Medical & Physiological Aspects of Yoga

by

Dr. F. CHANDRA,
B.Sc.(Hons.), M.B., B.S.(London), D.P.H.

Published by kind permission of
Yogashakti Mission, Bombay.

Dr. Chandra qualified in Medicine and Human and Experimental Physiology at London University. He practised abroad for twelve years and is now a Consultant Physiologist.

Dr. Chandra is well known in Britain and Europe for his lectures and papers on the physiological and psychological effects of Yoga. He also lectures on the religious and philosophical aspects of Hinduism and is Medical Adviser to a number of Yoga groups in Britain.

MEDICAL & PHYSIOLOGICAL ASPECTS OF YOGA

by Dr. F. J. CHANDRA, B.Sc.(Hons.), MB, BS, DPH.

Yoga in Britain mainly involves body postures (Asanas), breathing exercises (Pranayama and other types), and shallower types of Meditation (relaxation, withdrawal and concentration). Such activities have physiological effects, and some of these have been investigated, revealing certain interesting and beneficial results on the body.

(1) *LOCOMOTIVE SYSTEM:* The most obvious effect of Asanas is on muscles and joints. E. Radin (Seminars Arth. & Rheum. 2 '72) attributed the very low incidence of degeneration of the hip-joint in Eastern peoples, to the normal frequent use of the easy-Lotus position. This continually rotates and abducts the hips, thus maintaining movement in all planes and preventing the capsular contraction which threatens as one grows older. In the West, on the other hand, according to F. Dudley Hart (Pract. 212 1974) routine examination of the hips show that about 20% of adults over 55 years old, have decreased external rotation; and in patients with osteo-arthritic degeneration of the hips, all movements of those joints were diminished except flexion, which, being much used in sitting down onto chairs, remains painless up to 90°. He advocates avoidance of contraction of the joint-capsules by a set daily programme of physical exercises. It would appear that Yoga postures, which aspire to full ranges of movements, and which involve gentle stretching of soft tissues which restrict movements, would be ideal for this purpose. Many older persons in Yoga classes in Britain have reported improvement in the movement of shoulders, hips, and spine attributed to the postures used. Thus Asanas may not only prevent increase of stiffening of joints, but actually lead to a certain amount of improvement in the mobility of some joints afflicted with osteo-arthritis.

The effect of Asanas on back troubles depends on the nature of the underlying condition. In the many backaches of a non-specific nature, Asanas which flex, extend and rotate the back, will strengthen muscles, increase mobility and adjust posture. In Acute Prolapsed Intervertebral Disc, Asanas seem to have no place; but in chronic backache from long standing "PID", the element of pain from muscular spasm may be lessened by gentle stretching of the back muscles achieved by cautious forward-flexion Asanas, alternating with back-extension exercises.

(2) *CARDIO-VASCULAR SYSTEM:* Work on the physiological effects of the head stand, Shirsh-Asana, was published by S. Rao (J. Appl. Phys. 18 1963). It was thought that after 5 mins. in this position, about 500 ml. of blood gravitated from the legs, pelvis and abdomen towards the head. The mean blood-pressure

in the legs fell to almost zero, whilst that of the arms rose by about 15 points. The heart-rate was slowed by about 10 to 15 beats per minute, due to a carotid-sinus baroceptor effect. Oxygen usage was 50% more than when standing upright. Since in light exercise humans burn for energy 50% fat and 50% glucose, it seems that the head-stand is a rare exercise which does not increase the heart rate but yet enable some body fat to be burnt away. The head-stand has regularly been reported to cause beneficial mental subjective effects. This is not due to a general increase in blood-flow through the brain, since, in normal persons, the tone of the cerebral vessels causes an autoregulation of the blood-flow. A rise of blood-pressure bringing the mean arterial pressure to lie somewhere between 60 to 160 mm. of mercury, does not cause a general widening of the arteries of the brain, but rather probably a reactive general mild constriction, together with an increase in blood flow only through locally under-perfused areas. The net result would be an improved pattern of blood-flow, giving a better overall distribution. Because of the auto-regulatory tone of the cerebral blood-vessels, it seems that the danger of cerebral haemorrhage due to the head-stand is likely to be remote *unless* the blood-pressure is made to exceed 160 mm. Hg. mean level. Carbon-dioxide retention causes dilatation of the blood-vessels of the brain (maximum at 8% blood-CO2 level) and loss of auto-regulation. An increase in headward blood-pressure in Hypercapnia could then possibly damage weakened blood-vessels. It is therefore wise not to perform the head-stand immediately after some Pranayama breathing-exercises where a rise in blood CO2 occurs. D. D. Heistad (Anaesthesiology 41 1974) reviews evidence showing that during exercise, vasoconstriction occurs in resting muscle, and vasodilatation in active muscle. Also, low-pressure baroceptors respond to the rise in venous-pressure when the legs are raised and this causes decreased sympathetic tone in the vessels of the forearm muscles. The net result in the head-down/legs-up position, is a redistribution of blood into the forearm and other active muscles in the neck and back. This probably means that the blood-pressure in the arms is *more* than in the internal carotid artery at the level of the brain and this provides a further safety-factor protecting the blood-vessels of the brain. A Bouhys (J. Appl. Phys. 17 1962) found that in people tilted passively into the head-down position, the tidal-volume, breathing-rate and bronchomotor tone remain the same as in the upright position, but that the functional residual capacity decreased in proportion to the angle of tilt. This was perhaps due to the pressure of the viscera on the diaphragm, which reduced residual capacity by squashing some alveoli shut and reducing total lung-volume. It is probable, too, that stagnant secretions in areas in the smaller respiratory tubes where the cough-reflex and ciliary mechanism have failed through various pathological processes, may be drawn by gravity in the inverted position to areas where the cough-reflex and cilia still retain activity and can so aid expulsion later.

The Shoulder-Stand (Sarvangasana) combines the effects of the Head-Down position with those of the Chin-Lock. The CHIN-LOCK (Jalandhara) by itself:

(a) Stretches the vertebral arteries maximally and probably alters temporarily the flow-dynamics in those vessels. The many curves which a vertebral artery makes between its emergence from the vertebral canal of the axis and the formation of the basilar artery, impose continual increased stresses on areas of its wall where the stream impinges as it goes around each curve. It is likely that the chin-lock stretching of the vessel may be useful in relieving some of these stresses and retarding possible chronic degenerative changes in the vessel wall. The stretching of the vessel would also be expected to lessen, temporarily the sharpness of the curves and hence speed-up the blood-stream. This would increase blood flow through those parts of the brain supplied mainly by the vertebral arteries (the posterior third of the brain including the vital centres of the medulla, as well as the reticular activating system).

(b) Traction on the spinal cord causing movement of a few mm. This slight movement may be enough to free the cord and nerve-roots gently from early adhesions.

(c) Stretching of the posterior ligaments of the cervical-spine for more flexibility.

(d) Stretching of the muscles of the back of the neck (so often the site of spasm and pain) and strengthening of the muscles of the front of the neck.

(e) Pressure on the soft tissues of the front of the neck, including the jugular veins and the thyroid gland. The consequent reduction of flow in the external jugular veins, and the stretching of the vertebral veins (accompanying the vertebral arteries) and the vertical branches of the vertebral venous plexuses (around the spinal cord and the outside of the vertebral bodies) in the cervical region, causes a temporary redistribution of outflow of blood from the brain. When pressure is taken off the thyroid gland at the end of the Chin-Lock, the reactive increase of blood-flow probably causes a washout of thyroid hormone. As an increase of blood-flow through the gland is NOT associated with an increase in total output of thyroid hormone, it does not seem that the reactive hyperaemia causes any stimulation in the production of hormone (as has been claimed by some authors).

Some sufferers of Migraine in Britain have claimed that the Sarvangasana performed regularly has caused an initial increase in their symptoms, followed by a long-term decrease both in the frequency and the severity of migraine attacks.

Interesting work has also been done on the effect of the Shavasana on high blood pressure. K. K. Datey e.a. (Angiology 20 1969) studied the effect of this Asana done for 1/2 hour daily, on the blood-pressure of 47 subjects with renal, essential and arteriosclerotic hypertension, some never on drugs, some on effectual drugs and some on drugs but without benefit. He found that all obtained marked improvement subjectively, but that the overall success-rate was 52% as judged by improvement in blood-pressure. People with arteriosclerosis had poor results, whilst many with

essential hypertension benefitted significantly.

Despite description emanating from India of Yogis who could exercise voluntary control over certain aspects of their autonomic nervous system (e.g. pulse, blood pressure, calibre of blood-vessels), Western medicine for long insisted on dividing the nervous system into voluntary and involuntary (autonomic) parts. Now, however, ideas are rapidly changing. M. V. Bhole e.g. showed (Yoga Mimamsa xiii 1971) heart-stopping for up to 5.6 seconds by Yogic methods. This was objectively recorded on an ECG tracing. In the USA, experiments were done to show that individual functions of the autonomic nervous system could be brought under voluntary control by a specific learning process similar to that used for developing skeletal responses. Thus G. E. Schwartz (Sci. 175 1972) showed that 40 young volunteers could learn to increase or decrease, voluntarily, blood-pressure and heart-rate, both together, as well as separately and independently. They could not sustain rising of *both* pulse and blood-pressure for long; and most difficult of all was raising the blood-pressure, whilst lowering the pulse-rate. Schwartz used a light flash and a tone as feedback, for subjects to know when they had achieved the desired result. A money-award for each successful effort provided incentive to the subjects. The changes were small, but definite, i.e. about 15 mm. Hg. systolic pressure, 15 to 20 heartbeats per minute. Thus it appears that ordinary persons have inter-connections between the voluntary and the autonomic parts of the nervous system, and that these can be developed to a certain extent by learning. Yogis may therefore be regarded as people who have attained a very high degree of control over their autonomic nervous functions through long, arduous years of training by special esoteric techniques. Neal Miller (Sci. 163 1969) used voluntary learning through operant-conditioning as a superior method to classical (involuntary) conditioning; and he showed that alterations in blood-flow and activity of internal organs and glands could be achieved, voluntarily, by 'higher' learning. There is argument whether these effects are produced purely by the autonomic nervous system, or are secondary to manipulation of skeletal muscles; and the use of curare has so far produced equivocal results. The effects, however, remain clear. A remarkable account of the impact of mystical inspiration on body functions was given G.C.E. Pugh of the Division of Human Physiology of the Medical Research Council (J. Appl. Phys. 18 1963) and concerned the resistance to cold of an untutored Kashmiri named Man Bahadur, who slept out for 4 days without harm in a blizzard at 15,000' in the Himalayas at temperatures down to 15°C, without shoes or gloves. Harsh climatic conditions were subsequently recreated in the laboratory, and his reactions and absence of untoward effects were measured and confirmed.

The evidence for voluntary control of the automatic functions of the body reached such a high level of probability, that researchers devised Biofeedback as a quick method for achieving results. Here a visual-or sound-signal tells the subject when the desired effect has been obtained. The subject can then learn to prolong the effect; and in some cases he can establish a correlation between obtaining the effect, and a personal inner state or thought or action which can produce this effect. When

this correlation is established, the subject can dispense with the biofeedback equipment, yet nevertheless be able to produce the effect at will, in any place, and almost at any time. Yogis such as Swami Rama attached to the Menninger Foundation of Topeka, Kansas, USA, have shown some areas where voluntary control is possible. R. E. Ornstein in 'Psychology of Consciousness' (1972) reported that Elmer Green has demonstrated that Swami Rama can voluntarily increase his pulse to 300 per minute, or sharply drop his body-and skin-temperature, or go for 25 mins. into 'Yogic sleep' where all outward appearances indicate a stage-4 deep sleep with delta-waves on the EEG, but where the subject on awakening can recall anything that has been going on around him. He could also raise the temperature at one point in the hand and decrease it in another, so to create a temperature-difference of up to 11°. Biofeedback has been used to confirm and to extend such types of autonomic control.

Dr. Chandra Patel (Lancet 10.11.73) used biofeedback to confirm the beneficial effect of Shavasan on hypertension. Using finger electrodes, she recorded changes in skin resistance and converted these into an audio-signal. The patients tried to decrease or stop the signal by relaxing, as taught, in Shavasan. At home they were required to continue the relaxation exercises, but without the biofeedback apparatus. She found that 16 of her 20 subjects responded to the treatment, and that the effects lasted for up to 6 months. G. W. Pickering ('High Blood Pressure' 1968) postulated factors operating through the mind in the genesis of hypertension; and Dr. Patel here thinks that Shavasan influences these mental factors because of the relaxation, which perhaps allows faint internal signals from the autonomic nervous system to become amenable to detection and control, as the level of the normal masking 'noise' from muscles and environmental stimuli is gradually made to subside.

(3) *RESPIRATORY SYSTEM:* Interesting effects occur also in the respiratory system. Dr. M. V. Bhole (Yoga Mimamsa, April 1968) cites the Svarayoga branch of Yoga as asserting that healthy persons breathe more through one nostril than through the other, and that this dominant nostril alternates every hour. (Gay Gaer Luce in 'Circadian Rhythms' 1971, states that this occurs about every 3 hours). This effect is thought to be due to an autonomic reflex. V. E. Negus (Thorax 25 1970) showed that the nose rather than the glottis, is the main point of resistance in the upper respiratory tract, and that this resistance affects both the intra-tracheal and the intra-thoracic pressures, causing dilatation of pulmonary capillaries and pooling of blood in the lungs. Respiratory obstruction from enlarged tonsils and adenoids may be associated with pulmonary hypertension and other cardiac disorders, which may clear up when the obstruction is removed. B. Drettner (Ann. Otolar. St. Louis 79 1970) found subjects with nasal obstruction to have a decreased alkaline reserve.

S. Rao e.a. (J. Appl. Phys. 28 1970) showed that the Yoga Danda, a crutch used to obtain deep pressure in the axilla, caused an ipsilateral nasal engorgement and an

increase contralateral nasal airflow. This confirmed the earlier work of Dr. Bhole (1968) who found the effect to occur in about 2 mins. from application of the crutch. Stimulation of receptors in the nose and post-nasal space, can also alter tracheo-bronchial airway resistance, and bronchospasm can occur from reflex irritants in the nose (D. L. Chadwick, Pract 209 1972). These effects in various combinations probably underline the medical claims made for Yogic breathing exercises. Alternate-nostril breathing will produce alternating changes in pressure, depending on which is the patient's dominant and which the engorged nostril at the time. The pressure-changes or the increased velocity of the air-stream, by causing temperature, humidity and other physical changes around the nasal mucosa may stimulate nasal receptors and cause changes in pulmonary blood-flow with cardiac effects, as well as changes in the calibre of the lung airways.

In Dr. Bhole's standardisation of Pranayama, the subject breathes against resistance (imposed by closing one nostril or by partially closing the glottis), holding the breath and prolonging expiration, so that the time spent in inspiration, breath holding and expiration is in the ratio 1/4/2. If this is done for about 10 breaths, then at about the 6th breath, Dr. Bhole found that the alveolar-CO2 concentration reaches 7%, a level which produces depression of the brain from cortex to thalamus, with stimulation of the medullary centres (P. V. Karambelkar e.a. Ind. J. Med Res. 56 1968). This hypercapnia stimulates the respiratory-centres and dilates the larynx through a vagal effect (M. Dixon e.a. J. Physiol. 239 1974). As the subject continues Pranayama, he therefore voluntarily overrides these reflex effects, and establishes a controlled rhythm over these normally-dominant reflex autonomic patterns. W. R. Miles of Yale Univ. (J. Appl. Physiol. 19 1964) studied a male subject who did Ujjayi, Bhastrika and Kapalabhati types of Yogic breathing. He estimated that in any one, Ujjayi should normally increase the oxygen-usage by about 230% owing to the muscular work involved; but he found instead, in his subject, that the oxygen-usage went up by only 35%. Furthermore, although there was some respiratory preparation for Ujjayi (shown by a slow increase in ventilation before the exercise started), there was no after-effect on stopping, and normal breathing re-started at once. Thus neither the muscular exertion, nor the fight against autonomic reflexes produced the effects expected.

High levels of CO^2 which develop in Pranayama cause an increase in tolerance to CO^2, and Dr. Bhole considers (Ind. J. Med. Res. 56 1968) that these high CO^2 levels help Pranayama-adepts to tolerate in air-tight pits, a build-up to high levels of CO^2, which in turn reduces oxygen-consumption and enables such adepts to remain in these pits for up to 18 hours. In fact, Jal Vakil (Lancet 23.12.50) described a remarkable case of a Yogi who remained in a small sealed concrete-walled pit studded with nails, for over 62 hours, a feat which was witnessed by 10,000 spectators in Bombay.

Asthmatics are likely to benefit from Pranayama because of the practice in

breathing-out against resistance. The respiratory muscles are strengthened thereby, and a technique of breathing acquired which is precisely that needed to overcome the expiratory difficulty encountered in bronchial asthma. Stimulation of the palate or the oesophagus by passage of a rubber-tube leads to an outpouring of water secretions in the lungs, and this dilutes the tenacious, viscid mucus of the asthmatic and promotes expectoration. Bhastrika breathing with forced, quick expiration and passive slower inspiration, creates a Venturi 'suction' effect in the bronchi and pulls mucoid secretions into the main bronchi for expectoration.

As regards the nose, E. H. Hadfield (Ann. Roy. Coll. Surg. Eng. 46 1970) quotes work of Sir Victor Negus showing that is the *expired* air stream which reaches the paranasal sinuses. It is probable, therefore, that forced rapid expiration would tend also to suck material out of the sinuses and so drain them of secretions.

Hyperventilation from rapid, deep respirations causes lowering of blood CO^2 content, and this leads to cerebral vasoconstriction and to slower unloading of Oxygen from Oxyhaemoglobin. The result is a relative deprivation of the brain of Oxygen, and this may account for the mental effects which are associated with overbreathing. These effects are used in various religious and spiritual practices in several different communities all over the world.

(4) *ABDOMEN:* Turning to the abdomen, H. D. Johnson (Lancet 28.9.74) stated that the intragastric pressure in normal persons is usually only slightly greater than the intra-abdominal pressure at the same level. Dr. M. V. Bhole (Yoga Mimamsa Jan. 1971) used intra-gastric pressure as an approximation of intra-abdominal pressure, and he was able to show that negative pressures of up to—50mm. Hg. in Uddiyana, and—95mm. Hg. in Nauli can be produced in the abdomen. In single attempts, this suction in Uddiyana could draw in 360 ml. water into the stomach, 45 ml. into the bladder but none into the colon; where as Nauli could suck in 500 ml. into the stomach, 90 ml. into the bladder, and 250 ml. into the colon. This is used in the cleansing exercise called Basti, where it seems, water can be sucked-in as far as the ileo-caecal junction and then expelled. In Vayu Basti, air is drawn into the colon instead of water, and the possible interesting effects of Oxygen on the gut flora have yet to be investigated.

The abdomen may be regarded as a cavity containing a series of soft walled tubes. Thus the negative pressure which develops around the tubes (gut, blood vessels, ducts, renal pelvis and ureters) in Nauli and Uddiyana, may cause mild distension, and lead to redistribution of blood and the clearing of minor early obstruction in those tubes. These exercises, together with the head-down positions, are not advised for women during heavy menstrual flows lest a drop of blood be carried into the peritoneal cavity through the Fallopian tubes and cause chemical peritonitis.

By the same intra-gastric pressure measurements, Dr. Bhole also showed that 19 of the commonly used Asanas could be divided into a group which produced mild positive abdominal pressures (5 to 20mm. Hg.); a group producing moderate positive pressure (up to 50mm. Hg.) and a group producing high pressures (60 to 100mm. Hg.). Beginners should start with low-pressure Asanas, and gradually move on to those producing higher abdominal pressures. People with areas in their abdominal cage which are weaker than normal, should avoid the higher-pressure Asanas, or only do them under expert supervision.

(5) *MEDITATION:* Much work has been done on the Physiology of Meditation, mainly on subjects practising Transcendental Meditation (TM). The waves on the EEG (mixed with some theta-waves), a decrease in Oxygen-usage paper by K. Wallace e.a. (AM. J. Phys. 1971) is perhaps best known. These workers found that the state of meditation (TM) was characterised by alpha-waves on the EEG (mixed with some theta-waves), a decrease in Oxygen-usage and CO^2 elimination, decreased minute-ventilation and respiratory-rate and pulse, increased skin-resistance and forearm blood-flow, a mild metabolic acidosis (perhaps due to the production of lactic acid), but no change in blood-pressure, body-temperature, Respiratory-Quotient or finger blood-flow. They decided that it was a "Hypometabolic Wakeful State". The respiratory findings were confirmed by J. Allison (Lancet 18.4.70) using thermistors near the nose (to measure air-flow), rather than face-masks.

Some effects claimed for TM in the West are: (i) More stable CNS showing fewer fluctuations of GSR (Galvanic Skin Resistance) than controls in anxiety situations. (ii) Quicker recovery (judged by GSR speed of stabilisation) from stress imposed as a 100 decibel tone of 3000 Hertz heard at unpredictable intervals through earphones, (iii) Increased perceptual ability as judged by discrimination between frequencies of a warble-tone (or between different amplitudes of sound) before and after TM (iv) Improved speed and accuracy of hand/eye co-ordination when asked to trace a star-shape by looking at its mirror-image. (v) Cure for drug-addiction lasting at least 2 to 3 years. (vi) Cumulative improvement of learning-ability, as judged by short-and long-term tests. (vii) Faster reaction-time compared with controls using simple eye-closure instead of TM.

In the 1960's, R. W. Sperry studied the reactions of people with divided corpus callosum ('Split Brains') and this work was continued by Brenda Milner (Br. Med Bull. 27 1971) and R. E. Ornstein ('Pscyhology of Consciousness' 1972). Results showed that the left cerebral hemisphere was concerned with logical, analytical thought, linear sequences, words, clock time; the right hemisphere, on the other hand, deals with creative, holistic thought, body-sense, spatial relations, intuition, subjective time. Thus it seems that Meditation and mystical states largely depend upon the right cerebral hemisphere which may have more direct connections with the Hypothalamus than the left cerebral hemisphere. One can postulate that if intuition

emanates from an outside source, such as the collective consciousness made up of the interconnected, intertwined entities which make up this world (and appear clearly even at the Hadronic level of sub-atomic studies), or else from the Absolute Cosmic Power situated at Eternity and at Infinity in Time and Space, then the receptor-mechanism for such emanations may be sited in the right cerebral hemisphere, which, when completely activated produces a full awareness of this Absolute Power, leading to Samadhi.

Work on Sensory Deprivation tends to substantiate the claim that withdrawal of the mind from sensory impulses, as advocated in Pratayahara, can give rise to perceptions resembling some of those met with in ecstatic states. The methods used for producing sensory deprivation, however, such as lying motionless in a silent tank of fluid at body temperature, in the dark, nevertheless leave intact some sensory inflow; whereas Yogic withdrawal should ideally free the mind of all sensory inputs.

In summary, then, several lines of research confirm the benefits of many Asanas, and have opened up interesting and promising avenues for further work, as well as possibilities of reconciling many ideas emerging from modern Science with some of the ancient, longheld, religious beliefs.

Dr. F. Jadunandan CHANDRA, BSc.(Hons.) (Human & Experimental Physiology) (London). .....
(London). .....
2.12.1974 MB, BS(London) DPH(London)