Jawaharlal Institute for Postgraduate Medical Education and Research (JIPMER), Pondicherry is a premier medical and research institution in India and many studies on the beneficial effects of Yoga have been conducted here in the past decades.

In the year 2000, Central Council for Research in Yoga and Naturopathy, (CCRYN) Ministry of Health, New Delhi sanctioned a YOGA RESEARCH PROJECT with Dr Madanmohan (Director-Professor and Head, Dept of Physiology) as Principal Investigator and Dr Gopal Krushna Pal (Associate Professor, Physiology) as co-investigator. The author (Yogacharya Dr Ananda Balayogi Bhavanani) is the Senior Research Fellow of the project while Shri G Kumaran and Miss Lalithambika are the Yoga teacher and technical assistant respectively.

The Department of Science and technology (DSTE) under Pondicherry Government had also sanctioned a Yoga Project to Dr Madanmohan and Dr Gopal Krushna Pal. Some of these studies have been completed under that project with students of the Indra Nagar Government HSS.

Many studies have been conducted in the Department of Physiology in the last three years and this article aims to give the readers a brief idea of the scope of these research works.

Other members of the Physiology Department, JIPMER who have contributed to these studies are Dr P Vijayalakshmi (Associate Professor, Physiology), Dr Kaviraja Udupa (Senior Resident), Dr ES Prakash (Junior Resident) and Dr Asmita Patil (Senior Resident). Dr N Krishnamurthy (Scientific Officer-Cum-Tutor) and Dr Lakshmi Jatiya (Senior Resident) who have left the department recently were also actively involved in these projects. Mr Amudhan and Mr Surendiran (MBBS students) have also contributed to some of the studies through their ICMR (Indian Council for Medical Research) Student scholarships.

Dr Kaviraja Udupa (Senior Resident) successfully presented his MD (Physiology) thesis on how Pranayama training of six months influenced cardiac function as measured by Systolic Time Intervals in school children.

1. Effect of Suryanamaskar training on pulmonary function, respiratory pressures and handgrip in school children: Scientific literature is deficient on the effects of suryanamaskar on physiological functions. Suryanamaskar is an integral part of Yoga practice and consists of a sequence of movements synchronised with deep breathing. Although a number of studies have been reported on the beneficial effects of Yoga training, there is no report on the effect of suryanamaskar training on pulmonary function, respiratory pressures and handgrip. Hence, we planned to study the effect of suryanamaskar training on forced expiratory volume, forced expired volume in first second, peak expiratory flow rate, maximum expiratory pressure, maximum inspiratory pressure, handgrip strength and handgrip endurance. 42 school children in the age group of
12 to 16 were randomly divided into two groups of 21 each. Group I was trained in suryanamaskar for 6 months while Group II formed the control group. In both the groups, the above mentioned parameters were studied before and after 6 months of the study period. In Group I subjects, peak expiratory flow rate, maximum expiratory pressure, maximum inspiratory pressure, Forced expiratory volume and forced expired volume in first second increased significantly following suryanamaskar training. Handgrip strength and hand grip endurance also increased significantly after the training. On the other hand, in the control group, there was no significant increase in these parameters. We suggest that Suryanamaskar be used as an effective and inexpensive method to improve pulmonary functions and general health of school children.

2. **Effect of Yoga training on pulmonary function, respiratory pressures and handgrip in school children:** 20 school children in the age group of 12 to 15 years were given Yoga training (Asanas and Pranayamas) for 6 months. 20 age and gender-matched students formed the control group. Yoga training produced statistically significant increase in handgrip strength and handgrip endurance. Maximum expiratory pressure, maximum inspiratory pressure, forced expiratory volume, forced expired volume in first second, and peak expiratory flow rate also increased significantly after the Yoga training. In contrast, the increase in these parameters in the control group was statistically insignificant. Our study shows that Yoga training for 6 months improves lung function, strength of inspiratory and expiratory muscles as well as skeletal muscle strength and endurance. It is suggested that Yoga be introduced at school level in order to improve physiological functions, overall health and performance of students.

3. **A comparative study of the effects of slow and fast Suryanamaskar:** 42 school children in the age group of 12 to 16 were randomly divided into two groups of 21 each. Group I and Group II received 6 months training in performance of slow suryanamaskar (SSN) and fast suryanamaskar (FSN) respectively. SSN subjects were trained to perform suryanamaskar in a slow manner so that each of the 12 poses was held for duration of 30 seconds. Each round took 6 minutes to complete and 5 rounds were performed in 30-40 minutes. On the other hand, FSN group subjects were trained to perform surya-namaskar in a fast manner so that the 12 poses were completed in 2 minutes. 15 rounds were performed in 30-40 minutes. Training in SSN produced a significant decrease in diastolic pressure and an insignificant (3%) fall in rate-pressure-product, which is an index of load on the heart. In contrast, training in FSN produced a significant increase in systolic pressure and insignificant (4.5%) increase in rate-pressure-product. Although there was a highly significant increase in hand grip strength and hand grip endurance in both the groups, the increase in hand grip endurance in FSN group was significantly more than in SSN group. Training in SSN reduced the resting diastolic pressure and rate-pressure-product, which, indicates a decrease in load on the heart. In contrast, FSN increased diastolic pressure and rate-pressure-product. The present study shows that the effects of FSN are similar to physical aerobic exercises whereas the effects of SSN are similar to those of Yoga training.
4. **Acute effect of Mukh Bhastrika (bellows breath) on reaction time:** 22 healthy schoolboys who were practising Yoga for the past three months and could perform Mukh Bhastrika properly, were recruited for the present study. Visual reaction time and auditory reaction time were recorded before and after nine rounds of mukh Bhastrika. Mukh Bhastrika produced an immediate and significant decrease in visual as well as auditory reaction time. A decrease in reaction time indicates an improved sensory-motor performance and enhanced processing ability of central nervous system. This may be due to i) greater arousal, ii) faster rate of information processing, iii) improved concentration and/or iv) an ability to ignore extraneous stimuli. This is of applied value in situations requiring faster reactivity such as sports, machine operation, race driving and specialised surgery. It may also be of value to train mentally retarded children and older sports persons who have prolonged reaction time.

5. **Effect of Pranayama training on cardiac function:** Systolic time intervals are sensitive and objective measures of ventricular performance. Yogic breathing exercises especially bellows type of breathing are likely to produce hemodynamic alterations thereby affecting ventricular performance. Keeping this in mind we planned to study if training with Yoga breathing exercises has any effect on ventricular performance as measured by systolic time intervals. To the best of our knowledge no such study has been undertaken so far. 24 school going children were divided into two groups. Group I subjects (Pranayama group, n=12) were given training in Savitri Pranayama, Pranava Pranayama, Nadi Shuddhi and mukh Bhastrika and practiced the same for 20 min daily for a duration of 3 months. Group II subjects (control group, n=12) were not given any training. In both the groups, systolic time intervals were measured 10 minutes after supine rest at the beginning and end of the study period. Pranayama training resulted in increase in QS2I and PEPI, the increase being statistically significant. On the other hand, LVETI was reduced significantly. In contrast the changes in systolic time intervals in control subjects were not statistically significant. QS2I and PEPI are indicators of the effect of the parasympathetic nervous system on the heart while LVETI is an indicator of the sympathetic nervous system’s effect on the heart. Our study shows that Pranayama breathing can alter the ventricular performance as measured by systolic time intervals. Further studies can illustrate the underlying mechanisms involved in this alteration.

6. **A comparative study of the effects of slow and fast Pranayamas on physiological functions:** We planned to undertake a comparative study of the effect of short term (three week) training in Savitri (slow breathing) and Bhastrika (fast breathing) Pranayamas on respiratory pressures and endurance, reaction time, heart rate, blood pressure and rate-pressure-product. Thirty student volunteers were divided into two groups of fifteen each. Group I was given training in Savitri Pranayama, which involves slow, rhythmic and deep breathing. Group II was given training in Bhastrika Pranayama, which is bellows-type rapid and deep breathing. Parameters were recorded before and after three-week training period. Savitri Pranayama produced a significant increase in respiratory pressures and respiratory endurance whereas Bhastrika Pranayama produced an insignificant increase in
respiratory pressures and a significant increase in respiratory endurance. In both the groups, there was an appreciable but statistically insignificant shortening of reaction time. Blood pressure, heart rate and rate-pressure-product decreased in Savitri Pranayama group but increased in Bhashrika Pranayama group indicating that Savitri Pranayama decreases sympathetic activity while Bhashrika Pranayama increases it. It is concluded that different types of Pranayamas produce different physiological responses in normal subjects.

7. **Effect of Shavasana on cold pressor-induced stress:** Shavasana is known to enhance one’s ability to combat stressful situations. This study was planned to determine if the performance of Shavasana after training of short duration could modulate physiological response to stress induced by cold pressor test and the possible mechanisms involved. Ten normal adults were taught Shavasana and practised the same for a total duration of seven days. RR interval variation (RRIV), deep breathing difference (DBD) as well as heart rate, systolic pressure, diastolic pressure and rate-pressure-product changes in response to cold pressor test were measured before and after performance of Shavasana. RR interval variation (RRIV), deep breathing difference (DBD) are known indicators of the activity of parasympathetic nervous system Shavasana produced a significant increase in DBD and an appreciable but statistically insignificant increase in RRIV suggesting an enhanced parasympathetic activity. Significant blunting of cold pressor-induced increase in heart rate, blood pressure and rate-pressure-product by Shavasana was seen during and even five minutes after cold pressor test suggesting that Shavasana reduces load on the heart by blunting the sympathetic response. It is concluded that Shavasana can enhance one’s ability to withstand stress induced by cold pressor test and this ability can be achieved even with seven days of Shavasana training.

8. **Effect of Yogic relaxation training on hypertension:** Thirteen male patients of essential hypertension whose age ranged from 41 to 60 years were trained in Yogic relaxation techniques daily, Monday through Saturday for a total duration of 4 weeks. Systolic pressure, diastolic pressure, mean pressure and heart rate were recorded with a non-invasive semi automatic blood pressure monitor before Yoga training and at weekly intervals during the 4-week training period. There was a significant reduction in diastolic pressure, mean pressure, heart rate and rate-pressure-product after 2 weeks of Yoga training. Systolic pressure showed a significant reduction at 3 weeks. At 4 weeks of training there was a further fall in systolic pressure, diastolic pressure and mean pressure. Rate-pressure-product also showed a further significant decrease at 3 and 4 weeks. Before Yoga training isometric handgrip produced a rise in all the parameters that was significant only in systolic pressure indicating subnormal cardiovascular autonomic reflex response. After Yoga training, isometric handgrip produced a highly significant rise in all parameters except pulse pressure. Thus our study shows that Yoga training restores the autonomic regulatory reflex mechanisms in hypertensive patients and Yoga relaxation training of 4 weeks is effective in producing a significant decrease in blood pressure of hypertensive patients.
9. Effect of Shavasana on heart rate variability: The effect of Shavasana on heart rate and blood pressure is well known. However, its effect on heart rate variability (HRV) is not well known. Hence, we studied the effect of Shavasana training on HRV as measured by sympathovagal balance (SVB) and coefficient of variation of RR intervals (CVRRI). SVB helps to understand the balance between activity of the sympathetic and parasympathetic nervous systems on the heart, while the coefficient of variation of RR intervals (CVRRI) is a known indicator of parasympathetic activity. Twenty six school children (13 boys and 13 girls) aged 16 years were recruited for the study. Their blood pressure, heart rate and HRV were recorded in supine position under standard conditions. A 5-minute ECG was recorded and the RR interval series was subjected to fast Fourier transformation and an RR-interval power spectrum obtained. SVB was calculated as the ratio of low frequency (0.04 – 0.15 Hz) and high frequency spectral powers (0.15 – 0.40 Hz). The subjects were then given Shavasana training and practised the same under our direct supervision for a period of six weeks. Blood pressure, heart rate and HRV were recorded under similar conditions after the training period. Shavasana training produced a significant decrease in heart rate and systolic pressure, diastolic pressure, mean pressure and rate-pressure-product. There was also a significant increase in total power of the RR interval spectrum and CVRRI but no change in SVB. We conclude that the practice of Shavasana increases heart rate variability. This implies a “healthier” heart that will be able to withstand the stresses and strains of life better.

10. Effect of direction of head on heart rate and blood pressure: Indian culture stresses the importance of direction during performance of daily activities. Some Yoga teachers prescribe that the Yogic relaxation and polarity practices must be done while lying with the head towards the North in order to align oneself with the earth’s electromagnetic field. There is some evidence that earth’s magnetic field influences physiological functions. Hence, the present study was undertaken to see whether head direction has any effect on heart rate and blood pressure during supine rest. 43 normal healthy school children were recruited and their recordings were taken after 5 minutes of supine rest. The subjects were randomly assigned to lie with their head towards North, East, South and West directions on four different days. Heart rate and blood pressure were recorded at the end of 5 minutes of supine rest. Heart rate was lowest in North and highest in South, the difference being statistically significant by Student’s paired ‘t’ test. Systolic pressure was lowest in the North and significantly higher in the West. Lying supine with head towards North had the lowest rate-pressure-product as compared to the West. Our study demonstrates that lying supine with head in different directions has a definite effect on the heart rate and blood pressure. Further studies in different age groups and in hypertensive patients may help in understanding the mechanisms and implications of this phenomenon.

These studies have been presented at the Annual Conferences of IABMS (Indian Association of Biomedical Scientists), Annual Conferences of APPI (Association of Physiologists and Pharmacologists of India), International Yoga Festival, Pondicherry and at the
Kaivalyadhama Yoga Conference 2002. Some of the studies have also been published in Indian Journal of Physiology and Pharmacology (IJPP) and Yoga Mimamsa (Yoga Journal of Kaivalyadhama).

One of the positive spin offs of the Yoga Project has been the possibility of free Yoga training that has been imparted to a large number of persons. One of the aims of our project was to create an awareness and interest in Yoga amongst the general public and this aim is surely being realised under the guidance of Dr Madanmohan. More than 160 police trainees of Pondicherry Police are receiving yoga training. Nearly 140 personnel of Pondicherry Police department have completed two weeks of Yoga training in six batches. 60 students of Kendriya Vidyalaya in the JIPMER campus and more than 140 students of the Indra Nagar Govt HSS have received Yoga training for between 3 and 6 months. Nearly 100 patients suffering from various disorders have received Yoga therapy on referral basis from concerned departments and more than 100 staff and students of JIPMER have received training in various aspects of Yoga. 50 students of the Tagore Arts College have also received more than 6 months of Yoga training as part of the project.

I hope that this short overview of the various studies has given the reader some idea of the numerous works going on in Department of Physiology, JIPMER and I welcome any queries on these studies at yognat2001@yahoo.com.