Research in Yoga by the Methods of Modern Natural Sciences

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The worldwide popularity of Yoga in the recent times is often pridefully remarked by the Indians. Today there may be hardly any country worth the name where there are not a large number of people following some movement or activity, which goes under the name of Yoga, rightly or wrongly.

This fascination for Yoga is, no doubt, a result of the forces of circumstances. Yoga seems to be a panacea against the undesirable effects of the stresses produced as a consequence of the rush and hustle of life coming with the material progress. Efforts to introduce Yoga to the people of the Western countries made by the pioneers like Swami Vivekananda, Swami Ram Tirtha and others were, no doubt, causative in creating interest in Yoga at first, but the interest was limited to a smaller sphere comprising of people interested in spiritual and philosophical aspects of Yoga. Moreover, in this early period Yoga was erroneously looked upon as a peculiar religious movement linked with Hinduism or even a fad of some eccentric persons and so even shunned by a majority as against their own religions *viz.*, Christianity, Judaism, Islam etc.

That Yoga is fundamentally a non-parochial and secular discipline, an art and science, in fact a way of life leading to a better integration of the man is now generally well accepted and the old prejudicial attitude is largely disappearing. It is even recognised that the science of Yoga, which may some day be honoured as the 'Science of Sciences', can very well withstand the tests and criteria of modern life sciences and that the help of the other natural sciences can be taken to understand and elucidate the basic principles of the Yogic science in a clear and rational manner, in which the modern man wants to understand things.

The greatest credit for creating such an attitude about Yoga goes to the pioneer efforts of Late Śri Swami Kuvalāyananda. In 1924 he founded Kaivalyadhāma at Lonāvla, near Pune in Maharashtra,—the first institute of Yoga—where the attempts were made to co-ordinate this ancient science with the modern natural sciences on the basis of researches carried out with the use of the methodology and techniques of these latter.

In fact, as early as in 1920 Swami Kuvalayānandaji had started scientific researches on the physiological effects of certain Yogic practices employing the experimental investigative procedures of modern medicine, even before the founding of Kaivalyahdāma. Later after establishment of Kaivalyadhāma with developments of its various departments, branches and associated institutions, the researches were carried out in a more systematic manner and on a much wider scale.

The ancient treasure of Yogic knowledge is buried in the not very well-known storehouse of the old yogic literature. A lot of this literature has as yet remained to a great measure in the dark and has not been studied as critically and thoroughly as it is desirable. And without understanding what the ancient masters of this science have said in this sphere, it would be

impossible and also incorrect to develop the science further. Even the scientific research will have to build up its structure on the foundation of this research in yoga literature, which it being carried out by the Philosophico-Literary Research Department of the institution.

But the important work of co-ordination of the ancient yoga with the modern sciences is being carried out by the Scientific Research Department of Kaivalyadhāma. Here varying yoga practices like *Āsanas*, *Prāṇāyāmas*, *Ṣaṭkriyās* of *Haṭha Yoga* School, Meditational practices of various yoga schools are being studied in controlled experiments, to find their effects—physiological as well as psychological—on the human organism. Modern instruments and techniques from the fields of Biochemistry and Biophysics, Physiology including Electrophysiology and Radiology, Psychology and Psychometry, Physical education and physical fitness measurements *etc.*, are being utilised to evaluate objectively the changes produced by Yoga in man's mind and body.

As already mentioned, right in 1920 Swami Kuvalayānandji had made a start of such scientific research in Yogic field on modern lines. The first systematically planned and controlled experiments carried out by him in Baroda were investigations of the yogic practices of *Uḍḍīyāna Bandha*, *Nauli Kriyā*, *Basti Kriyā* and *Vastra Dhauti* by manometric techniques and with X-ray radiography.

These researches clearly showed the working and movements of various organs in the chest and abdomen during the performance of these Yogic *Kriyās* and very rationally explained that in *Uḍḍīyāna* and *Nauli* the pressure inside the hollow cavities, *e.g.*, stomach and intestines *etc.*, is reduced well below the normal, which is near about that of the atmosphere. This partial vacuum produced inside the abdominal organs was the cause which made it possible for Yoga students to suck various kinds of liquids in these internal cavities *e.g.*, water into the colon (large intestine) in *Basti Kriyā* and water, milk or even a heavy liquid like mercury into the urinary bladder through the urethra during *Vajroli Kriyā*. Thus these investigations proved that this strange feat of liquid suction inside the body was working on simple and natural laws. The mystery and awe were removed and the frequently made claim of miraculous yogic powers being behind the performance of such feats was exploded.

Since in those days of foreign domination and universal attitude of depreciating everything Indian, Swami Kuvalayānandaji found it impossible to get his researches published in the scientific journals or even popular standard magazines. He, therefore, was compelled to start his own journal, where he could place before the public these findings. Thus *Yoga Mīmāṁsā* quarterly started at the same time as Kaivalyadhāma in 1924 and these first scientific researches in the field of Yoga were published in this journal, being presented in such a manner that ordinary educated man conversant with English could also understand these. Though intermittingly, the journal is being published up-to-date and a lot of scientific research on Yoga, specially on its fundamental aspect *i.e.*, for understanding and elucidating the principles and mechanics lying at the basis of various Yogic practices rationally, with the help of modern methods of natural sciences, has been published in this journal. This will be briefly summarised in the following pages, when taking a general survey of modern scientific researches in Yoga.

Today a number of scientists, both in India and abroad, are getting interested in and even are carrying out researches related to Yoga. The findings of these researches are making the people interested in Yoga generally, and even a large number of scientists, specially to comprehend and recognise that the ancient discipline of Yoga can stand well tests of modern Western sciences. It is becoming also clear through these researches that Yoga can offer a number of benefits, which can and will enrich the life of humanity, irrespective of religion, creed, race, nationality, age, sex and such other limitations and even for those who may not be interested in the so-called spiritual gains.

It is for these reasons that all over the world a large number of persons are practising

Yoga in some form or other. Today there are everywhere in the world hundreds,—nay thousands of people attending some kind of Yoga centres or meets. And these include even scientists as for instance Dr. Salk, discoverer of Polio vaccine and winner of Nehru Puraskāra very recently, who acclaim Yoga on the basis of personal experience.

This present popularity, we may even say craze for Yoga, is no doubt a need of the times, since as said above the contemporary man exposed to stresses resulting from the so-called material advancement has become confused and disturbed and wants a peaceful happiness, which Yoga seems to promise, but this same present day man is not ready to accept things on make-believe, but wants an objective evidence for everything. Foreseeing this, it was that Swami Kuvalayānanda had embarked upon the almost unsurmountable task of trying to comprehend, elucidate and propagate Yoga in the framework of modern natural sciences. He had often expressed that this hard task, from which he was discouraged by almost all the leading personalities in various fields in India of those days, was a God-ordained duty for him, as otherwise he feared that Yoga will soon die out, as very few would like to learn or practise it in this present age of rationality and science mindedness.

Even after seeing this impact of the scientific and experimental research in the field of Yoga on creating the outlook of the scientificness and rationality of the Yogic practices and consequent arousal of interest in and stimulus for practice of Yoga in thousands of sādhakas all the world over and on the clarification of yogic principles and practices in such an easy and rational manner, that modern man who looks upon science as authority and even the scientists rigorously trained to accept objective evidence only, have begun to respect Yoga as a valuable discipline having potentiality to resolve many problems of the present day and future human generations. There are many people, among them even wellknown Yoga proponents, who are against such scientific researches by modern methods being carried out in the Yogic field. They opine that this will not add anything new to Yoga nor benefit it in any way and fear that this may even lead to a distortion of ancient traditional and true principles of Yoga.

But such views and fears have no real ground. The research in Yoga with application of the techniques of modern science is not going to and cannot change any Yogic principle. It is going to elucidate these principles and the mechanisms underlying various Yogic practices in the language of modern science, which will remove all mystery and mystification about yogic things and explain them in such a manner that they will be clearly understood by present day man, who easily understands this language and is not ready to accept things on blind faith, as of old, but respects things acceptable to science. In fact this will make people turn towards Yoga with open eyes and with a conviction in its valuableness—an effect which we are seeing already to-day.

No doubt, this will also explode myths and mysteriousness of special yogic powers and will leave less opportunities for imposters and pretenders of miraculous powers, claimed through Yoga. But this will be a healthy and desirable thing.

There is another aspect of still greater significance of the need and value of this scientific yogic research. Ancient Books on Yoga have frequently made explicit statements that Yoga is for all irrespective of any limitations of religion, age, caste *etc.* In these statements it is implicit that Yoga signifies a means for spiritual advancement and objectives. Today every one agrees that even though the spiritual aspect of Yoga is really most important and highest, the benefits which can be derived from Yoga on other levels *viz.*, physical and mental, are also highly valuable and useful to man universally even in his day to day empirical life. It is stressed by all the Yoga teachers that Yoga will help to enrich the life of every man whatsoever may be his profession, or age or sex or religion *etc.*, and so it need be taught to and should be practised by each and every person. It is being advocated that Yoga should be taught to every child, even compulsorily, in the school itself, it should be imparted to even labourers, factory

workers and so on. So far so that it has been proposed that army and police personnel be trained in yogic practices.

Such proposals are not whimsical nor senseless. They are really worth taking into consideration seriously and if worked upon in right manner they will make the life of people more fruitfully creative and happy and will provide answers to many problems which humanity is facing today.

But upto very recent times the notion about the value and utility of yogic techinques for objectives even of our day to day worldly life was not there. So in the old literature and tradition very little indication is there of how to derive such benefits from Yoga. The research with controlled investigations about the applicability of yogic techniques for specific condition will provide answers to such questions.

Thus prior to the current century Yoga methods were rarely used for treatment of diseases. But the researches related to the application of yoga practices for therapeutical purposes have given very valuable information. During the last decade or two a number of medical practitioners, trained in Western or standard official medical systems, have recognised the value of yoga techniques for alleviations of certain very refractory disease conditions and disorders and are taking help of the yogic practices—mainly *āsanas*—for treating these.

A great demand for introducing Yoga in schools and colleges is there. To some extent this has been even brought into actuality. Thus the State of Maharashtra a few years back initiated a plan of training teachers of middle schools and high schools in yogic practices, with a view to introduce Yoga in schools in Maharashtra, although the scheme was interrupted midway. The Union Minister of Education has several times announced that directives are being given to introduce Yoga as a subject in schools all over the country and courses and syllabi for both students and school-yoga teachers have been published by the government of India. Gharote and Ganguli from Kaivalyadhāma Research Laboratories have observed specific deficiencies of muscular strength and flexibilities in school children of various age groups, which they, on the basis of their other data, advise to be made good through training in yoga practice (Indian Journal of Medical Research, 63, 1242, 1976).

Proposals have been put forth to introduce yogic training (treatment ?) in reformatory schools for rehabilitation of delinquent childern and into prisons to reform the offensive tendencies of inmates. Shri K. B. Sahasrabuddhe and his colleagues have even started some such work in Thana prison and have claimed good results out of it.

Few years ago there was a proposal from the then Director General of Health Services of the Armed Forces of India to make yogic exercises a part of general training in all the three wings of the services. Some research projects were also started in the Armed Forces Medical College, Pune. But the proposal went no further.

Similar proposal for introduction of yogic exercises in the training programme of the police force have been put forward and some exploratory work has been started in the state of Maharashtra. Gharote and Ganguli have reported (Indian Police Journal, July—September 1976 p. 34) marked improvement in flexibility and physical fitness in a group of police trainees practising Yoga (*Āsanas, Prāṇāyāma etc.*) along with their routine training as compared to the group having the usual training.

Some time back there was a news in the daily papers that Yoga in form of Transcendental Meditation was already made a compulsory part of Air Force personnel training in U. S. A.

Some two decades ago one Director of Armed Forces Research Organisation of U. S. A. had approached Kaivalyadhāma authorities for getting some research in Yogic states being carried out, which was expected to resolve some very hard to overcome difficulties encountered by them in connection with the training and preparation of space flight pilots.

All such proposals and movements are welcome, both from the points of view of Yoga

as well as from that of the happiness and real advancement of the humanity. But in such special situations, where definite objectives and specifically limited effects are desired, every thing recommended and propounded in traditional yoga, which has man's spiritual development as the sole goal, may not be advisable to be included in the yogic training having such limited and specific aims. Research projects specially planned and designed to give answers to such specific problems will only show the way and then, based on these findings the programmes of yoga training for special groups and situations could be arranged. This utility of the yogic scientific research is of prime importance in the present context.

If such caution is not observed and yogic things are introduced arbitrarily and haphazardly, situation may arise where yogic practices may be branded, no doubt erroneously and baselessly, as non-beneficial or even deleterious. This is what probably happened in Russia, when reports were published in news-papers with such captions as "Yoga branded as Dangerous in Russia."

Certain yogic practices were taught and included in the training of Olympic Atheletes and it was found that in them some untoward effects were produced. But there are so many doubts involved as to whether this conclusion was arrived at in a correct manner—(1) Whether the yogic practices were judiciously selected ? This would have been possible if the yoga experts were well-versed in yogic principles and also the physical training principles and could understand the precise requirements of the situation and could adjudge what to include and what not to, in order to produce the desired change. (2) Whether yoga practices were taught and performed correctly ? (3) Whether yogic and non-yogic training was mixed and this with proper care ? If such precautions were not observed the findings may give distorted view of the facts.

The same may be true in case of the adverse reports from the same source about the effects of *Śīrṣāsana* published cursorily in the news papers a few years earlier.

There was indication that the opposition to Yoga had some implications about idealogical and philosophical background of Yoga not being acceptable to the Soviet socialistic attitude. But here again only the researches carried out on strictly controlled and scientific lines will remove the misunderstandings and consequent opposition to yoga and we think that this is what has already been happening. We know that in spite of these news-paper reports, researches are being conducted in Russian laboratories on different applied aspects of Yoga. The number of Russian tourists visiting Yoga centres is on the increase. Even official delegations are being in India to examine the utility of Yoga and Yogis and Indian scientists working on yogic problems are being invited on official level to that country.

Having thus seen the need and significance of scientific objective research relating to Yoga, we may very briefly review the outcome of such researches carried out so far.

The earliest researches of Swami Kuvalayānanda on *Nauli, Uḍḍīyāna, Dhautī* and *Bastī*, which are like starting post on the path Yogic scientific research have been already mentioned.

Extension of these studies revealed that in such yogic practices the chest diaphragm and the ribs could be moved inversely to each other independently, which was revelation for Anatomy and Physiology.

This work was followed by blood pressure studies during *Śīrṣāsana, Sarvāṅgāsana* and *Matsyāsana.* A gradual small rise in diastolic pressure but no significant change in systolic pressure was found. Generally the blood pressure during these *āsanas* rose moderately in the beginning but fell down towards and sometimes became normal after a few minutes.

Later investigations in Kaivalyadhāma Laboratories confirmed these findings and it was observed that subjects having several months' or years' practice of the inverted postures showed practically very little or no increase in either diastolic or systolic blood pressure during their performance.

Shankar Rao made studies about *Śīrṣāsana* and found that there was about 12—17

mm. Hg. increase in systolic, diastolic and mean blood pressures as compared to supine position.

These findings show that *Śīrṣāsna* is not very dangerous for a normally healthy man and could be practised also by persons with mild or moderate high blood pressure with caution and in degrees.

Shankar Rao also found that during *Śīrṣāsana* the energy expenditure is increased by 48% over the general metabolism, but investigations carried in Kaivalyadhāma Laboratories showed this to be about 25-30%. He has also measured the changes in various respiratory volumes in supine, upright and *Śīrṣāsana* positions and found that vital capacity is lowest in *Śīrṣāsana* along with highest pooling of blood in the thorax amongst the three positions.

The pressure changes occuring in thorax during *Prāṇāyāma* were compared by Kuvalayānanda with deep and normal breathing which showed how *Prāṇāyāma* could help better circulation. Respiratory exchange studies in *Prāṇāyāma* indicated that from gaseous exchange aspect long duration of a round of *Prāṇāyāma* and long duration of *Kumbhaka* were not more valuable than the shorter ones. Also that in this respect *Prāṇāyāma* did not have any advantage even compared to normal restful breathing. This finding removed the popular misconception of oxygen enrichment of blood by *Prāṇāyāma*, which would be unphysiological and brand *Prāṇāyāma* as energy expending and fatiguing. On the other hand, these findings are in consonance with the tranquillisation effect claimed about *Prāṇāyāma*.

Behenan, Miller and also Shankar Rao, on the other hand, have reported increased oxygen utilisation during *Prāṇāyāmic* breathing, which as said would not go well with peaceful feeling expected from *Prāṇāyāma* practice. The different findings may be due to different methods used, the observations being on small number of subjects and also probably due to the *Prāṇāyāma* technique and phase lengths being different.

Kuvalayānanda and Karambelkar examined the possible effect of a fairly long (45') duration of *Prāṇāyāma*-round performance on the acid base equilibrium of the body. Through the urinary acid excretion studies they came to the conclusions that no disturbance is produced in this equilibrium with such a continuous long practice of *Prāṇāyāma*.

Their studies on gas exchange and circulating blood cell number alteration with *Kapālbhati* breathing showed that even a minute's performance of *Kapālbhati* increases the number of red and white cells circulating in the blood by about 15% over that in rest. Also that befitting to its inclusion in the six purificatory processes of *Haṭhayoga* it increases oxygen absorption by 10 to 15% and the carbon dioxide elimination by 10 to 12%. This also is a proof that in their mysteriously sagacious way the ancient yogis were quite correct in distinguishing this breathing technique from *Prāṇāyāma* and classifying it into *Śuddhi kriyās* ; without the help of modern instrumentation methods, whereas many modern yoga teachers confuse with and often erroneously speak of *Kapālbhati* as *Prāṇāyāma*.

Studies of pressure changes produced in the internal body cavities in *Āsanas* and other yogic *kriyās e.g., Agnisāra, Vyāghra-Karaṇī* and *Gajakaraṇī* demonstrated highly positive pressure production. Thus the voluntarily producable positive and negative pressures of yoga practices would have beneficial effects on circulation, glandular secretions, nerve centre and nerve plexus stimulation, decongestion and consequent better functioning of various organs and system.

It has been demonstrated by the author and colleagues that uropepsin is decreased by the practice of *yogāsanas*, a result of the relaxation maintained and tranquillisation produced by these ; while with practice of *Daṇḍa* and *Vastra Dhautis* this excretion is increased. *Vastra Dhauti* showed the effect very markedly. This thus explains that *yogāsanas* can help reduce stresses, probably both mental and physical. Also it shows that *Dhautis'* work as a physiologically regulated corticoid therapy by stimulating adrenocorticoid secretion with a feed back effected through gastric stimulation, clarifying their benefactory and curative effect in asthma, eczema and other allergic conditions.

It was also demonstrated that *Dhautis* regulate the nastric acid secretion in judicious manner and thus they can be useful in setting right both hypo- and hyper-acidity conditions.

Swallowing of air in the stomach is a part of *Plāvini Prāṇāyāma*. It was found that gastric acid secretion is largely inhibited in subjects who swallowed air in this way or also in whose stomach it was pumped in through a tube and a pumping syringe. This measure thus could help hyper-acidity patients.

Yogic training in *Āsanas* (22), *Prāṇāyāmas* (2) and *Kriyās* (2) caused a reduction in the fibrinolytic activity of blood indicating that these yoga practices, specially *Āsanas*, are not to be equated to the physical exercises which increase the fibrinolytic activity.

Apparently similar practices, both in designations and manipulations, *e. g.*, *Uḍḍīyāna, Uḍḍīyāna Bandha* in *Prāṇāyāma, Uḍḍīyāna Mudrā, Tadagi* and *Tadagi Mudrā* could be differentiated precisely with respect to the differences in the chest and abdominal manipulations and their possible effects, by graphically recording in details the abdominal and chest movements in these practices. This is a good instance of the modern instrumental research helping clarification of yoga techniques.

A subject trying to cut the under-attachments of the tongue to set it free, so that it could go up far into the upper nasopharyngeal cavity below the skull, which is traditionally done in *Khecharī Mudrā*, it was seen that when he had progressed fairly, so that his tongue could go well in the upper naso-pharynx, his oxygen consumption in basal condition (B.M.R.) was 25% below the normal, which was quite normal prior to his taking to this practice. But further examinations at intervals showed no further reduction and the BMR become stabilised at this new level.

One subject able to enter into a deep absorption state through a *Laya Yoga* practice, which could be designated as "*Laya Samādhi*", showed 20% less oxygen requirement during sitting in meditation than his normal oxygen requirement in basal state in lying down rest. This no doubt was made up slowly in post meditative state. E.E.G. records of this subject in such meditational state showed spread of "alpha" wave activity over practically all brain areas in the early stage, a phenomenon very often observed in meditation by many other workers and interpreted as an indication of alert relaxedness. But later when the subject entered into still deeper state, as adjudged from no physical response and no EEG change with external stimuli (even very painful), many channels showed at interval of a few seconds a marked flattening of the graph—often completely a straight line, indicative of complete silence of parts of brain—a finding very perplexing. Unfortunately these findings could not be rechecked and confirmed due to certain difficulties.

The concept of *Iḍā-Piṅgalā* respiratory channels and the claims of *Svarayoga* were examined. It was seen that even persons in good health do not breathe equally through both nostrils all the time. In 85.5% persons the breathing through one nostril was more than the other, without any apparent cause. Use of a small crutch or of hot or cold pads or pressure under the arm-pit opened the nostril on the opposite side. About 10% subjects responded in an opposite manner, and few did not show any response even after $1\frac{1}{2}$ hrs. stimulus application. By a long practice a few subjects could induce the change of nostril breathing flow merely by willing without using the crutch etc. It was also demonstrated that characteristic electrical changes were produced in the inner regions of the nostril which were partly influenced by the respiratory activity of the nostril and partly by the mental activity and psychological state of the subject. This new study-branch has been designated as 'Electronasography'—ENG, for short.

Electromyographic investigation of activity of various muscles during different *Āsanas* proved that with proper training even difficult *Haṭhayogic Āsanas* could be done with great relaxation (*Prayatnaśaithilya*) as recommended in Pātanjala *Yoga Sūtra* II, 47. This only could give

the psychological and spiritual benefits fully from the *Āsanas*, which otherwise may become mere physical exercises. Subjects' capacity to relax is also generally improved in an overall way.

Bhole studied the effect of turning the head to one side on the relative transparency of the two sides of the lungs with X-ray fluoroscopy in the Radiology section of Kaivalyadhāma. It was seen that the ventilation is more on the side to which the head is turned. This explains one of the benefits accruing from practices like *Brahmamudrā*, *Vakrāsana etc.*, and could be used therapeutically in certain lung conditions.

Gharote and associates in Physical Education Research Wing of Kaivalyadhāma have reported the following results observed in groups of subjects trained in *Āsanas*, some *Prāṇāyāmas*, a few *Kriyās*, *Mudrās* and *Bandhas* :—

(1) Significant improvement in the Cardiovascular efficiency.

(2) Improvement in various flexibility measures *viz.*, forward flexion, backward extension, extent flexibility and dynamic flexibility, while no change was found in shoulder and ankle flexibilities.

(3) Physical Fitness Index Scores as measured by Fleishman Battery of Basic Fitness tests showed a significant increase in both males and females.

(4) Improvement of the tone of the abdominal muscles, which is very poor in most people and for which other systems of physical training have no exercising techniques as good as yoga.

(5) Vital capacity and Breath-holding time were significantly increased.

V. Pratap, H. C. Kochar and associates from the Psychological Section of the Kaivalyadhāma have noted the following effects of yogic training and practice of the similar type :—

(i) Handsteadiness scores showed a marked improvement, which is indicative of physical as well as mental steadiness claimed by Yoga through practice of *Āsanas* and *Prāṇāyāmas*.

(ii) Autonomic balance measured by A score method of Wenger showed generally a shift towards parasympathetic side. But the subjects having either sympathetic or parasympathetic extremes came into normal range of scores and those within the normal range also showed a betterment as their scores usually shifted towards the standard mean as a result of Yoga practice even of a few weeks.

(iii) Free Association test examinations showed a reduction in Free Associations of thoughts, indicative of increased relief from emotional conflicts as a result of Yoga practice.

(iv) Leg persistence, which serves to measure emotional stability, was found to have increased even after one month yoga practice.

(v) Railwalking tests indicating body control and balancing ability evidencing neuromuscular co-ordination level also showed improvement after yogic training.

(vi) Scheier and Cattell Neuroticism Questionnaire tests proved that a month's yoga practice reduces neurotic tendencies markedly as a result of resolution of emotional conflicts.

(vii) Studies employing Questionnaire tests *viz.*, N.S.Q., A.S.Q., H.D.H.Q. were made on groups practising yoga for varying periods. Significant reduction in Total Neuroticism, Anxiety and Hostility was seen with demonstration of better emotional equilibrium.

(viii) Memory drum test was given (1) to a group of adult, males and females and (2) to a group of schoolboys before and after a programme of three weeks of yoga practices. Both groups showed significant improvement in immediate memory after even such short yoga course.

(ix) Tests for production of mental fatigue were given to see the effect of *Ujjayi Prāṇāyāma* practice on this. The *Prāṇāyāma* delayed significantly the onset of mental fatigue.

The above running-survey of work done in Kaivalyadhāma Laboratories shows that the objective is to elucidate the psycho-physiological principles behind the Yoga practices, rather

than to find their therapeutical application or to study and understand the strange and abnormal feats performed by some yoga adherents.

Another such attempt recently started is of Udupa, Singh and their coworkers from the Institute of Medical Sciences, B.H.U., Varanasi. In their studies on Yoga *sādhakas* practising *Āsanas, Prāṇāyāma* and a few *Mudrās, Bandhas* etc. for 6 months or so they have noted similar beneficial effects. Their findings are :-

(1) Reduction of (over ?) body weight.

(2) Improvement in pattern of respiratory functions *viz.*, reduction of respiratory rate, increased expansion of chest, increase in vital capacity and in breath-holding time.

(3) Increased resistance to physical stress evidenced by stabilisation of respiratory functions.

(4) Increase in adreno-cortical activity, which will prepare the subjects to withstand stress in a better manner.

(5) Reduction of serum cholesterol, helpful in reducing tendencies for arterio— and atherosclerosis.

(6) Reduced fasting blood sugar suggestive of increased insulin activity leading to sugar and protein sparing.

(7) Restoration of serum protein levels to optimum.

(8) Electroencephalographic studies revealed a lowering of neurohumoral activity. On the whole the alpha index and mean voltage were increased. This appears to indicate diminution of the feeling of anxiety and production of relaxed wakeful state.

(9) Psychological assessement made by them led to similar conclusions as above.

(a) M.P.I. test showed decreased neuroticism index after yogic training.

(b) Mental Fatiguability index was also lowered.

(c) C.M.I. showed lowering of subjective complaints.

(d) Performance Quotient was increased.

(e) Memory Quotient was improved.

Another group working for similar fundamental understanding and evaluation of yogic practices with regard to their psycho-physiological effects on human organism is of Drs. O. P. Bhatnagar, K. S. Gopal and colleagues from JIPMER. Pondicherry.

They have studied the anatomical changes and effects of various *Haṭhayogic Bandhas* on the inner organs specially in the *Prāṇāyāma* viz. prevention of undue pressure on heart and big thoracic vessels, acceleration of veinous drainage from the head, strengthening of respiratory muscles as well as abdominal and pelvic accessory muscles, avoidance of ill-effects of *Prāṇāyāmic* practice on persons having hernia, piles etc.

The polygraphic studies carried out by them including ECG and EMG recordings gave similar results as noted with such studies by other workers. They have found that in well trained Yoga practitioners muscles electrical activity is very low, so also heart rate and respiratory rate are low, while peripheral blood flow respiratory amplitude are more in well trained subjects practising *Āsanas.*

Improvement in muscle tone and efficient cardiorespiratory adjustments after the practice of *yogāsanas* have been observed by these workers.

Reduction and stabilisation of blood pressure, decrease in pulse rate and betterment in respiratory function as a result of practice of *yogāsanas* and *Prāṇyāmas* have been reported by them.

In biochemical studies also their results are in agreement to those reported above.

Transcendental Meditation (TM) is a technique which is developed and propagated by Maharshi Mahesh Yogi and organisations sponsored by him. This seems to be an adaptation of *Mantra* and *Laya yoga* techniques, modified to suit modern conditions and specially the Westerners. It has, therefore, become very popular specially in U. S. A. and other Western

countries and a lot of research stimulated and supported by Mahesh Yogi's Organisations and directed towards the evaluation of TM effects has been carried out in various centres during recent years. TM is claimed to produce following results :—

(1) Decreases in metabolic rate, respiratory rate, heart rate and cardiac output, indicative of restful relaxed condition.

(2) Blood lactate is markedly reduced, helping to alleviate anxiety neurosis and attacks and high blood pressure.

(3) Increase of Galvanic skin resistance, an additional indication of deep relaxation and emotional stabilisation. Fewer G.S. responses indicate increased stability of nervous system and rapid habituation of G.S.R. denotes a better withstanding to stress.

(4) E.E.G. studies show a state of restful alertness with a high brain wave synchrony and it is claimed that the patterns are indicative of a "Fourth State of Consciousness", different from ordinary wakefulness, drowsiness and deep sleep.

(5) Reaction time is faster and perceptual ability is increased.

(6) Improvement is seen in (i) perceptual-motor skills, (ii) intelligence growth rate, (iii) learning ability, (iv) academic performance, (v) job performance, (vi) productivity, (vii) job satisfaction, (viii) relationships with superiors, (ix) co-operation and relationship with co-workers.

(7) A number of psychological tests *viz.*, Freiberger Personality Inventory, Personal Orientation Inventory, Rotter's Locus of Control Scale, Bendig's Anxiety Scale, Anxiety Scale of the Institute for Personality and Ability Testing, Netherlands Personality Inventory, Northridge Development Scale, Minnesota Multiple Personality Inventory, Spielberger Anxiety Scale etc. have shown improved psychology and mental health with reduction of anxiety, better emotional stabilisation with good personality development and increased self-actualisation.

(8) With respect to application to betterment in undesirable social conditions and in disease conditions following benefits have been claimed—(a) Improvement in (i) high blood pressure and (ii) asthmatic condition. (b) Relief from insomnia and faster recovery from sleep deprivation. (c) Increased resistance to disease. (d) Reduction in use of alcohol, smoking and drugs. (e) Better rehabilitation of prisoners and (f) Reduction of criminal tendencies.

This is a vast array of benefits and this is what has attracted world attention to TM and made it so popular. It also shows convincingly the value and importance of scientific research applied to yogic practices, which make them easily acceptable universally. TM is in fact a fraction of yoga and even it seems to produce such astounding benefits. Evidently if the innumerable practices and techniques of various yoga schools could be studied as thoroughly as TM the information will be all to the good for the real progress and happiness of humanity.

Ananda, Baldevsingh and Chhina and Wenger and Bagchi and Therese Brosse have carried out studies with EEG cum polygraph on a number of yoga practitioners. Their findings in general are similar to other EEG findings mentioned above.

These workers also have tried to examine the claims of heart and pulse stoppage of various yogis using ECG recording. Brosse had arrived at the conclusion that Yogis examined by her could slacken their heart rate. But this has been disputed by Anand *et al* and Wenger and Bagchi. They also did not find in some other yogis making such claims any evidence of heart stoppage or even significant slackening.

In Kaivalyadhāma laboratories, in one subject, it was observed both by ECG and X-ray fluoroscopic examination that the heart beats of the subject disappeared completely for 3 to 6 secs. (about 5-8 beats), when he performed *Jālandhara* and *Uḍḍīyāna bandhas* simultaneously. Several days practice of these *bandhas* by other subjects produced very minor slackening, if at all, in the heart rate, suggesting that the effect in the case of the former subject may be a result of many years' practice.

Govindsvamy and associates (from AIIMH, Bangalore), Anand *et al.* (from AIIMS, Delhi) and Karambelkar *et al.* (Kaivalyadhāma Lonavla) have studied the burial feat of some yogis, along with those of other control subjects. Govindsvamy and associates used a usual dug-out pit, which is quite pervious to air exchange due to porosity of soil and so they were not definite about their conclusions. Ananda *et al.*, on the basis that the oxygen consumption was significantly reduced below the basal level in the case of the Yogi, while it was not so in the two controls' cases, concluded that Yogis could control and reduce voluntarily then oxygen requirement. Karambelkar *et at.*, on the other hand found reduction in oxygen consumption in the case of every subject—Yogi as well as non-yogi—during his stay in an airtight pit. They conclude that reduced oxygen requirement is not a result of the voluntary control of the Yogis, but a natural consequence of the sedative and tranquillisation effect of the accumulated CO_2 in the pit. On the contrary the lowering of oxygen consumption was highest in non-yogi controls and was relatively smaller in the yoga practicants, showing an inverse relationship with duration in years of yoga practice. This means that lowering of oxygen requirement is a response to CO_2 stress, which yogis stand better as indicated by their maintenance of the metabolic rate.

On therapeutical application of Yogic practices, it is to be noted that *Āsanas, Prāṇāyāmas, Mudrās, Bandhas, Kriyās* and the various purificatory processes have been mainly utilised in this sphere and have been acclaimed to have given very remarkable results in treatment and cure of various psychosomatic functional disorders. In this respect the *Mudrās, Bandhas* and the purificatory practices are very valuable and rather unique contribution of Yoga in the field of treatment of diseases.

However the application and evaluation of more psychological and spiritual techniques of Yoga like meditation, *Japa*, etc., which also can do much in this field, specially for betterment in psychological derangements, have not been seriously undertaken and need much greater attention, seeing to the findings of researches on TM.

Reports of every good improvement, as good as a complete cure, of a large percentage and number of asthma patients coming from Bhole *et al.* from Kaivalyadhāma, Govindrajan and Gopal Reddy from Cardiac and Thoracid Clinic (Madras), form a land-mark in the sphere.

Very good benefits in treatment of different cardiac conditions and high blood pressure have been reported by Datey and his associates, Tulpule and his coworkers and others. Datey's evaluation of *Śavāsana* as a specially helpful technique in these cases and his demonstration of good control of the condition and rehabilitation of the patients, with lessening of the use of drugs, through judicious practices of Yoga *Āsanas* etc. have aroused great interest in the medical world all over.

Good improvement in diabetics has been claimed by Tulpule and others and has been observed in Kaivalyadhama hospital and other Yoga centres. Reports of Yogic treatment camps of diabetes from Vishwayatan Yogashrama of Delhi and Jaipur Yoga Centre note very remarkable in improvement, even cure, of this condition. But these reports have not been accepted in Medical circles and need a checking and confirmation from other workers.

Good results are claimed for digestive and metabolic disorders by workers in this field, but satisfactory data substantially supporting such claims are not available.

This very cursory survey gives just a brief glimpse of the research in Yoga completed so far employing the methods and gadgets of the modern sciences. A number of individuals and groups, besides those mentioned above, are working in India and elsewhere to find out more information on such lines about Yoga. Interest in the West in Yoga is growing rapidly and as a result larger number of scientists are attracted towards and are trying to understand yogic science in their own way. Even Communistic countries of East Europe have a large number of followers of Yoga and among these are many scientists. These latter are not just following yoga and many of them are carrying out researches in the field. Thus there are very valuable researches going on in Hungary, Roumania, Czechoslovakia, Poland and even in Russia on

Yogic techniques. Even new processes and gadgets are being developed, which will be very helpful in throwing light on the Yoga practices. Instance of these are the very recently invented 'Kirlian Photography' and 'Electronography', which study photographically the effect of special radiations on/of the human body and organs and seem to have very great potentiality to give more detailed information about the changes in the human organs than even the X-rays.

Though the above survey of research work may give an impression that a great lot of work has been done in the field. It has been already mentioned that probably a still greater amount of work and a larger number of workers could not even be named either for want of space or as enough information about them was not available to the author at this writing. The reader who may be interested may get further information from the works noted in the references at the end.

Yet the number and variety of Yoga practices and techniques of various Yoga schools is so large that we may say that only the surface of the problem is scratched. But we may be quite hopeful that with growing interest there will be much more research done with greater availabilities of funds, facilities and workers. And certainly the outcome will be a better and lucid understanding of Yoga, leading to greater attraction for its practice and this will lead, no doubt, to betterment and happiness of humanity.

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