Resistance Unit

TABLE 13

TPR (ABSOLUTE RESISTANT UNIT ARU)

	MAP		CO		TPR in $Nm^{-5}s$	
	C_1	R_1	C_1	R_1	C_1	R_1
P_gN_tF	88.33	88	5.5	3.7	128.48±1.70	190.24±1.00
N_tM	90.33	89	4.5	3.7	160.56±1.80	215.76±1.60
N_tF	86.67	86.67	3.6	3.0	192.64±0.90	231.12±0.70
	C_8	R_8	C_8	C_8	C_8	R_8
P_gN_tF	86.67	79.33	5.6	3.7	123.84±1.90	171.52±1.60
N_tM	86.33	86.00	3.0	2.9	230.24±1.70	237.28±1.50
N_tF	81.67	81.00	2.6	2.1	251.28±1.06	308.56±0.60

TABLE 14

TPR WITH THE SURFACE AREA PUT INTO CONSIDERATION

	MAP		COI		TPT in $Nm^{-5}s$	
	C_1	R_1	C_1	R_1	C_1	R_1
P_gN_tF	88.33	88	3.37	2.30	209.68	306.08
N_tM	90.33	89	2.90	2.10	249.20	339.04
N_tF	86.67	86.67	2.40	1.76	280.88	393.92
	C_8	R_8	C_8	R_8	C_8	R_8
P_tN_tF	86.67	79.33	3.40	2.30	203.92	275.92
N_tM	86.33	86.00	2.40	2.10	287.76	327.60
N_tF	81.67	81.00	1.80	1.40	362.96	472.88

TABLE 15

RRT EFFECT ON VASCULAR COMPLIANCE

	C_1 SV	C_1 PP	C_1 Compliance	R_1 SV	R_1 PP	R_1 Compliance
P_gN_tF	70	55	1.27±002	61	54	1.13±001
N_tM	62	55	1.13±003	61	57	1.07±001
N_tF	55	50	1.10±005	54	50	1.08±002
	C_8			R_8		
P_gN_tF	68	56	1.21±006	61	46	1.33±003
N_tM	58	48	1.18±002	54	48	1.13±001
N_tF	44	39.5	1.11±005	44	40	1.10±003

SV = Stroke Volume

PP = Pulse pressure

TABLE 16

EFFECT OF RRT ON PULMONARY PR 0.2 PRU

	TPR(in PRU) C_1	TPR(in PRU) R_1	PPR C_1	PPR R_1
P_gN_tF	16.06	23.78	3.21	4.76±001
N_tM	20.07	26.97	4.01	5.39±002
N_tF	24.08	28.89	4.82	5.78±002
	C_8	R_8	C_8	R_8
P_gN_tF	15.48	21.44	3.10	4.29±001
N_tM	28.78	29.66	5.76	5.93±002
N_tF	31.41	38.57	6.28	7.71±001

TABLE 17

SYSTEMIC PR (SPR) TPR - PPR

	TPR -	PPR	SPR	TPR -	PPR	SPR
	C_1			R_1		
P_gN_tF	16.06	3.21	12.85±010	23.78	4.76	19.02±012
N_tM	20.07	4.01	16.06±002	26.97	5.39	21.59±011
N_tF	24.08	4.82	19.26±006	28.89	5.78	23.11±001
	C_8			R_8		
P_gN_tF	15.48	3.10	12.38±020	21.44	4.29	17.15±012
N_tM	28.78	5.76	23.02±009	29.66	5.93	23.73±003
N_tF	31.41	6.28	25.13±005	38.57	7.71	30.86±006

PR = Peripheral Resistance
TPR = Total Peripheral Resistance
PPR = Pulmonary Peripheral Resistance

TABLE 18

EFFECT (% RESPONSE OF ILIOSACRAL ANGLE ON THE RESPONSE TO RRT

TN = 10 Trial = 4th

	= 90^0	105^0	120^0	120^0
O_2-Consumption	8%	12%	10%	? sleep
Heart Rate	5%	14%	7%	?
CO_2-Elimination	11%	11%	15%	?
Respiratory Rate	8%	14%	12%	?
Impedence Pneumogram	5%	16%	12%	?
Electroencephalogram	25%	25%	10%	?

TABLE 19

EFFECT (ON % RESPONSE) OF MUSCULAR RELAXATION (MR), CLOSURE OF EYES (CE) AND MANTRA (Mt) RRT ON HEART RATE, RESPIRATORY RATE, IMPEDANCE PNEUMOGRAM

TN = 10 TRIAL = 4th

	MR	CE	Mt	RRT
HR	2%	1%	8%	18%
RR	2%	6%	1%	15%
IP	6%	3%	4%	12%

TABLE 20

THE EFFECT OF TIME ON RESPONSE

TN = 10 TRIAL = 4th

	Morning 8 - 10 a.m.	Afternoon 1 - 3 p.m.	Evening 7 - 10 p.m.
HR	15%	18%	8%
RR	15%	20%	10%
IP	12%	14%	11%

Environmental condition kept normal.

TABLE 21

FUNCTIONAL (DYNAMIC FITNESS TEST DATA AFTER RRT PRACTICE

N = 40

	C					R				
	X	Y	Z	SCORE	PFI	X	Y	Z	SCORE	PFI
10 Nurses	112	108	82	600	50	84	60	56	400	75
10 Med. Students	98	90	82	550	54.5	70	60	50	360	83.3
10 Cleaners	95	85	70	500	60	72	58	45	350	85.6
10 Soldiers	90	81	69	480	62	65	53	42	320	90

PFI = Physical Fitness index

X, Y and Z are number of Pulses taken by 1st minute 2nd minute and 3rd minute.

TABLE 22

EFFECT OF RRT ON PHYSICAL WORK CAPACITY AT 85% MAXIMUM HEART RATE (PWC 85% HRm) i.e, THE AMOUNT OF WORK NEEDED TO ELEVATE HR to 85% OF THE MAXIMUM

	C			R		
	Work (w) Kgm	VO_2max	SV(ml)	Work (w)	VO_2max	SV
10 Nurses	366 at 60 rpm	1.97 ± 001	200 ± 6	396.5 at 60rpm	2.05 ± 003	213 ± 5
10 Med. Students	549 at 50 rpm	1.70 ± 001	248 ± 4	597.8 at 50rpm	1.80 ± 002	$261\pm$[illegible]
10 Cleaners	610 at 60 rpm	1.93 ± 005	250 ± 3	713.7 at 60rpm	2.15 ± 001	$270\pm$[illegible]
10 Soldiers	610 at 70 rpm	2.10 ± 002	273 ± 5	732 at 70rpm	2.30 ± 003	$290\pm$[illegible]

TABLE 23

EFFECT OF RRT ON EXERCISE FACTOR

	CO^C	CO^R	mVO_2^C	VO_2^R	Exf_C	Exf_R
10 Nurses	0.40±011	0.67±003	0.70±010	0.80±016	51%	84%
10 Med. Students	0.60±001	0.64±004	1.30±022	0.82±008	46%	70%
10 Cleaners	0.70±012	0.88±002	1.64±012	1.02±007	43%	86%
10 Soldiers	0.60±021	0.87±003	1.40±003	1.14±021	43%	62%

CO = Change in Cardiac Output
mVO_2 = Change in cardiac oxygen consumption
Exf^2 = Exercise Factor.

TABLE 24

OTHER PARAMETERS RELATED TO CARDIAC DYNAMICS

HEATHER INDEX & RRT INFLUENCE

	Pre Exercise (C_1)		Oost Exercise (C_2)		Post Exercise R_8)	
	n/s	sec	n/s	sec	n/s	sec
	$(d_z/d_t)max$	(Q - Z)	$(d_z/d_t)max$	(Q - Z)	$(d_z/d_t)max$	(Q - Z)
P_gN_tF	1.79	124×10^{-3}	1.87	89.67×10^{-3}	2.03	73.33×10^{-3}
N_tM	1.89	124.67×10^{-3}	2.00	93.33×10^{-3}	2.33	78.33×10^{-3}
N_tF	1.71	112.33×10^{-3}	1.91	83.33×10^{-3}	2.19	73.33×10^{-3}

$(dz/_{dt})max/Q-Z$ C_1	C_2	C_2/C_1	$(dz/_{dt})^R max/Q-Z$	
14.4±02	21.0±01	1.5 approx.	27.70±03	2 approx.
15.2±04	21.4±05	1.5 "	29.0±03	2 approx.
15.2±04	22.9±03	1.5 "	29.9±04	2 approx.

FIG.4

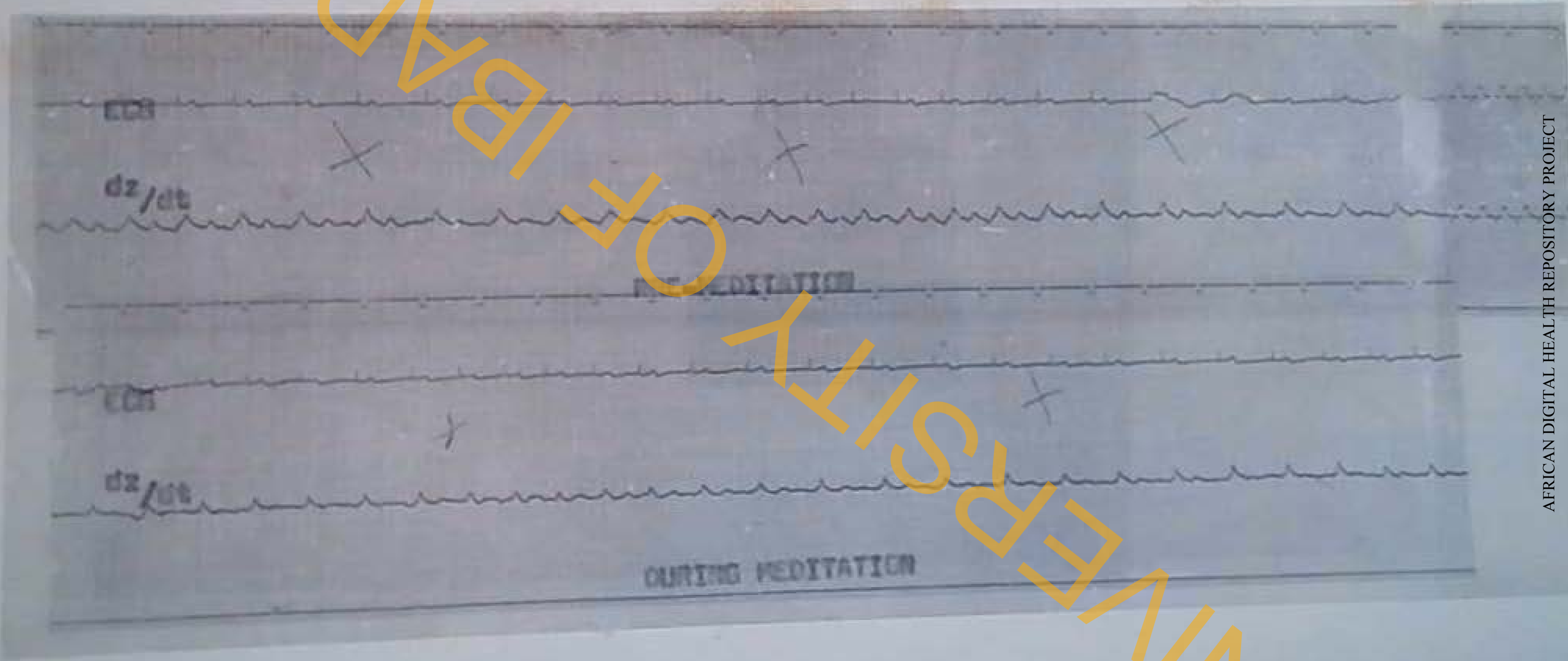
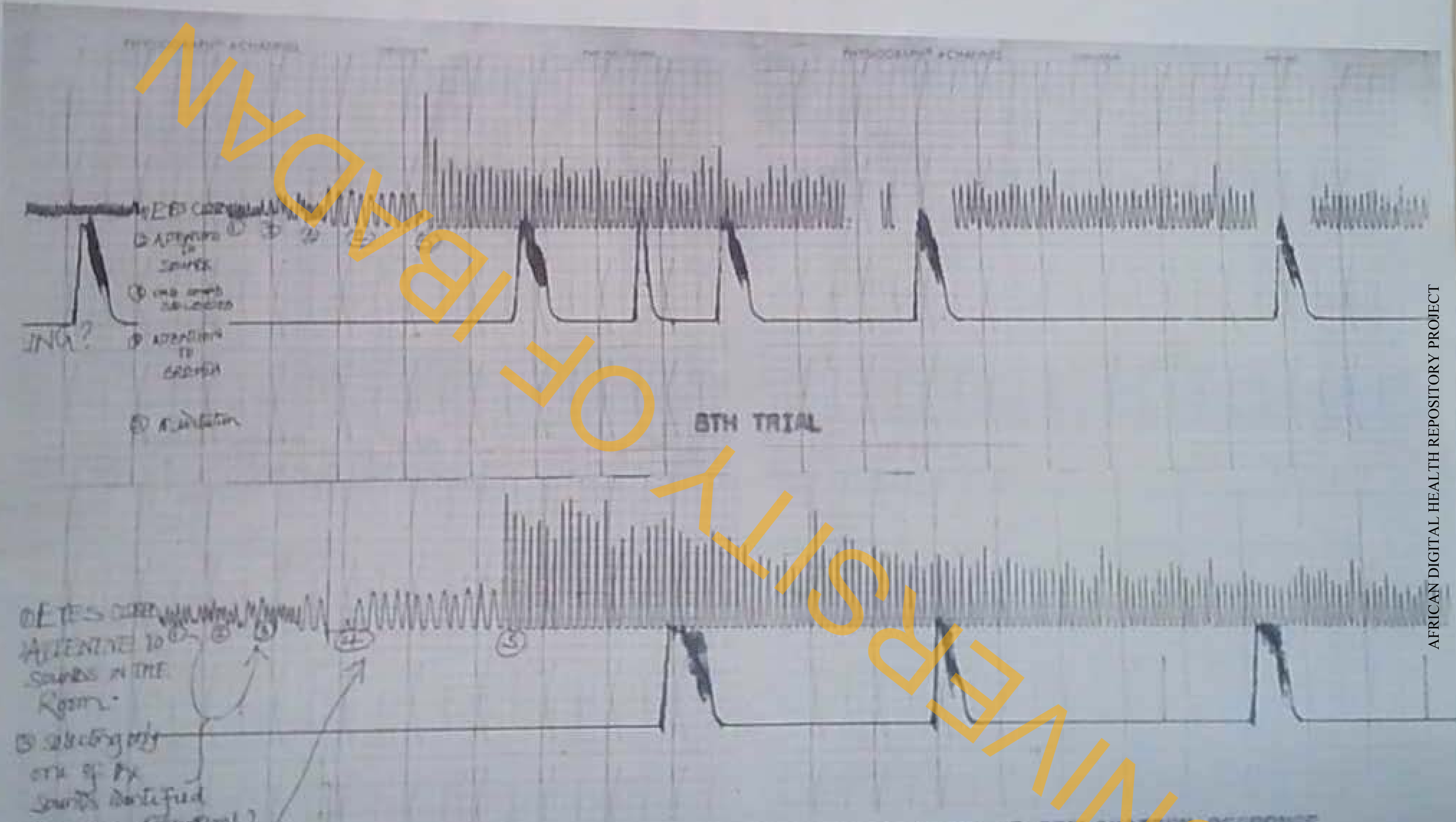


FIG.5

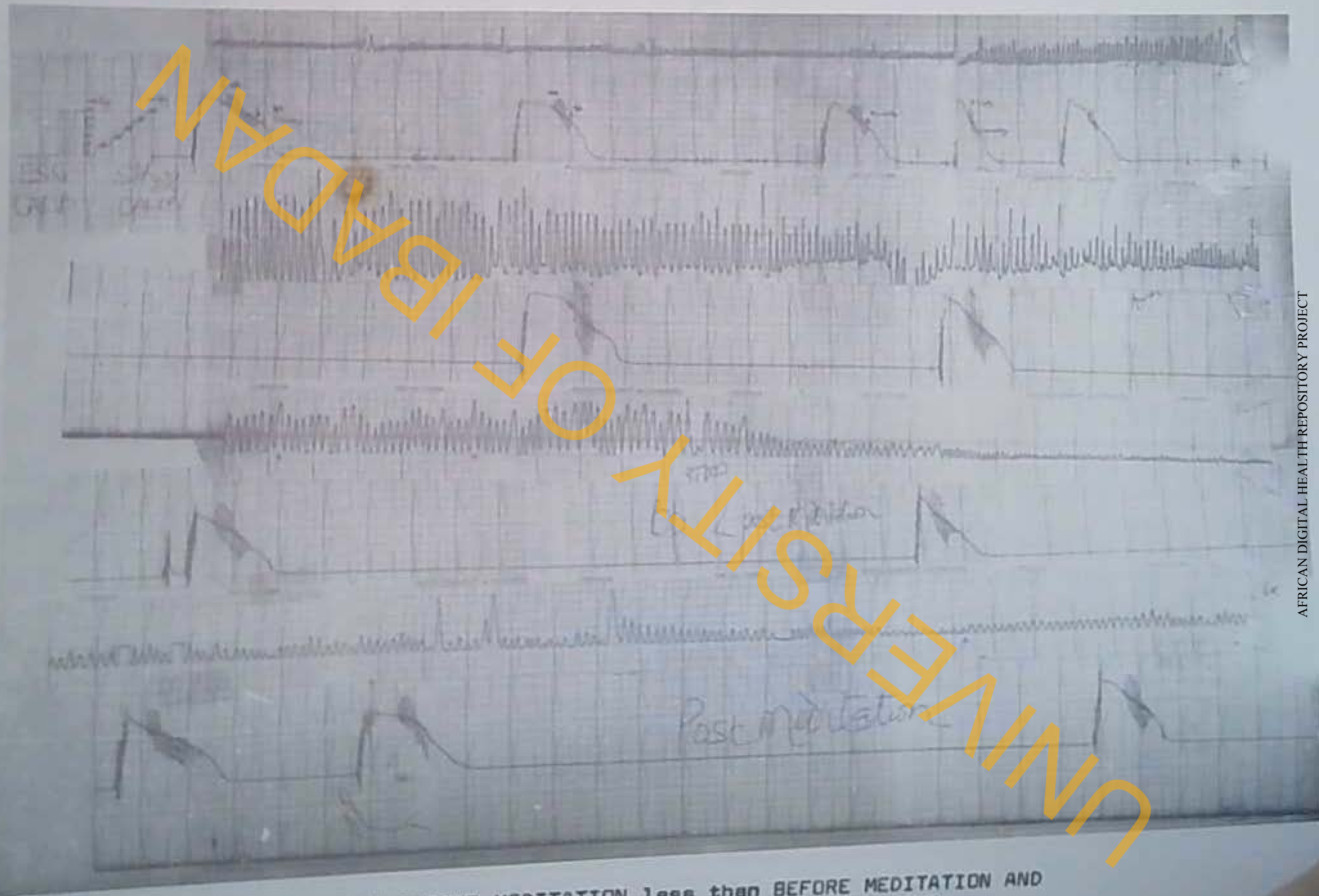


IN THE SAME SUBJECT, THE REPRODUCIBILITY OF "RELAXATION RESPONSE IS DEMONSTRATED IN THE PATTERNS OF THE IMPEDANCE PNEUMOGRAMS OF OF THE 1ST & 8TH TRIALS

FIG.6

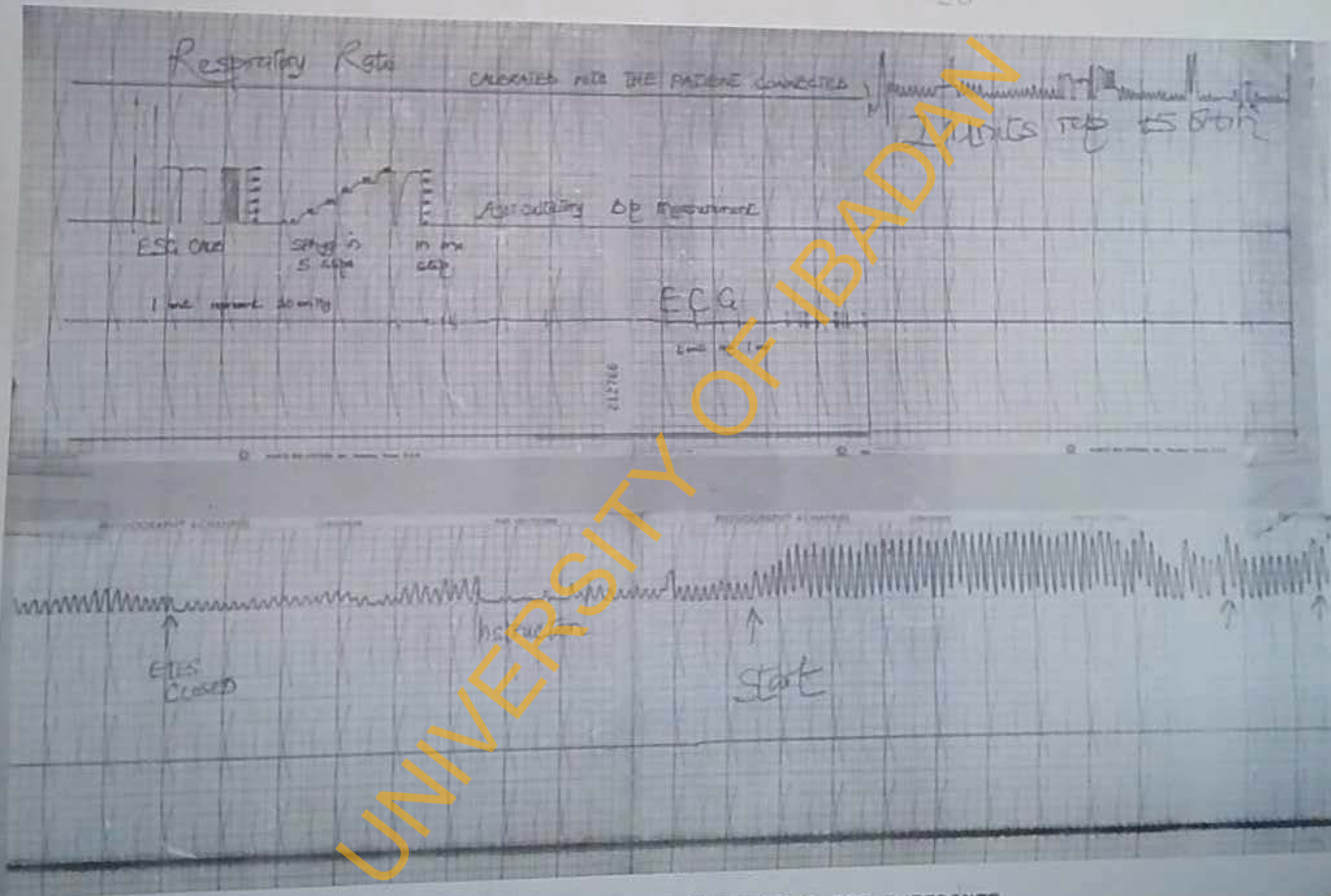
A SIMULTANEOUS RECORDING OF THE PARAMETERS ON A SIX-CHANNELLED PHYSIOGRAPH

FIG.7



BLOOD PRESSURE (BP) DURING MEDITATION less than BEFORE MEDITATION AND AFTER MEDITATION. (IP MEASURES THE EXTENT OF RRT ACHIEVEMENT.

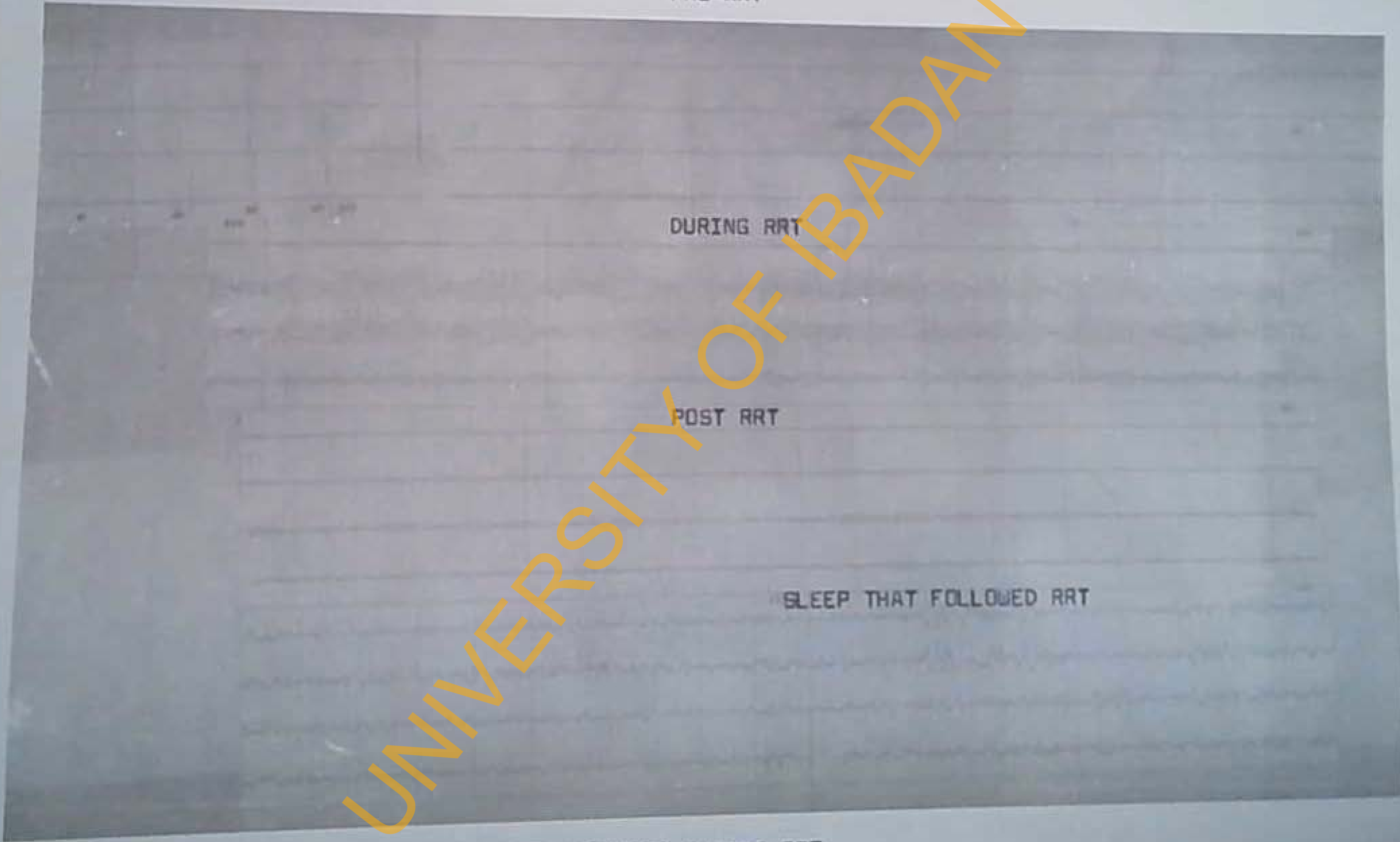
FIG.8b



CALIBRATIONS OF RESPIRATORY RATE, BLOOD PRESSURE & ECG IMPEDANCE PNEUMOGRAM IS SHOWN TO VARY WITH THE INSTRUCTION CARRIED OUT.

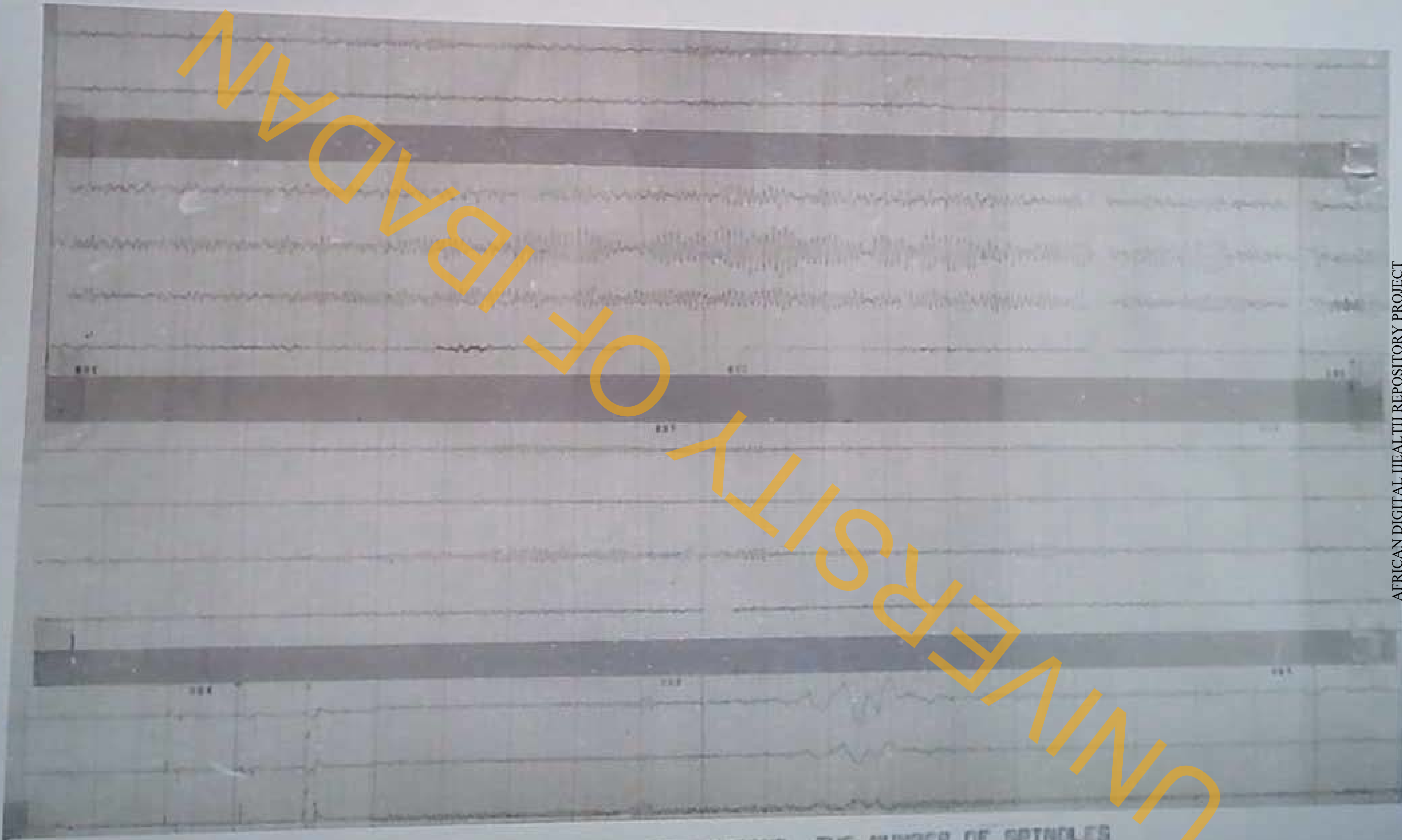
FIG.9

PRE-RRT



ALPHA SPINDLES ARE MORE PRONOUNCED DURING RRT

FIG. 10



EEG WAVE FORMS COMPARING THE CYCLE PER SECOND, THE NUMBER OF SPINDLES AND THE AMPLITUDE OF THE WAVES DURING ART AND POST ART.

CHAPTER 5

ANALYSIS OF RESULTS

The collection, tabulation, calculation of various indices describing the central tendencies, degrees of variability, relative standings and correlations from any set of observations represent, broadly speaking, the scope of "descriptive statistics". The results shown in the previous chapter are a tabulation of collected data with columns for the description of the Mean as a measure of the central tendency, the Range as a measure of the variability or scatter and the Percentage as a measure of the relative standing where appropriate. Mean, range and percentage are the statistical ideas presented so far here not only because they satisfy the purpose of the text but also because they are the most readily understood representative of their class.

The Mean

In each volunteer the mean of five responses taken from the six recorded observations Pre, During and Post RRT periods were obtained in the first place. Since the individual volunteer belongs to a group (sample) and in so far as it is the group, rather than the individual, that counts in the overall assessment of the data, the mean for the group is calculated from the mean values of which the group is comprised.

$$\frac{\Sigma (\bar{X})_n^1}{N} = \bar{\bar{X}}$$

Where Σ is the summation of the mean values $\bar{X}$ From 1 to n where n is the number of individual means. N is the number of observations.

The Range

The smallest mean in each sample is shown as it varied from the largest. This is done only in one instance (i.e. in Table 1) and in that single instance it is considered suffice in as much as the purpose was to compare the variability of the parameters so as to select which of them is reliable as an indicator of the psychophysiologic technique adopted. This is only the sketch of idea needed for a projection.

The Percentage

This measure of relative standing was considered useful here because the experimental scope revolves around finding by how much the Relaxation Response values differ from the control. The percentage offers a straight forward comparison.

However, because of the high probability of errors normally attendant to the high degree of inconsistency in biological systems (assuming it is not compounded by the errors due to equipments and that due to the experimenter's acuity) the means, the ranges, and the percentages have their limitations in representing the actual facts about the population, even when they are adequate for the sample.

To predict, therefore, the future or learn things about a population, it is necessary to employ the branch of statistics

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To predict, therefore, the future or learn things about a population, it is necessary to employ the branch of statistics that goes beyond description to infer unknown data from known data. This is the scope of inferential statistics. The main tools of inferential statistics are: point estimates, confidence intervals and significance Tests. In point estimation, the best single or group of value that can be used to estimate a parameter is selected. This is the premise on which all the graphs shown in the text are based. The confidence interval is considered here unnecessary because the experiment is not aimed at obtaining any precise value, but the relative standing of values. In order therefore, to determine whether the means of the paired data (control and RRT values) are significantly different from each other, the strategy of testing the Null hypothesis is adopted. In other words, the test is to see whether the mean differences can be explained as chance fluctuation about a common mean in the population.

Statistical Test of significance were not shown on the table but mentioned where they are specifically relevant in the discussion, that is, that section of this text that expartiates on the descriptive and inferential statistics of the data presented in the previous chapter. Where it was necessary, the parametric t-test for paired data was adopted on the assumption that the sample was normally distributed.

Since the 5% level is more "generous" in accepting statements as true than is the 1 percent level, it is less likely to miss real differences or effects existing in nature and so, this is the level of significance adopted here.

The information relevant to this aspect of inferential statistics shown on the table is the standard deviation of the means, called the standard error of the mean (symbolized SEM or Sm) is easily estimated from the formular $Sm = \frac{s}{N}$ where s is the estimated standard deviation and N the number of observations. Thus the means are express $\pm$ SEM.

$$t = \frac{\text{Difference in the Means of Means}}{\text{standard Error of the difference in Means}}$$

$$= \frac{\bar{\bar{X}}_1 - \bar{\bar{X}}_2}{\frac{s}{N}}$$

where s =

$$\sqrt{\frac{(\bar{\bar{X}}_1 - \bar{\bar{X}}_2)^2 - (\frac{(\bar{\bar{X}}_1 - \bar{\bar{X}}_2))^2}{\cdot})}{(N - 1)}}$$

The Null hypothesis is that there is no difference in quantity $\bar{\bar{X}}$ before and after RRT application and that, consequently $\bar{\bar{X}}_1$ & $\bar{\bar{X}}_2$ are drawn from the same normal population and that $\bar{\bar{X}}_1 - \bar{\bar{X}}_2$ is normally distributed about a mean equal to zero.

In analysing these results, statistics (tool for induction) and Mathematics (tool for deduction) were employed to the required advantage. In the previous paragraphs methods of induction were stated. In this paragraph and the succeeding ones mathematical deductions from the measured data are discussed.

Cardiodynamic and Haemodynamic variables

Measured data for individuals are not shown to allow for the economic management of space and for the neatness of presentation, otherwise, 5 x 16 x 8 data (the number of sessional observations, number of parameters and number of trials) would have been shown for each of the 120 volunteer subjects, meaning 120 Y-axis columns and 640 X-axis columns!

Mathematical deductions were made for

1) stroke volume
2) cardiac output
3) cardiac output indices
4) cardiac efficiency
5) left ventricular work
6) left ventricular ejection rate
7) Myocardial oxygen consumption index
8) Peripheral resistance
9) vascular compliance and
10) Mean arterial pressure

From the measurements of

1) Heart rate
2) Transthoracic electrical impedance
3) Electrocardiogram
4) Blood pressure and
5) Oxygen consumption

With the following acting as signal parameters

1) Electroencephalogram and

2) Impedance pneumogram

Table 2

Stroke Volume is calculated according to Kubicek and Kanegis (1970) from the equation

$$V = \frac{L^2}{Z_o} / \left(\frac{dz}{dt}\right)_{max} \text{ LVET}$$

where V = left ventricular volume

P_o = Blood resistivity as determined by the Haematocrit (Kubicek's noraogram) assumed for normal people with 45% Hct to be about 135 ohms

L = Mean Distance between $\neq_2$ and $\neq_3$ (the two inner electrodes) kept constant at 24 cm recommended

Z_o = Mean Body impedance of about 25 ohm in all the groups

$(dz/dt)_{max}$ = Maximum rate of reduction in maximum Transthoracic Electrical Impedance (TEI) accompanying the cardiac cycle. TEI is inversely proportional to the blood within the heart and the great vessels. Its first derivative here is being utilized to estimate the left ventricular stroke volume, the rapid ventricular ejection phase.

T = Left Ventricular Ejection time (LVET) in seconds obtainable from the simultaneous waveforms recording of ECG and Electrical Impedance, R-Z or Dr Loran Heather's Q-Z.

Also in the calculation of Heather Index (Table 24)

$(dz/dt)_{max}/Q\text{-}Z$ Amount Injected per time

Claimed by Loren Heather (1970) to be a very sensitive index of cardiac responses to exercise. In a normally functioning Heart it should increase during exercise. Since $(dz/dt)_{max}$ coincides with the rapid ejection phase, it is a measure of cardiac ability to cope with stress.

The Heart Rates (HR) was calculated in hearts per minute from TEI tracings thus: (Table 3)

60c/t

where c = Number of cardiac cycles during an interval of t sec

t = Nd

where N = Time line interval (1)

d = Each time line in seconds (1/vp)

If, for example,

Paper speed = Vp (mm/sec)

Duration = Lmm on the segment of tracing

then HR = 60c/ND = 60c/L ÷ 1/vp

<u>e.g.</u>

$c = 5$

$N = 95mm$

$V_p = 25mm/sec$

$d = 1/25$ or $0.04sec$

$60c/Nd = (60 \times 5)/(95 \times 0.04)$

$= 79$ beats per minute (bpm)

(In all cases, below reference was Singh Yang, et al. 1974).

The Control for each observation is calculated as a mean of Pre- RRT and Post- RRT values as the central tendency of visceral behaviours outside the meditational periods except where it is stated otherwise.

Cardiac Efficiency (CEff) = CW/mVO_2 (Mentioned only under general discussion)

if CW = SV x MAP and

$mV/2$ = MAP x HR

$$CEff = \frac{SV \times MAP}{MAP \times HR}$$

$= SV/HR$

Total Peripheral Resistance TPR was obtained thus

MAP/CO (Table 12)

in Hybrid Resistant Unit (HRU)

of mmHg L^{-1} min^{-1}

or in Absolute Resistant Unit (ARU)

of Nm^{-5} sec

HRU & ARU are known as

Peripheral Resitant Unit (PRU)

Vascular Compliance = SV/PP in ml mmHg^{-1} (Table 15)

Pulmonary Vascular Resistance PPR)

= 0.2 PRU Table 16)

Systemic vascular Resistance (SPR)

= TPR - PPR Table 17)

Harvard Test for Functional or Dynamic

Fitness Test (Table 21)

Physical Fitness Index

$$= \frac{\text{Exercise duration (sec)} \times 100}{2\ \text{(Total Number of Pulses)}}$$

Exercise

Start^{O}	Time	1	1½	2	2½	3
Period	No. of					
O	pulses	X	wait	Y	wait	Z

For example,

PFI for 5 minute exercise

$$= \frac{5 \times 60 \times 100}{2(X + Y + Z)}$$

S	Score		
	55	=	Poor
(55 - 64)%		=	Low average
(65 - 79)%		=	Average
(80 - 89)%		=	Good
90%		=	Excellent

(Table 22)

Maximum Heart Rate = 220 - Age in Years

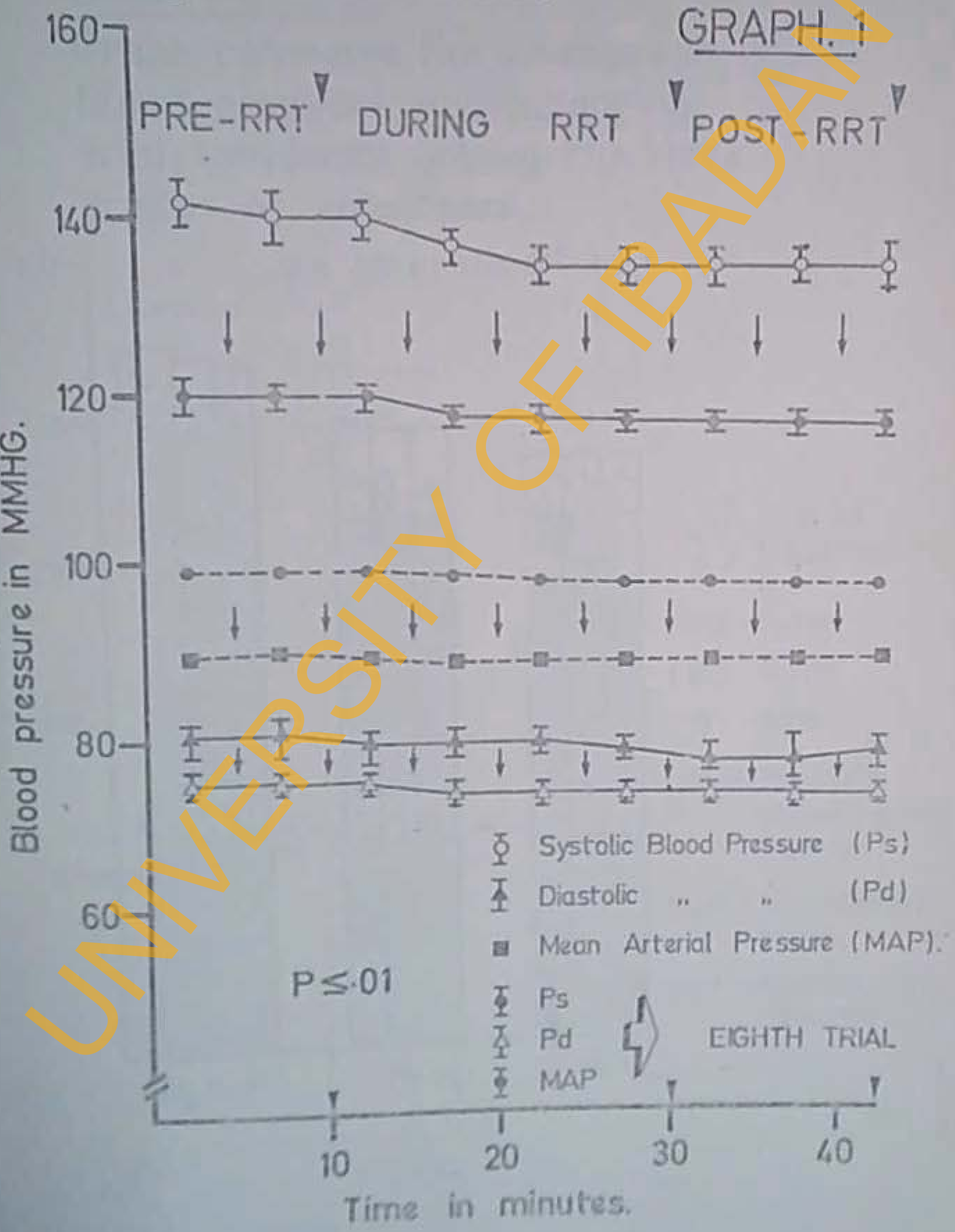
Work done on Ergometric Bike = Watts

70 Watts = 1Kcal = 427 Kgm

Another Index of cardiac Response to exercise when working against 40 watts at 30 rpm (Table 23)

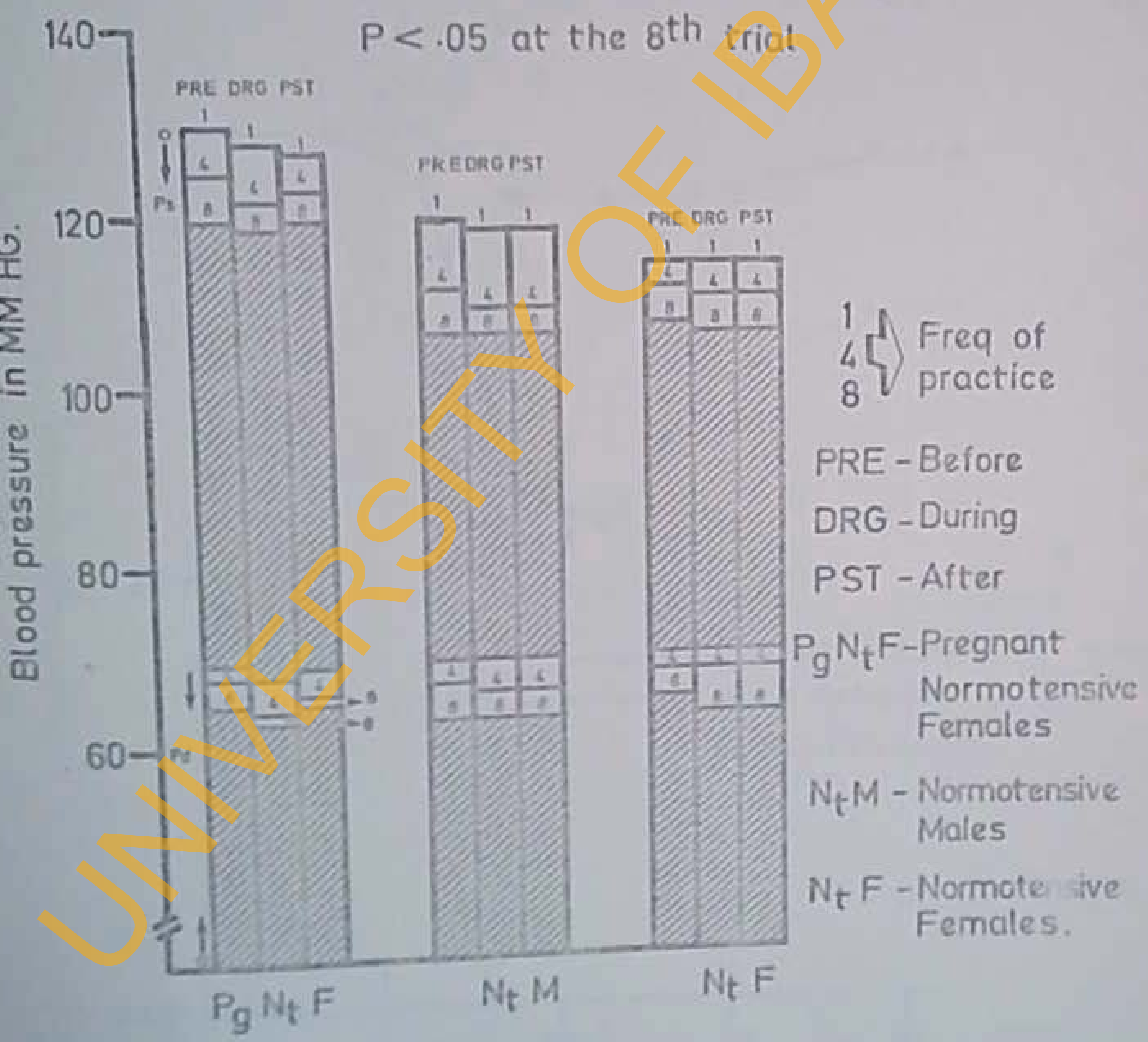
$$\text{Exercise Factor (ExF)} = \frac{\text{cardiac Output} \times 100}{\text{oxygen consumption}}$$

Graph of blood pressure changes in five subjects in their first, and eighth RRT trials.



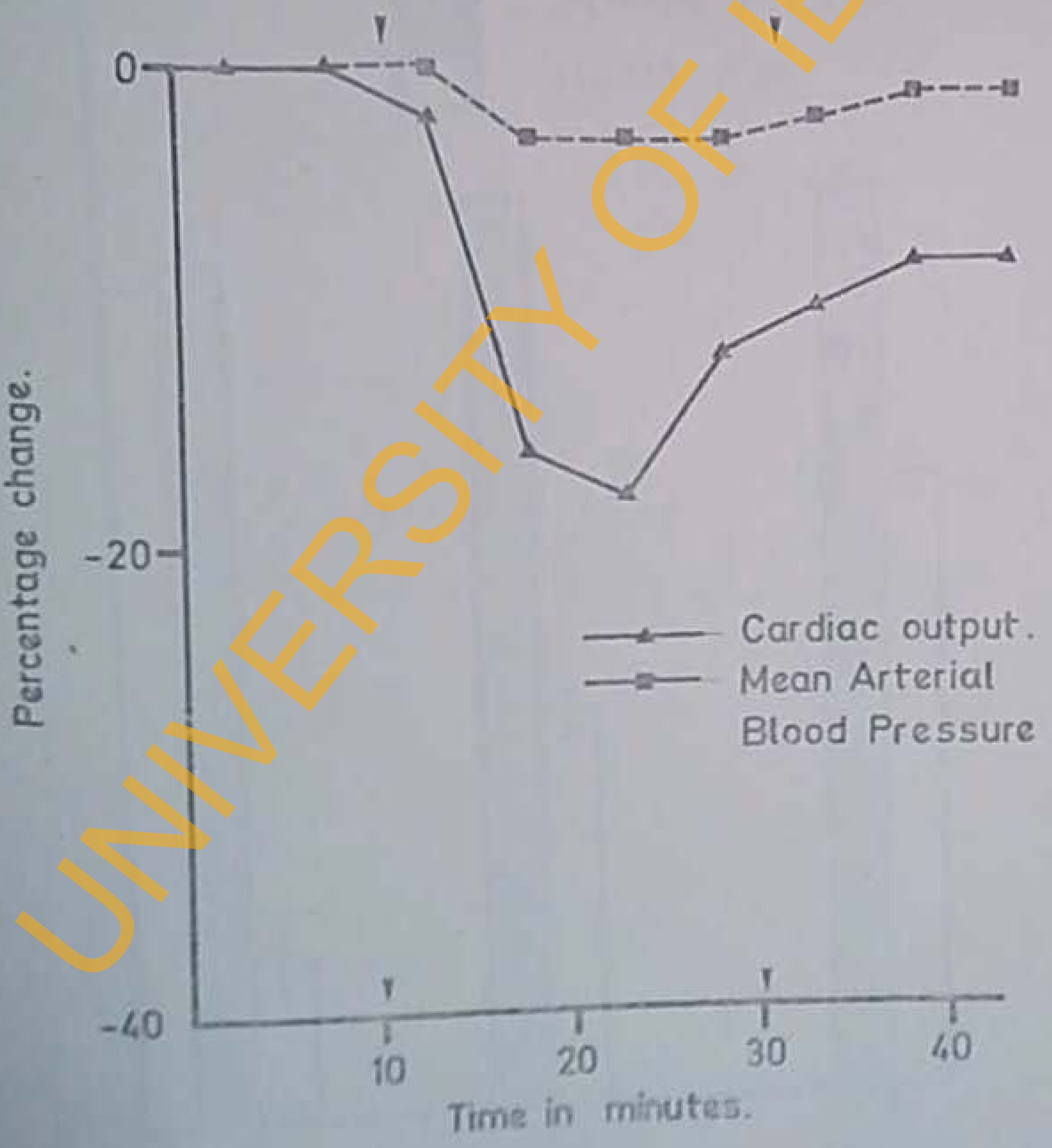
GRAPH. 2

Graph compares the changes in blood pressure accompanying trial frequency among the three groups of volunteers.



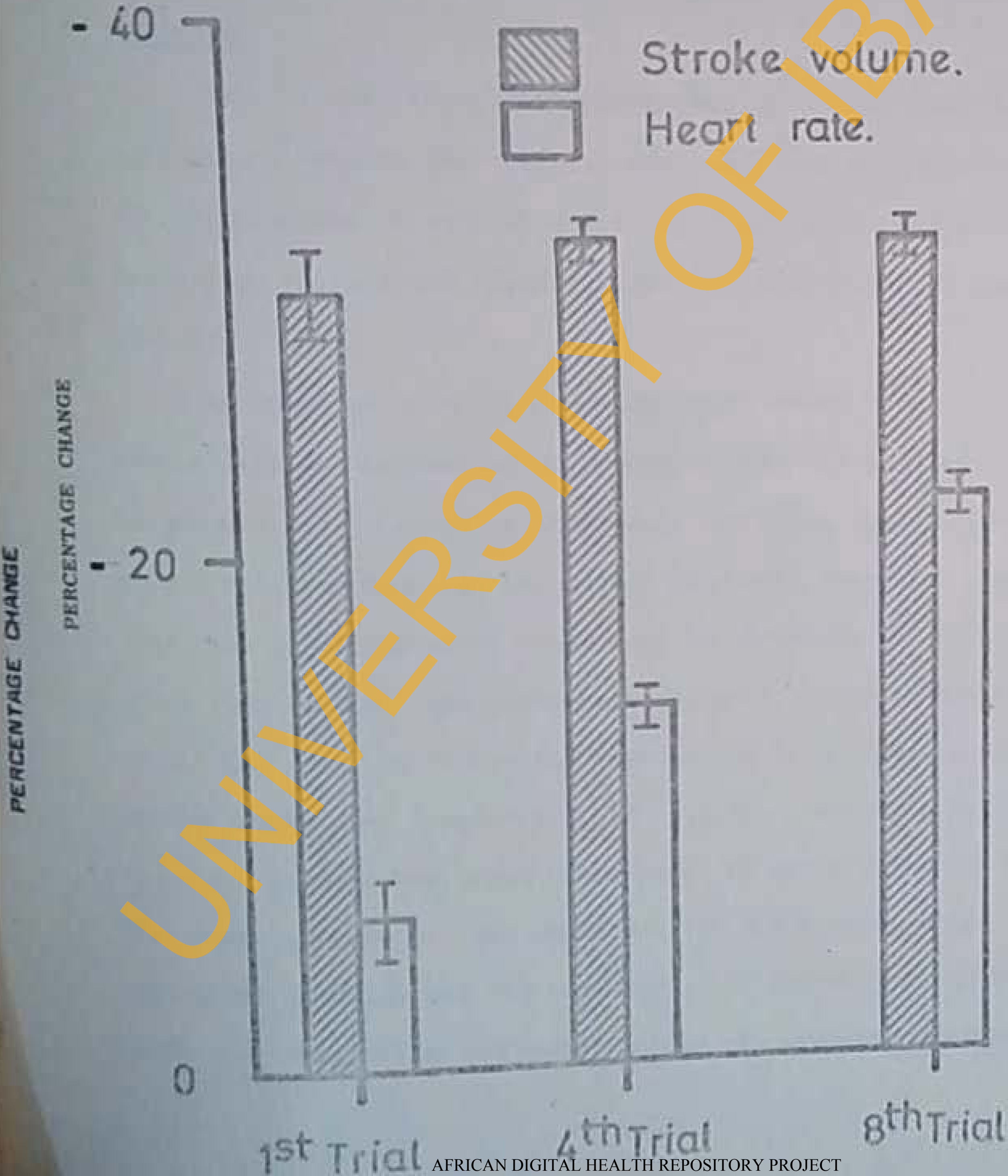
GRAPH. 3

Graph compares the changes occuring in cardiac output and mean arterial pressure during a single RRT session in a volunteer who had practiced RRT for five days at 20 minutes a day.



Graph 4

Pecentage change in heart rate and stroke volume in five normotensive males (18 - 25 Years) during three RRT trials.



CHAPTER 6

COMMENT ON RESULTS

The results presented came from observations made in the three main phases of the work and the adjunct phase which gives an idea of the effect of RRT on the physical performance at work. This discussion would be made under the pertinent phase.

Phase One

This is the pilot phase which aims at establishing a correlation between the visceral responses and the responses to the RRT practice as well as selecting which of the parameters claimed by the earlier investigators can be regarded as the most reliable.

As shown on Table 1, O_2-consumption, Heart Rate Changes, carbon dioxide elimination, Respiratory Rate and Impedance pneumogram give a range of percentage reduction which is not only persistent but also big enough to arouse interest. For this test, the total number of volunteers involved was 62, 9 out of which were female. The percentage of people that did not respond at all was 10%. To reduce the variability of the result, the age of adults were limited to $\geq 18 \quad \leq 30$. The EEG data are separated because the trend of response is not a reduction like in the other parameters. The amplitude (in microvolts) increased during the practice and the number of 9-10 cycles per second wave forms (Alpha spindles) increased. This was persistently observed.

The correlation coefficients always tend to Unity in all the observations (i.e. there is positive correlation between the psychological and physiological moieties in each session of RRT practice).

However, to correct for the deficiency of the earlier investigators who had no means of telling when or to what degree the volunteer is practising the technique, one needs to juxtapose an equipment which measure the most reliable correlates of Relaxation Response while attempting an investigation in to new areas. The first step in this direction is to select which of the parameters earlier claimed to be affected are the most reliable correlates.

It is easy to find that EEG stands out as the best: followed by Impedance pneumogram (IP). The two have additional advantages of

1) Visual assessibility
2) Reproducibility
3) Instantaneous presentation
4) Electronically representable in graphical forms and
5) Convenient for the volunteer and the experimenter.

(Refer to the Figures 4 - 10).

Not only is oxygen-consumption and carbon-dioxide elimination cumbersome and time consuming to measure on the part of the investigator but also they are intrussive on the convenience of the practitioner, a fact which probably explains the low percentage responses. Heart

Rate change is the least responsive and it, in addition, fluctuates with sinus arrythmia.

Phase Two

Having established that there is a correlation between the technique and the visceral responses, a new set of parameters were investigated. Such parameters are such that inductive and deductive inferences are drawn regarding the dynamics of the cardiovascular system. The new set of parameters are:

(1) Stroke Volume (left ventricular)

(2) Blood pressure

(3) Cardiac output

(4) Peripheral resistance

So far, to my knowledge there had been no publication regarding stroke volume and peripheral resistance measurements. Regarding Blood Pressure,

(1) Transcendental Meditation (TM) reported no change

(2) Contention, ditention, sentic cycles, Progressive Relaxation had not been applied

(3) Yoga and hypnosis gave inconsistent and inconclusive results.

About Cardiac output

(1) There is no published investigation

(2) The only example mentioned in the literature during the 26th annual conference of World Physiologists was based on Transcendental Meditation as taught by the

Gurus (Wallace (1970).

(3) Even that example was by catheterization which is invassive and intrussive to the fundamental premise of the psychophysiologic Technique.

In this work, to be able to estimate cardiac output from the values of left ventricular volumes, Heart rate (in contra-distinction to Heart rate changes discussed in phase one) measurements were carried out. Table 2.

The total number of subjects involved was 60 out of which (a) 11 (18.33%) failed to respond, (b) 4 (6.67%) responded by volume increase, (c) 45 (75%) responded by volume decrease. The number responding by greater than 5ml volume increase was 1 (1.67%) of total or 25% of (b)); those responding by less than 5 ml volume increase are 3 (5%) of total or 75% of (b)). The number that responded by more than 5 ml volume decrease are 24 (40% of total or 53% of (c)); those responding by less than 5 ml volume decrease are 21 (35% of total or 46.67% of (c)). The number of (b) that responded by first Trial was 50% (b) and the number responding by second Trial was 100% (b). The number of (c) responding by 1st Trial was 66.67 of (c) the number responding by second trial was 70%, by third trial was 75% and by the 8th trial was 100%. This shows an improvement with trial frequency and the trend of response was reduction. Within the groups shown, there was a correlation between the age, sex as well as

Gurus (Wallace (1970).

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	% change	1st Trial		% change	8th Trial
I	PgN_tF	12.86%	II	10.29%	
	N_tM	1.61%		6.90%	
	Nt^F	1.82%		6.82%	

whereas the % difference of 8th trial values relative to

1st Trial control values

III	PgNtF	12.86%
	NtM	12.90%
	N_tF	23.64%

From the above analyses (I & II), it would appear that pregnant women are sensitive to acute RRT practice and that the other groups improve with trial freqnency while the pregnant ones stabilized. In III where the 8th trial results were compared with the starting control values, all the three groups were found to have responded well. The gradual fall in stroke volume seem to have overwhelmed the restoration mechanism. Table 3.

Total number of subjects = 60

(a) Number responding by increased frequency = 1 (1.67%)

(b) Number " " decreased frequency = 53 (88.33%)

(c) Number not responding at all = 6 (10%)

" of (b) responding by beats/min = 43

71.76% of total

(81.13% of (b)

Number of (b) responding 5 bpm = 10

16.67% of total

(18.87% of (b)

Number of (b) responding by 1st trial = 22

36.67% of total

(41.51% of (b)

Number of (b) responding by 2nd Trial = 41

68.34% of (b)

Number of (b) responding by 4th Trial = 50

83.33% of total

(94.34%) of (b)

Number of (b) responding by 8th Trial = 53

100%)

The trend of response was reduction. The optimum trial (like in the previous case) is the 4th.

However, unlike the stroke volume, the heart rate was likely to be more under a neural than humoral control. The % difference of the eighth Trial values relative to the first Trial controls are higher.

One thing common to both Tables 2 and 3 are the fact that Normotensive female subject responded more in chronic practices.

In Table 4, the cardiac output considerably differed from the control values whether relative to 1st Trial or to 8th Trial.

In Tables 5 and 6, the cardiac output index and the cardiac work Index which allow an inter-group comparison reveal no real difference in the groups regarding the way they responded or the degree of their responses. The Heart is shown to do less work, be it in acute or in chronic responses. The cardiac output reflect the pattern of Heart rate response. The dominance of negative chronotropy in its determination is thus underlined.

In Tables 7 and 8, the total number of subjects = 80

Number responding positively (by pressure rise)	= 2 (2.5% of total)
Number " negatively (by pressure fall)	= 62 (77.5%)
" not responding at all	= 16 (20%)
" responding by diastolic fall only	= 8 (10%)
" " " systolic fall "	= 4 (5%)
" " " both diastolic and systolic fall	= 50 (62.5%)
" " " 10mmHg systolic fall	= 30 (37.5%)
" " " 10 " " "	= 20 (25%)
" " 1st Trial	= 13 (16.25%)

Number responding by 2nd Trial = 20 (25%)

Number responding by 4th Trial = 60 (75%)

Number responding by 8th Trial = 80 (100%)

The diastolic, systolic, mean arterial and pulse pressures hardly varied from control values in any single RRT session even though the general tendency was towards a fall. Chronicity of RRT application did not affect the above listed parameters. There was probably an intervening factor that maintained these pressures even in the fact of cardiac output fall. However, chronicity of RRT application changed the basal values (fall) as depicted on graphs 1 and 2.

Tables 9 and 10 reflect the resultant patterns of the combined effects of responses on tables 2 and 8, this produced a lowering of left ventricular stroke work and to a greater extent the left ventricular stroke work rate $P < 0.05$ (t-test).

In Table II, the response pattern of oxygen consumption index of the myocardium resembles that of the stroke volume in which any initial decrease in the control values is maintained such that the control for one RRT session differ in the successive ones with a general tendency toward reduction. However, the response to acute and to chronic RRT applications are similar, suggesting a probable combination of neuronal and endocrine participation $P < 0.005$ (t-test).

Tables 12, 13, and 14 explain the observation made on tables 7 and 8 in which the cardiac output fall fails to affect the blood pressures as expected. From the increase in the total peripheral resistance must be the compensating factor P < 0.05 (t-test). However, it is not yet known what role the baroreceptors might be playing. The inclusion of Tilt table experiments and Vasalvasa manouvres in any future investigation may bring out the effect of gravity posture and other variables from which extrapolations can be made as regards the role of the baro-receptors.

As shown in Table 15, vascular compliance varied only slightly (P > 0.05 t-test). This shows that the slight decrease could have been due to chance fluctuation. Hence, the visco-elastic integrity of the vascular system are not affected by the practice of RRT.

Tables 16 and 17 show that the contribution of the systemic arteroles, pre and post sphincters are more relative to the pulmonary. This is expected because anything otherwise would mean a reduction in tissue ventilation and hypoxia.

Table 20 exhibits a circadian rhythm. This probably suggests the participation of a hormone that shows that pattern of rhythm. This may be due to the effect of, but further work has to be done.

Phase Three

To find the effective component of the stimulus situation (RRT) that gives rise to all the observed response patterns, the different aspects of the behavioural model are separated and the percentage responses calculated.

Table 19 shows that muscular relaxation only, closure of eyes only, the call-out of mantra only or the regularized thoracic rhythm with contemplation only cannot account for the observed responses. In fact the individual responses cannot be said to be summated; but perhaps they combine synergistically.

Table 18, at an iliosacral angle of 90^{o} or thereabout, (that is, when the subject sits straight) some responses were elicited but they are quite smaller than when at an angle of $\geqslant 105^{o} \leqslant 120^{o}$. At an angle of $> 120^{o}$, the responses were appreciable but the EEG and Impedance Pneumogram indicated an interference of sleep conditions (see the figures attached to the results) such that it become difficult to separate which response is due to which condition.

ADJUNCT PHASE

Functional or Dynamic Fitness Test After RRT Practice

Man is not a sedentary animal, therefore, it is only reasonable to take into consideration the dynamic moiety of his endeavours in any technique developed to boost the efficiency of his organs. The subject was subjected to strenuous exercise to find out how well he could endure and how fast he could recover. Bock, et al. (1928) found out during exercise that the pulse curve alone quite accurately depicts the physical state. Further research by Dill and Brouha (1937), following this basic premise led to a simple means of measuring a man's efficiency for hard muscular work. Pulse before exercise is ignored, because it has been shown that neither the basal or the resting pulses has any significant relation to an individual's performance-capacity nor to his physical fitness index (Gallagher and Brouha, 1943; Brouha and Heath, 1943).

Tables 21, 22, 23, and 24 show that the cardiac response to the various levels of work improved with the practice of the technique. To obtain the results on table 22, Maximum Heart rate for any volunteer estimated by

$$HR_{max} = 220 - Age \text{ (in years)}$$

The subject was then allowed to work on a bicycle ergometer until the pulse rate is 85% of the estimated maximum. The work done at such a time would be extrapolated to the values corresponding to the stroke volume (measured) on the Astrand-Rhythming Normogram. The point where it bisects the maximum oxygen consumption is taken as a measure of the physical work capacity at a submaximal pulse rate PWC_{85} which, in this work was found to have improved.

In all the other experiments work was kept constant at 40 watts at 30 revolutions per minute for fifteen minutes except in the Harvard test (Table 21) where only five minutes recommended, was used.

CHAPTER 7

GENERAL DISCUSSION

The pilot phase which is the first phase of this work revealed that the claims contained in the literatures as regards the effects of some psychophysiological techniques on oxygen consumption, carbon dioxide elimination, pulse rate, respiratory rate, respiratory depth and electroencephalographic wave-forms are, to some extent also true of the "Relaxation Response Technique" described by Benson, et al. (1974). It appears, however, that variables like oxygen consumption, metabolic rate and electromyogram still require a more cautious appraisal. For example, it is necessary to be specific as regards the muscles on which the electromyographic recordings had been made during relaxation. The muscles of the limbs scarcely participate in bearing the weight of the body under the conditions of the experiment and so, any electromyogram from those sites may not be a useful indicator of relaxation. The electrical signals consequent upon the cardiac cycles (electrocardiographic signals) are larger than those emanating from the skeletal muscles of the trunk particularly the lumbar region which bears most of the body weight and so, the interference of the electrical waves was difficult to remove. Even without all these difficulties, the electromyogram would still be deficient as an indicator of the success of "Relaxation

Response Technique" practice as it depicts only the physical moiety of the response.

Oxygen consumption per se is hardly useful as a measure of the success of achievement of RRT either, because it is only a net value which gave no indication or consumption in the priority areas like the brain kidney and the heart tissues. In fact, since subjects were to remain still, the skeletal muscles' activities were made to approach zero and so, the oxygen consumption would be proportionately attenuated. Since the skeletal muscles constitute about 40% of the total body weight and consumes about 25% of the total oxygen, it would be expected that a significant reduction in its oxygen consumption, even if reduction in other tissues remained unchanged, would mean a significant reduction in the total oxygen consumed by the body.

One other problem about oxygen consumption was the difficulty imposed by the method of measurement in current use; the open and close circuit which are too intrussive to the conditions guiding the practice of the technique. Masks and Flow meters present another serious problem; when the tidal volume becomes very small, the small increase in dead space involved in breathing through a mask and flow meter becomes proportionately more significant. This probably produce a subjective difficulty often complained about by the subjects under these conditions.

Allison, (1970) described another method based on the assumption that the build-up of carbon dioxide was responsible for the subjective dysponea and to overcome these difficulties, these small thermistors (STC type P22) were suspended from a light plastic head-band so that the upper two lay approximately 1 cm from each nostril and the third was situated about the same distance from the mouth. All three were connected in series and heated by a small current so that in still air their temperature stabilized at about 180°C. This comparatively high temperature was chosen to mask the difference in temperature between expired and inspired air. Thus when air was taken in or expelled from the nose or mouth, the rate of energy dissipation from the thermistors was increased, resulting in a fall in their mean temperature. The summated change in the three thermistors was transmitted to a servo system consisting of a self-balancing bridge which actuated a recording pen... the temperature of each termistor was related in non-linear way to the velocity of air passing over it while the mean thermistor temperature was related in a still more complicated way to the volume passing over it in one minute (minute volume) .

Despite this impressive precaution, he concluded, after experimenting with subjects engaged in the practice of trans-cendental meditation, "this meditation is a purely mental technique in which the attention is engaged upon increasingly abstract mental activity; during its successful course, the subject is unaware of physical sensation or external events, although attention may become deflected to them. The investigation was undoubtedly a disturbing factor in these experiments, for it led inevitably to a concern with respiration, which is normally quite unnoticed during this type of meditation ...

The same problem is associated with the measurement of metabolic rate, unless it is by the use of calorimeter big enough to house a man in a relaxed mood, like the Atwater-Rosa human calorimeter which is not easy to provide. Apart from this, the measurement of the total heat out-put of a man by direct calorimetry is a difficult procedure and is seldom attempted nowadays. Besides, whatever method adopted, the result is only a summation of the total metabolism. It gave no evidence or insight as regards what happened in the liver and the splanchnic area which constitutes 27% of the resting metabolism, or in the brain (19%) or in the heart (7%) or in the kidney (10%) or in the skeletal muscle (18%) or in the other parts (19%) since the psychophysiologic technique affect these organs by no means to the same extent, the percentage contribution to the reduction would be difficult. It could have been more useful, in assessing the favourability of the reduction, to know what happens in these areas.

The exploratory phase, the second phase of this investigation revealed that it is quite unnecessary to employ a traditional tutor (GURU) to teach the meditational technique, "Relaxation Response Technique" employed in the current investigation. As indicated earlier, the percentage of the total subjects responding to the practice are always more than 50% at any time. In fact, the percentage usually increase with frequency of practice and only a few responded in a deviant form from the general direction. Even this can be explained as a probable function of individual idiosyncracies and seriousness put into the practice.

One modification that contributes in no small measure, to the success of this phase is the juxtaposition of equipments which indicate the achievement of Relaxation Response to that which measure the visceral changes to the response. Otherwise, one would have based all the result of the investigation on the assumption that the subject achieved the Relaxation Response.

Burton, (1975) while advising the student of cardiovascular system wrote:

> sensible man, if he were appointed to be a member of a river conservation authority, would make it his first task to become thoroughly acquainted with the whole of the river bed, the sources of the rivulets, their successive confluences, the depth and width of the contributing streams, the volume of water, the volume flow and the fall in height in all the branches and in the final river. So it should be with the student of the circulation .

The following sketch of plan for control of circulation is considered fundamental to the discussion of the results obtained during investigation.

1. General Rule: Flow = Pressure drop/Resistance
2. Priorities: Brain, heart. Control driving pressure in aorta to constancy, by special reflexes. Keep resistance to flow of brain relatively constant-change resistance of coronaries somewh t by local nervous control.
3. General Control: (a) By mass action of sympathetic nerves;
   (a) by circulating hormones;
   (b) by universal aerobic metabolite (carbon dioxide)
4. The Heartshall be independently rhythmic, but controlled by nerves for general control of circulation.
55. Special Local Control: (a) Different vessels can respond differently to the same circulatory hormones
   (b) special (parasympathetic) nerves to special organs.
6. Local Autonomy of Control: (a) By local metabolites (carbon dioxide, lactic acid, PH) - that is, reactive hyperaemia.
   (b) Inflammatory reactions to disease and pathology.

Considered pivotal to the basic physiological functions necessary for survival is oxygen utilization. It is the process which ensures an adequate oxygen supply, and not oxygen consumption per se, that qualified for emphasis in this phase, the scope of which, therefore, is limited to the dynamic inter-relationship of the cario-pulmonary and vascular systems while at rest and while tat work. This phase is consequently divided into parts I and II. The results obtained were (a) those from tracing and (b) those inferred or calculated from (a).

<u>Exploratory Phase</u>

<u>Haemodynamics</u>

The forces which cause, alter and regulate the flow of blood under the stipulated conditions of the experiment are here considered. The volume (V) of blood flowing through a circulating system increases with the perfusion pressure (P) and decreases with resistance R in Poisseuille's experimental law $V = P_1 - P_2\ r^4/8L\eta$ where $P_1 - P_2$ is the arteriovenous pressure difference, is 3.1416, r is the tube radius, L is the tube length and η is the fluid viscosity. Also, resistance to flow is defined as a ratio of driving force $(P_1 - P_2)$ to the flow (V)

$$R = P_1 - P_2/V = 8L / \eta r^4$$

= Product of viscosity (inner fluid friction) and tube geometry.

In a viscoelastic system of tubes through which a non-Newtonian fluid flows by compromising turbulent and streamlined patterns, the applicability of the Poiseuille's law in toto depends upon whether resistance is independent of pressure and flow. The peripheral resistance, the sum of resistances in the parallel shunts is a totality of all factors affecting blood flow.

The regulation of circulation has as its chief function the maintenance of adequate flow of blood to all organs and it can be altered, at any given pressure, to suit the tissue metabolic needs by local adjustment of Peripheral resistance. However, a decrease in flow to one organ increases flow to the other in so far as there is no fall in pressure, that is, if the mechano-receptors (stretch receptors) at the aortic arch and carotid sinus interven. It would appear that this may be the case considering the results in Table 12 which showed an increased peripheral resistance, a decrease in cariac output and a decrease in blood pressure. For the time being, as a first approximation, only the relationship between the input and output (transfer function) would be discussed and the component of the system responsible for this relationship would be postponed till later.

$P_1 - P_2$ or $\triangle P$, the arteriovenous pressure difference is approximately equal to the mean arterial pressure (MAP) which directly varies with the total peripheral resistance, pulse rate and systolic discharge. The latter hardly changed during RRT practice and the slight change observed was a reduction and since there was no appreciable change in pulse pressure, the arterial distensibility or compliance only slightly reduced. This implied that the smoothness of blood flow was not affected by RRT practice. The quotient of the arteriovenous pressure difference and the resistance was reduced; this implied a reduction of volume flow in the arterial network and unless there was leakage, the blood in the venous reservoir must have increased, thereby resulting in an increased venous return. This should be manifest in the systolic discharge. However, the latter was slightly decreased. The myocardial contractility could have been badly affected, as it would appear that blood "leaked" into some priority vascular regions from the arterial network.

639 muscles constitute about 40% of the body mass and receive about 25% of the total volume flow and so at least about 25% of the total peripheral resistance probably is due to vasoconstriction in the arterioles of the skeletal muscle, (Guyton, 1970) which under the condition of this experiment should be relatively inactive or minimally active. If the vasoconstriction is due to -receptor activation, the same a

priori applies to all other vascular beds where the vascular geometry is determined by α-receptor activation. Therefore, the volume flow must have been redistributed presumably to the areas where α-adrenergic activity is poor like the myocardium, pulmonary bed and brain.

The subjective feelings of well-being often expressed by the subjects after the RRT sessions is difficult to explain. It was, however, observed that consequent upon blood flow re-distribution, more blood was available for aeration in the pulmonary circulation. The well aerated blood returned to the heart to be pumped into the systemic circulation- and the coronary circulation which is well positioned to divert more than 5% of cardiac output into the myocardium, only about 2.5% of the body weight, where 10% of the total oxygen consumption is accounted for. Then the brain a mere 4% of the total body weight, were more than 10% of the oxygen consumed by the body is utilized, now consequent upon redistribution, received more than 15%, its normal share of the total volume flow. Perhaps the increase in perfusion of these vital areas gave the subjects the feeling of well-being.

The re-distribution could be explained by the fact that the heart which beats about 1.09×10^5 times per day and each time observes less than 0.45 sec rest deserves some priority in any process which ensures the removal of metabolites and chronotropy implied an increase in the ejection fraction, the quotient of stroke volume and a diastolic volume ratio, because the heart met the circulatory demand more in force than in rate.

Positive chronotropy is more metabolically costly in terms of myocardial oxygen consumption than positive inotropy (Boerth, et al., 1969 and Seagren, et al. 1971) and as such, RRT practice reduces the metabolic cost accompanying cardiac activity. In fact, the ventricular pump performance is measured in terms of the ejection fraction, an index of myocardial contracticity therefore, the reduction in minute volume flow considered commensurate to the low level of physical and mental activity accompanying the RRT practice, is not only metabolically economical but also favourable to the cardiac efficiency. The latter is particularly so, because the strength of myocardial contraction is markedly influenced by the time interval between beats (Bowditch, 1971) and in this case, the diminished frequency of beats allow greater time for the metabolic equilibration.

It is possible to estimate the velocity of flow in the circulation by applying the common sense law of flow called the equation of continuity which states that the product of the total cross-sectional area (A) and the mean velocity (v) delivery of metabolic fluel. Also, the brain which under the course of the experiment was made to divert its complex activities towards an increasingly abstract focus, a change which would inevitably require a metabolic re-adjustment that may, in no small measure, be demanding in terms of oxygen utilization.

It is hardly surprising therefore that greater success was achieved in the posture adopted during the investigation (ilio-femoral angle greater than 105^{o} less than 120^{o}) which brought the head nearer the heart level, the zero reference while it lightened the burden on the heart due to the term P in the equation $E = P + \rho gh + \frac{1}{2}\rho V$ by decreasing the variable h (where ρ is blood viscosity or resistivity in g/cm^3; P the pressure gradient in dynes $/cm^2$; g the acceleration due to gravity in cm/s^2; h the arbitrary datum level and v the redistributed flow to the brain.

Cardiac poutput, a product of pulse rate and the difference between the end diastolic volume and the end systolic volume, was in the course of the experiment reduced. The equation describing the minute volume flow from the heart reflect the stroke volume contribution in as much as the difference in end diastolic volume and the end systolic volume showed little change from control values. The predominance of inotropy over must remain the same, unless blood is lost outside the system, A x V must be invariant and equal to the volume of flow per minute (c) or per beat (s) that is:

$$v = C/A \text{ cm/min or } \frac{S \times s/_{HR}}{A} \text{ cm}^3 \text{ sec}$$

(where HR is the heart rate) C in this experiment was reduced relative to A, therefore the velocity was decreased but this may not be true of every vascular bed depending on the nature of local or autoregulatory control mechanisms present and the extent to which vasomotor activity affect the geometry of the vessels. The resultant is such that the circulation time is reduced. This means the time of contact between blood and the tissues perfused is greater and diffusion of metabolic substrate and product is probably more complete. Therefore, what the subjects have lost by reduced respiratory rate, under RRT practice, is compensated for by a great extraction and collection of respiratory gases in the tissues.

In fulfilling its function as a hydraulic pump within the circulatory system, the heart does less "pressure work" under the condition of RRT practice, that is, it internally overcomes the resistance of the series elastic element at a reduced work. According to Evans and Matsuoka (1949) it is metabolically costlier to do "pressure work" than "volume work" performed externally by the muscle shortening with a load which, in this case, is the systolic discharge. "Pressure work" is linearly related to the afterload, the diastolic pressure which was found to decrease with RRT practice. "Volume work" was more involved in this experiment because the heart still managed to discharge about the same volume of blood even in spite of a decreased venous return by reducing the end systolic volume. The net cardiac work is thus accompanied by less metabolic activity.

The results were found to be the same irrespective of occupation, sex, diet or race. The difference in response is more in degree than in kind. In this discussion, no attempt is made to compare individual responses, a function of idiosyncracies and seriousness of motive, instead the average for each group is compared with their control values over the period of the trials were made.

The Energetics of the Cardiac Cycle:

The heart functions in vivo as a hydraulic pump, but it is primarily a muscle. Thus, it is pertinent to analyse first the mechanics of cardiac muscle and then apply these results to the functional characteristics of the heart as a hemodynamic pump within the limits imposed by the condition of the experiment. Preload and Afterload would, later in the following discussion, mean end diastolic pressure (venous input) and aortic pressure (diastolic respectively).

When the muscle is stimulated and excitation - contraction coupling occurs, the contractile element (CE) shortens and develops force, Sonnenblic, et al. (1962). This is called the active state of the (CE) which represents the time course of the onset and termination of the biochemical processes occuring at active sites along the actin and myosin myofilaments which produce force and shortening. Because of the spring-like properties of the series elastic element (SE) the active state of CE is translated into mechanical force development or shortening only after some delay. The course of mechanical contraction equivalent to the ejection phase (the Isovolumetric contraction and protodiastole are ignored) is thus governed by the contractile properties of CE, the duration of CE active state and the elastic properties of the SE. While comparing response between individuals, the three factors are important but while comparing the response of the same individual under two or more conditions (like in the control and RRT sessions) only the duration of CE active state may vary.

For example, the impedance cardiographic tracings showed that the R - Z interval (where R is the ECG R spike and Z, the point of $(dz/_{dt})$ that is, the time interval between stimulation and effective mechanical force development increases above control values during RRT. Since, in the same individual, the properties of SE and Ce are constant, this observation shows that only the CE active state must have been responsible for the increase. Since the first derivative of the intrathoracic impedance change is obtained in the rapid ejection phase, the increase in the R - Z interval shows that the active state attains a maximum slowly, that is the rate (rather than duration) at which the maximal isometric tention (e.g. in isovolumetric phase) that the contractile unit is able to develop or bear without lengthening at that moment was decreased. So this allowed the series elastic component to be more gradually stressed; that is, intensity of the active state while overcoming the vasoelattic was reduced. The metabolic cost in terms of oxygen utilization is expected to be less, because the rate at which work was done (Power output) was less, Rate of ATP formation would cope more with rate of ATP examination.

In the simplest terms work (W) equals force (F) multiplied by the displacement (L) and Power (P) is work per unit time or force multiplied by velocity (V)

$$P = F(^{dl}/_{dt}) = FV.$$

Thus, work performed is the power integrated as a function of time: $W = (F. \ ^{dl}/_{dt}) \quad dt = \int_{t_0}^{t_1} F \, dl = F. \ \Delta L$

the kinetic component of work ($\frac{1}{2} mv^2$) comprises less than 5% of work even in severe exercise and has been omitted. Effective cardiac work is that which produces forward movement of blood against arterial pressure. This includes only that work accomplished during systolic ejection when a volume (stroke volume) of blood is delivered into the aorta (or pulmonary artery) against the existing arterial pressure (diastolic).

To avoid integrating over the period of systolic ejection, because of the constantly changing pressure and volume (P & L), the left ventricular work per minute is obtained from the formula

$$LVW/min = SW \times HR/1000 = SV \times MAP \times HR/1000$$

this value was found to be decreased by RRT practice both in acute and chronic situations. The ratio of work done (useful energy output) and the total energy expenditure (work + heat) is equivalent to the chemical energy expended (e) thus efficiency (Eff) can be represented by

$$Eff = W/e$$

since practically all energy consumed in the myocardium is linked to oxidative metabolism, myocardial oxygen consumption (mVO_2) can be considered an equivalent of the total chemical energy. The efficiency ratio becomes

$$Eff = \frac{W\ (pressure + kinetic)}{Total\ m^{V}O_2 - resting\ m^{V}O_2}$$

since the clinical index for myocardial oxygen consumption is

mVO_2 = MAP x HR

and the LVSW (left ventricular stroke work) is

SV x MAP

therefore, a clinical index of cardiac Efficiency is

Dff = LVSW/mVO_2

$$\frac{SV \times MAP}{MAP \times HR}$$

= SV/HR (obtainable from Tables 2 & 3).

These expressions of efficiency relate only oxygen consumption to effective cardiac work and neglect the factors linking the chemical and the mechanical processes. A closer approximation to true cardiac efficiency is the ratio of the contractile element work (CEW) to chemical energy of activation (AE) and chemical energy work minus the resting energy (RE):

Eff = CEW/(CAE + WE) - RE)

From the available information regarding the difference between the control values of stroke volume and Pulse rate, the change in efficiency of the normotensive male and female hearts would be (from table 4) (1.02) - 0.90) = 0.12 cm^3 min/beat experiment the heart improved its efficiency as a hydraulic pump.

The fact that the heart (improved) gave an output in the excess efficiency of the power applied) shows that the Laplaces relationship

$\bar{\bar{T}} = (\bar{P}\ \bar{r})/2d$ recommended by Badeer in 1963 for the heart (where $\bar{\bar{T}}$ (stress) = mean force per unit cross-sectional area of wall during systole, $\bar{P}$ = mean transmural pressure during systole, $\bar{r}$ = mean systolic radius and d = thickness of wall during systole) would mean a reduction in wall tension in the cause of ejection since the end diastolic volume (due to venous return) responsible for (P) was reduced, and the wall thickness increased by an improved inotropic response and the radius decreasing with the rate of myocardial shortening (which increased with increased efficiency). Under the condition of this experiment, the ventricle developed less tension in producing the same volume of blood against the existing arterial pressure the "mechanical advantage" is more for the subject under RRT practice.

The difference of the mean arterial pressure and the right arterial orifice pressure (the pressure gradient) is approximately numerically that of the mean arterial pressure.

Mechanism of Response to RRT

Benson and Klipper (1974) in their book captioned "The Relaxation Response" suggested that the RRT is the human equivalent of the tropotropic endophylactic response elicited during the Hess's experiment in cat (1957). It is not clear how Benson and Klipper (1974) arrived at this conclusion as Hess electrically stimulated some regions of the hypothalamus before obtaining such responses whereas the process which lead to the Relaxation response is a dynamic integrated impulse exchange between very many foci at the cortical and sub-cortical levels. Besides, electrical duration, magnitude, intensity and frequency occurring at specific synpases, after a great deal of inhibiting and facilitatory modulation, cannot be compared with the externally applied electrical stimulation which, may be, excite more than the required number of synpases and hardly with any modulatory influences of higher or neighbouring centres.

While it is clear that Hess was able to demonstrate a response opposite the emergence (Fight-or-Flight) response in man, some reservations may have to be made about a postulate which attempts to equate the Relaxation Response with it. Rather alternative mechanism for the "Relaxation Response" could be postulated.

When one discovers that the RRT practice invariably leads to a reduction in Heart rate, cardiac output, blood pressure, respiratory rate etc. one might be tempted to think that it is opposite to the sympatho-adrenal emergency reaction. This is only to some extent true when one considers that the subject under RRT is supposed to be physically and emotionally relaxed, it is different from mere resting of muscles; it is also coupled to a process which impels focus. This process would probably be accompanied by a diversion of impulse traffic through unusual routes to unusual centres and regulated via a new set of feedback loops connecting the cario-inhibitory, cardio-acceleratory, vasopressor, vasodepressor, respiratory and other visceral centres.

Any pathyway opposite the sympatho-adrenal would probably be along the parasympathetic but the tonic vasomotor and cardio-inhibitory responses indicate that the two autonomic modes of regulation were involved in the relaxation response. The suspected diversion of flow to other vascular beds is probably fascilitated by vasodilation in those beds.

On the basis of the findings in the present study, it could be postulated that the optic, sensory and temporal areas having been partially shut off from the regular excitatory stimuli of the external environment, under the stipulation of the experiment, reduced the frequency of impulse to the integrating feedback loop of the somatic aspect of control, a situation similar to sleep but for the partial nature of the shut off. In fact, the findings were similar to those obtained in the same subjects while sleeping.

However, in degree and sometimes, in kind, RRT significantly differed. This implied that the ultimate pathway probably differs. At the sub-cortical level, the hypothalamus with the limbic system constitute the control tower for the autonomic activities. So, indeed it must be actively involved in the visceral changes accompanying the RRT. A train of impulse exchange would occur between the primary centres (e.g. cardiac and vasomotor in the medulla and mid-brain respectively). The lower motor neurones eventually activated would depend on the type of cortical contribution and interference at the different centres, to produce a circulatory change commensurate to the change in demand of the various visceral organs under the conditions provided by the norms of RRT.

Probably, one other factor distinguishing the "Relaxation Response" from sleep is the impulse traffic re-schedulement that would probably accompany the process of abstract focusing of attention, the prime feature of the transcendental meditation on which the Benson's RRT was based. The diversion of impulse flow cannot but have a consequence on cortical control of visceral activities.

The beauty of the Relaxation Response is the long lasting effect chronic and the change in basal values at progressive trials. This shows receptor organs (e.g. the baroreceptors in the aortic arch and carotid sinus). Probably too, their sensory input are modified by the changes in their target centres.

It is possible that hormonal participation occurs in the control of the longterm visceral changes to the Relaxation Response. There is, however, no strong evidence available in the findings of the present study to suggest this. The number of pregnant normotensive women experimented upon was too small to be taken as representative of the pregnant population (between their 4th and 6th months of gestation). However, their average responses were usually, in degree, more pronounced than those of the nomotensive male and female groups. This may be due to hormonal accompaniment of gestation.

Haemodynamic Aspect of Mechnism

It has been shown how the RRT practice may probably have influenced the complex circuits of impulse by approximation and compromise of some pathways in favour of others. This would culminate in visceral changes that would probably approximate and compromise some functions in favour of some others.

Physical bases of mean arteral and pulse pressure have already been discussed. Arterial pressure can be regulated by variation in cardiac output or peripheral resistance or both. In acute studies, normal cardiac changes to changes in peripheral resistance is to increase output for a decrease in resistance, vice versa. Thus any effect on pressure is at least attenuated. This relationship underlines the importance of peripheral factors in determining cardiac output (given normal myocardial contractility) by controlling the flow of blood from arteries to veins. Conversely, primary changes in output lead to reciprocal changes in resistance, tending to maintain constant pressure. Baroreceptor reflexes are often implicated in this mode of regulation. Chronic changes could lead to a long-term readjustment to normal values.

In this study, the reciprocal relationship of output to resistance was demonstrated but peculiarly; the blood pressure was reduced rather than remain constant. Even the variables, the produce of which determined the output, Pulse rate and systolic discharge, were found also to be peculiarly related; the systolic discharge scarcely decreased whereas the heart rate was significantly reduced.

It may be difficult to advance a mechanistic explanation, for it may in the final analysis found to be too simple or too complicated to be satisfactory. All the same, it is hereby considered suffice to drop a hint or two about the possibilities. It is possible that, under the circumstance of the experiment, the metabolic activities of the muscle relatively tend toward zero and given an adequate perfusion, metabolites hardly accumulate. Since the caliber of vessels particularly depends on the equilibrium between the α-adrenergic activation and the local control, the equilibrium shift would favour the unopposed vasopressor effect of the tonically active α-receptor. This, coupled with the so-called sigma effect on the blood viscosity, increased the peripheral resistance in the skeletal muscle. Since the latter accounts for more than 40% of the total body weight and contains more than 25% of the resting volume flow, the total peripheral resistance would reflect the change in the vascular bed of the muscles, that is an increase. This would transiently affect the venous return and the systolic discharge according to the Frank-Starling's law of heterometric cardiac control until the Anrep phenomenon of homeometric control overcome this transient change in favour of positive inotropy which resulted in the nearly constant systolic discharge. Probably, due to the total peripheral resistance increase, there was a transient increase in the pulsatile pressure which was enough to produce a deformation of the stretch receptors (mechanoreceptors) in the aortic arch and the carotid sinus from where afferent impulses travel cephalid in the vagus and glossophanyngeal nerves respectively to the cardiac and vasomotor centres. Efferent impulses travel along the two component of the autonomic system - sympathetic and parasympathetic. Of these the sympathetic is of greater importance because of its wider distribution to the peripheral vasculature and in the heart, going to both atria and ventricules whereas the parasympathetic branch supplies sino-auricular and auriculo-ventricular nodes. While sympathetic activity is vasoconstrictive in the vasculature, it is positively inotropic (but weakly so) due to the small β-receptor activation whereas the parasympathetic stimulation of the nodes result in bradycardia.

It must be borne in mind that the above possibility is subject to the influence of the limbic system, the hypothalamus and the motor cortex all of which may have modified the rate, intensity, frequency, magnitude and pattern of impulses sent to the visceral centres under the condition of this experiment. So, another possibility is that the cardio-acceleratory response was compromised in favour of cardiac inhibitory and vasopressor centre accorded a pre-eminence over the vasodepressor centre consequent upon the interplay of inhibitory collaterals, interneurones and motor neurons. Or just that the chemical environment created by Relaxation Response, through complex coding and decoding of computational messages, resulted in the observed viceral regulation.

It was observed throughout the experiment that the visceral changes were maintained for a long time. In fact, the basal values showed a progressive decrease. The RRT could be regarded as being in the same class with the classical (Pavlovian) conditioning, instrumental conditioning, operant conditioning and the other similar learning situations. If this is so, RRT may more appropriately be called Autonomic Conditioning since it involves an establishment of new association or development of new connections between stimulus and response, a feature common to all known methods of conditioning.

One of the oldest theoretical controversies in learning theory concerns the question of just how does conditioning occur. Pavlov believed and many authors after him assumed that classical conditioning is a neocortical phenomenon. It was supposed to be the only level of the nervous system with the plasticity necessary for the development of what appear to be new connections between stimulus and response. Later experiment showed, however, that conditioning can be induced in decorticate animals (Hilgard and Marquis, 1940), and in spinal preparations (Dykaman and Shurrager, 1956), albeit only after prolonged training using intense stimuli. Still more recently single neurons have been found to exhibit responses that are considered to be conditioned (Tauc, 1967). Consequently, the capacity for conditioning is now regarded as a generalized property of neurons, not necessarily dependent upon the organisation of a higher nervous system.

Another point of uncertainty has been the relation of somatic muscular movement to conditioning, because it was supposed that a feedback to the nervous system from skeletal muscles was needed for the conditioning process. The truth of this concept has been tested through the use of drugs, e.g. curare, that block somatic movement. Conditioning does occur in animals under the influence of curare, and the conditioning persists into the post curare period (Black, et al., 1962; Solomon and Turner, 1962). Miller (1969) reported that "learning" was facilitated by administration of curare. He suggested that this was because the drug removed "... interference from skeletal responses and distraction from irrelevant cues.

All the above reports relate well to the RRT practice except that the stimulus situation is less specific, it is hardly an externally applied one. The stimulus and response pathway is a motor-motor type unlike the sensorimotor types. It is distinguishable that it is a mass visceral response to a sorted pehenomenon in the brain.

Cardiodynamic and Haemodynamic Changes in Response to Muscular - Work After Practice of RRT

Tables 21 to 24 show that the cardiac output in exercise preceeded by RRT is calculated from the product of systolic discharge and a fixed Pulse rate (obtained by increasing the work done step wise until the criterion level is reached. It is found to increase with RRT practice.

The maximum oxygen consumption was read from the Astrand-Ryming normogram from the Knowledge of the work-done and the physical work capacity at 85% maximum pulse rate of the subjects. The percentage of the ratio of cardiac output change and oxygen consumption change equals the exercise factor, taken as an index of cardiac response to exercise. This ratio was found to increase after RRT than in exercise before RRT. (Table 23) the scores were better using the Harvard Test and this means the subjects can work for more than without stressing the heart. This shows that the RRT improved the physical fitness. (Table 24) the ratio of tension development in the contractile element active state obtained as Q - Z on the tracing and the ejection frequency decreased with exercise and more so after RRT, meaning that less tension accompanied the ventricular performance even when there is an increase in the preload and the afterload.

RRT practice created a reserve in the haemodynamic and cardiodynamic which can be mobilized on demand. This improves the physical performance without be-labouring the heart.

CHAPTER 8

SUMMARY AND CONCLUSION

Physiologically, man has been too exposed to assault by drug usage, socio-economic tensions, psychophysical trauma and geo-political strain to function as expected within the limits provided in the fundamental survival scheme, drawn by natural selection over the aeons of evolution. Several attempts had been made to reset his integrity and the "Relaxation Response Technique" is probably the latest. It is claimed, by its proponents, to be a panacea. They quoted some ancient practices which are neglected because the practitioners capitalize on the religious aspect of the phenomenon. The results may be so astounding that instead of being critically analysed, they are viewed through a haze of imagined mysticism, esoterism and occultism. Recent scientific investigations on the subject have revealed that there is not an iota of meaphysical illusions to be found in the various techniques. In fact, Yoga sentic cycles, contention, Zen etc. could have achieved more if given scientific backing.

Transcendental Meditation, the most widely investigated to date is still a crude technique. The Relaxation Response

Technique (RRT) described by Benson is a scientific approach to Transcendental Meditation. It was used in this work to investigate cardiac output and Blood pressure in sedentary as well as in subjects doing a known amount of work. Mathematical inferences regarding Peripheral resistance, vascular compliance, stroke index, cardiac output index, effective cariac work, left ventricular efficiency and left ventricular ejection rate were made from the measurements of mean arterial pressure, pulse pressure, myocardial oxygen consumption, systolic pressure, diastolic pressure, Heart rate and stroke volume.

In course of the investigation, it has been established that

(1) It is not obligatory to employ any traditional meditator, or a guru to teach the technique since subjects quite easily achieved the response.

(2) More than 60% of the samples responded by the 4th Trial and by the 8th, a 100%.

(3) Since most of the results were significant (P 0.05) t-test), simple bedside diagnostic equipments can detect the difference.

(4) Blood pressure was stabilized by the reciprocal relationship between the cardiac output and the peripheral resistance.

(5) The stroke work and clinical myocardial oxygen consumption index decreased well enough to enable the heart build up a reserve that can be made available under stress.

(6) The cardiac work under RRT condition was more due to ionotropy than chronotropy.

(7) The vascular compliance hardly changed from their control values, a fact that implies an intact integrity of the viscoelastic system.

(8) All these are independent of whether the volunteer is old or young, male or female, starved or fed.

(9) The stimulus situation, if modified, will probably be less as effective.

(10) The optimum iliosacral angle for RRT is $> 105^{\circ} < 120^{\circ}$.

(11) The PWC_{85}, or any form of physical fitness or endurance test are withstood to a greater extent after RRT practice.

(12) The claims by earlier workers regarding the various meditational techniques on oxygen consumption, basal metabolic rate, carbon dioxide elimination, respiratory rate etc. are, to a large extent, also true of the RRT except that Electromyogram is difficult to measure and oxygen consumption carbon dioxide elimination as well as Basal Metabolic rate methods proved too intrussive to the subjects and

(13) Electroencephalogram and impedance pneumogram are the most correlated responses to the technique.

From the above findings, it is concluded that

(1) The RRT is beneficial to the cardiodynamic and haemodynamic well-being.

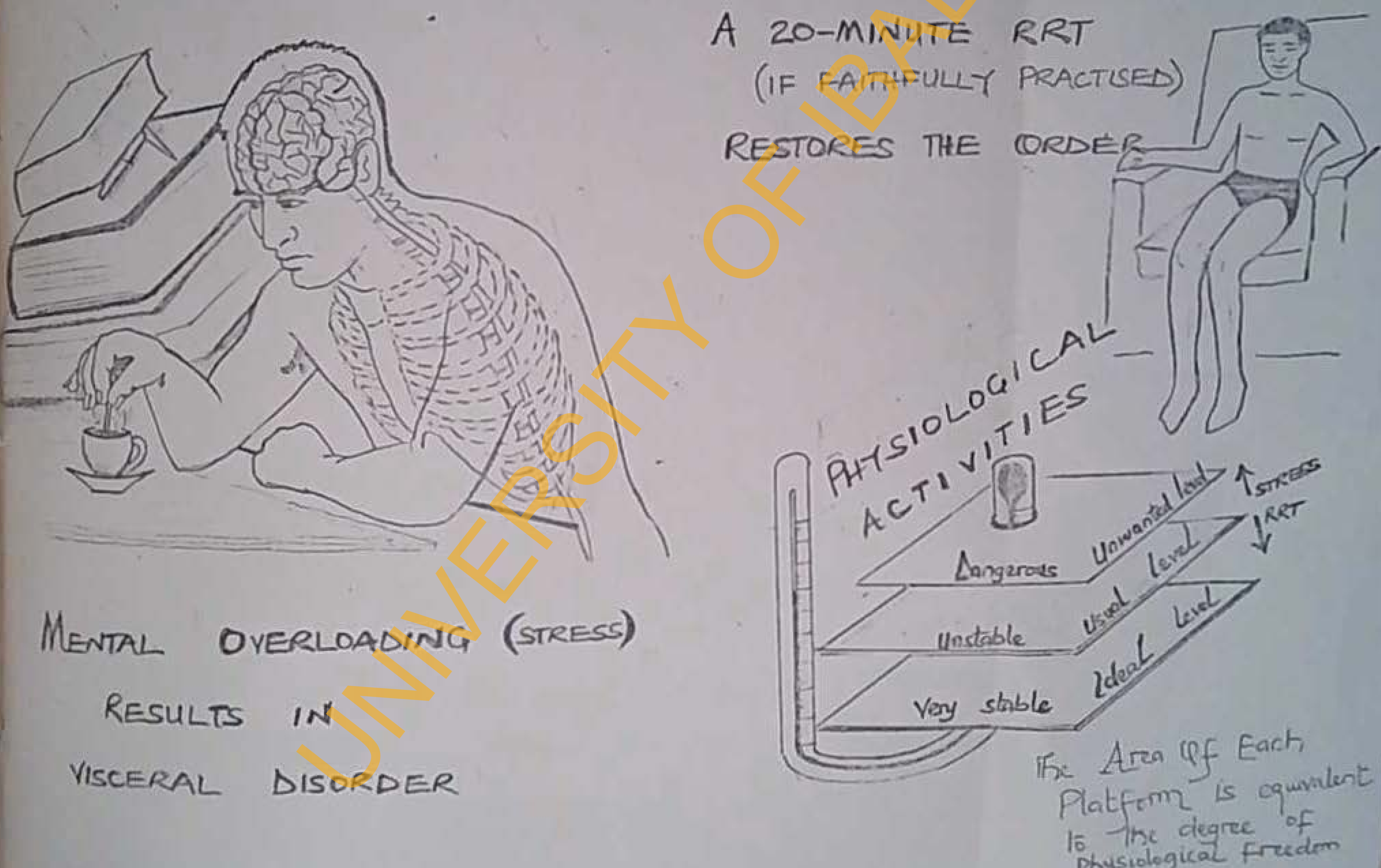
(2) For an optimum result, a twenty-minute practice should be observed every day for a minimum of eight days at a stretch.

(3) No hallucinatory episode was found to accompany such a venture and so it is guaranteed.

(4) The RRT needs no special skill or training and anyone can use it.

(5) Athletes, or any sportsman for that matter need RRT for a greater mark.

FIG.3


A 20-MINUTE RRT
(IF FAITHFULLY PRACTISED)
RESTORES THE ORDER
PHYSIOLOGICAL ACTIVITIES
STRESS
RRT
Unwanted level
Dangerous
Usual level
Unstable
Ideal level
Very stable
The Area of Each Platform is equivalent to the degree of physiological freedom
MENTAL OVERLOADING (STRESS)
RESULTS IN
VISCERAL DISORDER

CHAPTER 9

TASKS AHEAD

The problems still awaiting solution are:

(1) The role of baroreceptors in the elevation of total peripheral resistance.

(2) The mechanisms of the cardiodynamic and haemo-dynamic changes observed.

(3) The contributions of the endocrine and nervous systems to the cardiovascular response patterns.

(4) The responses of any sample of a population with non-organic cardiovascular derangement to acute/chronic applications and the responses to work after the 8th practice in males and females.

(5) Is the bradycardia observed consequent on an increase in vagal tone? If so, how does thes affect the gastro-intestinal and other vegetative functions under the influence of such a tone?

(6) The pathways involved in the attainment of the Relaxation response.

(7) Since Pregnant women showed a greater proclivity to respond than any of the other groups, it is yet to be investigated if (and which part of) sexual cycles as well as the associated phenomena synergizes or inhibits the responses.

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APPENDIX

Experimental Protocol

All factors that tend to affect the autonomic response pattern are carefully screened in the four basic elements describing the Relaxation. Response Technique:

(1) Environment

- Quite, calm, with minimum distractions
- Constant temperature of about 27^{0}C.
- Atmospheric pressure ± 10^{0} Absolute
- Well ventilated
- Neither too dark nor too lit

(2) A mental Device

- Visual or
- Audio

Depending on the experimenter's discretion;
if audio, a suggested mantra repeated with
expiration for 20 minutes with the eyes closed.
If visual, an object to gaze at for that 20-minute duration.

(3) A Passive Attitude

- No active avoidance of distraction
- Concentration on the audio visual device
- No worriness as regards how well it is performed
- Maintainance of "Let it happen" attitude.

(4) Comfortable Position

- That allows minimum muscle strain
- But enough strain to distract sleep

- Optimum iliofemoral angle of about 105^0
- Soft props to surround the vertebrae and head

Moreover, the following precautions are observed

(1) Proper orientation of subjects regarding the purpose and the value of the research. They are to be educated about the procedure and given enough time to understand the working of the apparatus. All these were necessary in order to secure their maximal cooperation and motivation.

(2) The time of the experiment is noted and the data categorized accordingly.

(3) Sex, age and diet are noted and noted for reference in the discussion

(4) The medical history is taken prior to experimentation

(a) to build a psychological confidence in the subject (who would genuinely feel you are trying to help)

(b) to allow you construct a picture of your subject in such a perspective that renders the final analysis easy.

(5) Avoidance of any equipment that may introduce discomforts, so that measure can be taken during the relaxation response.

(6) Equipments are calibrated pre-relaxation and post-relaxation to forestall any systematic error.

(7) Subjects shall not be under any medication if in the normotensive class.

(8) Blood pressure measurements woule be made only at Inspiration (to and the effects of sinus arrythmia and pressure changes accompanying the respiratory rythm).

Experimental Paradigm

Volunteers are told:

"We are about to measure some of your body functions considered useful to the current research that may invariably turn out to be beneficial to all of us. Please, your cooperation will be much needed. All you need to do is contained on the blackboard in front of you. You have all the time in this world to read and understand it. Just give a nod if and when you have satisfied yourself.

On the Blackboard:

"You are welcome to practice the new technique that is meant to relieve you of all your physical and mental tensions. Please

(1) Sit down quietly in the place provided and make yourself very comfortable.

(2) Close your eyes to shut out the distractions of this environment. We don't want you to be distracted.

(3) Relax your muscles beginning from your toes and progressing through your trunk to your face.

(4) Breath deeply in and out for some time and gradually allow the natural rythm to take over. To make sure it takes over is by being passively aware of it.

(5) Choose a word in your mind. Let it be a single syllable, like "ONE", "GOD", "YES" or a loved name.

This monosylabism is for convenience. And the exercise is to aid your passive break of distractive thought train.

(6) Call it to yourself with each component of the rythm: IN OUT, IN .... OUT and let each word or mantra come out with the OUT.

(7) Continue for 10 - 20 minutes. A tap on the table tells you about the expiry.

(8) Still close your eyes and sit quietly for five more minutes in the same passive attitude.

(9) Do not worry whether or not you are achieving a deep level of relaxation. Just permit relaxation to occur at its own pace; but when distracting thoughts occur, ignore them and concentrate on the word you are calling.

(10) Now open your eyes, still remaining calm.

On the Recording Panel

Pre-selected indication of Relaxation Response is watched out for as revealed by the Pilot Studies in the Respiratory Rate Pattern, psycho-galvanic skin resistance and electroencephalogram. Then

(1) Blood pressure measured at inspiration or at expiration

(2) The Heart rate, or the pulse rate

(3) The electrocardogram

(4) The cardiac output

From where compuration were made about

(5) Cardiac work

(6) Peripheral resistance

(7) O_2-consumption through regression correlation of Heart rate

(8) Cardiac efficiency

(9) Cardiac work Index (surface area read off from a normogram)

(10) Cardiac output Index.