Yoga is a way of life based on sound philosophy and scientific evidence. Being holistic, it is an ideal way to promote health and prevent disease. Although yoga is beneficial for all ages, it is highly recommended for adolescents. Adolescence, the period between childhood and adulthood is characterized by rapid biological and psychological growth and development. It can be a tumultuous stage in one’s life. Adolescents frequently experience physical and mental health problems and yoga is ideal to manage them.

Biological maturity or puberty that starts earlier in girls than in boys is due to sequential physiological processes that lead to sexual maturity and reproductive capacity. It involves hypothalamo-pituitary-gonadal axis. There occur important changes in central nervous system, gonads, adrenals, skeletal muscles, bones and body composition. Secondary sex characteristics develop which are distinct in boys and girls. Size of viscera including heart and lungs increases. In girls, growth spurt starts at 12 years and they reach the final height of about 163 cm at the age of 16. In boys, the growth spurt begins at 14 years and they reach the final height of about 177 cm at the age of 18.

Although psychological development is tumultuous, it generally proceeds without disrupting life of the adolescent. Rapid sexual maturation without concomitant emotional and intellectual maturity can cause problems which are precipitated and / or worsened by problems in family or education. Psychological development of the adolescent can be described in 3 stages  i) Early adolescence (10-13 years) during which the adolescent is concerned with his/her developing body, ii) middle adolescence (14-16 years) during which there is rapid cognitive growth and iii) late adolescence (17-21 years) which is the period of establishment of personal identity. Raging hormones and biological maturity without parallel emotional and intellectual development can lead to mental health problems. The adolescent may become impatient and aggressive and prone to risky and violent behavior. Risky driving and risky sexual behavior can result in disability and death. The problem can be effectively managed by jnan yoga which will help development of rational competence and desirable social behavior. Karm yoga can channelize the raw energy of the adolescence for the larger social good. Adolescence is the period of development of personality and personal identity. Hence, independence as well as graduated increase in responsibility needs to be emphasized.

In the past decade we have conducted many studies on the immediate, short term and long term effects of yoga training on adolescent subjects of Pondicherry. These studies have been conducted at the Jawaharlal Institute for Postgraduate Medical Education and Research (JIPMER), Pondicherry through CCRYN, ICMR and DSTE sponsored projects as well as in the Advanced Centre for Yoga Therapy Education and Research (ACYTER), a collaborative venture between JIPMER and Morarji Desai National Institute of Yoga (MDNIY), New Delhi. These studies demonstrate the beneficial effects of yoga training on physiological

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functions and general health of the adolescent subjects. A brief description of these studies follows:

**Effect of surya namaskar training on pulmonary function, respiratory pressures and handgrip of school children:** Scientific literature is deficient on the effects of suryanamaskar on physiological functions. Surya namaskar is an integral part of yoga practice and consists of a sequence of movements synchronized 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 surya namaskar training on pulmonary function, respiratory pressures and handgrip strength. Hence, we planned to study the effect of surya namaskar 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 handgrip 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 surya namaskar be used as an effective and inexpensive method to improve pulmonary functions and general health of adolescent school children.

**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 (asans and pranayams) 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 and overall health and performance of adolescents.

**A comparative study of the effects of slow and fast surya namaskar:** 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 surya namaskar (SSN) and fast surya namaskar (FSN) respectively. SSN subjects were trained to perform surya namaskar 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.

**Acute effect of mukh bhasrika (bellows breath) on reaction time:** 22 healthy schoolboys who were practising yoga for the past three months and could perform mukh bhasrika properly, were recruited for the present study. Visual reaction time and auditory reaction time were recorded before and after nine rounds of mukh bhasrika. Mukh bhasrika 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.

**Effect of pranayam training on cardiac function:** Systolic time intervals are sensitive and objective measures of ventricular performance. Yogic breathing exercises especially bellows type 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 (pranayam group, n=12) were given training in savitri pranayam, pranav pranayam, nadi shuddhi and mukh bhasrika 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. Pranayam training resulted in increase in QS and PEP, the increase being statistically significant. On the other hand, LVET was reduced significantly. In contrast the changes in systolic time intervals in control subjects were not statistically significant. QS and PEP are indicators of the effect of the parasympathetic nervous system on the heart while LVET is an indicator of the sympathetic nervous system’s effect on the heart. Our study shows that Pranayam breathing can alter the ventricular performance as measured by systolic time intervals. Further studies can illustrate the underlying mechanisms involved in this alteration.

**A comparative study of the effects of slow and fast pranayams 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) pranayams 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 pranayam, which involves slow, rhythmic and deep breathing. Group II was given training in bhastrika pranayam, which is bellows-type rapid and deep breathing. Parameters were recorded before and after three week training period. Savitri pranayam produced a significant increase in respiratory pressures and respiratory endurance whereas bhastrika pranayam 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 pranayam group but increased in Bhastrika Pranayam group indicating that Savitri Pranayam decreases sympathetic activity while bhastrika pranayam increases it. It is concluded that different types of pranayams produce different physiological responses in normal subjects.
**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 schoolchildren (13 boys and 13 girls) aged 16 years were recruited for the present 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.

**Effect of direction of head on heart rate and blood pressure:** Indian culture stresses the importance of direction during performance of various activities. Some yoga teachers prescribe that the yogaic 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 direction of head has any effect on heart rate and blood pressure during supine rest. 43 normal healthy schoolchildren 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.

**Modulation of cardiovascular response to exercise by yoga training:** This study reports the effects of yoga training on cardiovascular response to exercise and the time course of recovery after the exercise. Cardiovascular response to exercise was determined by Harvard step test using a platform of 45 cm height. The subjects were asked to step up and down the platform at a rate of 30/min for a total duration of 5 min or until fatigue, whichever was earlier. Heart rate (HR) and blood pressure response to exercise were measured in supine position before exercise and at 1, 2, 3, 4, 5, 7 and 10 minutes after the exercise. Rate-pressure product [RPP = (HR x SP)/100] and double product (Do P = HR x MP/100), which are indices of work done by the heart were also calculated. Exercise produced a significant increase in HR, systolic pressure, RPP & DoP and a significant decrease in diastolic pressure. After two months of yoga training, exercise-induced changes in these parameters were significantly reduced. It is concluded that after yoga training a given level of exercise leads to a milder cardiovascular response, suggesting better exercise tolerance.
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