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ORIGINAL PAPERS

Efficacy of Yoga on Pregnancy Outcome

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ABSTRACT

Objective: To study the efficacy of yoga on pregnancy outcomes.

Design and setting: Three hundred thirty five (335) women attending the antenatal clinic at Gunasheela Surgical and Maternity Hospital in Bangalore, India, were enrolled between 18 and 20 weeks of pregnancy in a prospective, matched, observational study; 169 women in the yoga group and 166 women in the control group.

Methods: Women were matched for age, parity, body weight, and Doppler velocimetry scores of umbilical and uterine arteries. Yoga practices, including physical postures, breathing, and meditation were practiced by the yoga group one hour daily, from the date of entry into the study until delivery. The control group walked 30 minutes twice a day (standard obstetric advice) during the study period. Compliance in both groups was ensured by frequent telephone calls and strict maintenance of an activity diary.

Main outcomes: Birth weight and gestational age at delivery were primary outcomes.

Results: The number of babies with birth weight $\geq$2500 grams was significantly higher ($p < 0.01$) in the yoga group. Preterm labor was significantly lower ($p < 0.0006$) in the yoga group. Complications such as isolated intrauterine growth retardation (IUGR) ($p < 0.003$) and pregnancy-induced hypertension (PIH) with associated IUGR ($p < 0.025$) were also significantly lower in the yoga group. There were no significant adverse effects noted in the yoga group.

Conclusions: An integrated approach to yoga during pregnancy is safe. It improves birth weight, decreases preterm labor, and decreases IUGR either in isolation or associated with PIH, with no increased complications.

INTRODUCTION

The normal growth and development of the fetus can be adversely affected by a number of factors such as infections, complications of pregnancy such as pregnancy induced hypertension (PIH) or diabetes, teratogens, and psychosomatic stress. Pregnancy is a unique state of physiologic stress which necessitates physical, mental, and social adaptation. In earlier observational studies in the 1960s, psychosocial measures have been examined as possible risk factors contributing to adverse birth outcomes.

Animal experiments have convincingly demonstrated that prenatal maternal stress affects pregnancy outcome and results in early programming of various organ systems with permanent changes in neuroendocrine regulation and behavior in offspring (Mulder et al., 2002). Recent well con-

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trolled human studies indicate that pregnant women with high stress and anxiety levels are at increased risk for spontaneous abortion, preterm labor, malformations, and asymmetric growth retardation (Mulder et al., 2002). Evidence of long-term functional disorders in the offspring after prenatal exposure to stress is limited, but retrospective studies (Stott and Latchford, 1976; Weinstock, 1997) and two prospective studies support such effects (Huizink, 2003; Van den Bergh, 1992).

Stressors during pregnancy vary from life events (e.g., divorce, serious illness, or death of a relative or friend) to daily trials and tribulations (e.g., domestic affairs, financial or social problems). During exposure to a stressor, the whole system of stress regulation, consisting of the hypothalamus–pituitary–adrenal cortex system (HPA axis) and the sympathetic nervous system–adrenal medulla system, is activated (Mulder et al., 2002). Various hormones, including corticotropin-releasing hormone (CRH), adrenocorticotropin-releasing hormone (ACTH), cortisol, and noradrenaline, are released in large quantities into the systemic circulation. Pregnant women respond differently to identical stressful stimuli, depending on genetic factors, personality traits, previous experience, and social support. In addition, normal pregnancy is associated with physical alterations, hormonal changes (often associated with rapid changes in mood), anxiety regarding labor and fetal outcome, all of which potentially worsen the stress response. The interaction between all these factors renders evidence-based stress research with pregnant women difficult and complicated.

Several attempts have been made to reduce stress in pregnant women (Fenster et al., 1995; Villar et al., 1992). These efforts were primarily directed at optimizing social support and environment through regular telephone calls, home visits by health care workers, counseling, and providing education to promote healthy living. A large randomized controlled trial including 2235 women at high risk for low birth weight, conducted by the Latin American Network for Perinatal and Reproductive Research, concluded that although high levels of psychosocial distress during pregnancy played an independent role in determining adverse pregnancy outcomes, this could not be ameliorated by psychosocial interventions conducted during pregnancy. The core interventions included 4 to 6 home visits during which emotional support, counseling, and social networking was provided (Langer et al., 1996). Similarly, other apparently sound, logical interventions to reduce perinatal stress did not prove effective when rigorously evaluated. A recent Cochrane Database Systematic Review (Hodnett and Fredericks, 2003) undertook a meta-analysis of 16 trials (with a total of 13651 women), and concluded that programs offering additional social support for at-risk pregnant women were not associated with improvements in any perinatal outcomes, but were associated with a decrease in caesarean births and an increase in elective termination of pregnancy. These interventional programs probably failed as they were very focused and not holistic or comprehensive. Yoga, on the other hand, uses a holistic approach to stress reduction and has been used to promote positive health for centuries in India (Collins, 1998).

Reduction in stress through the integrated approach of yoga therapy (IAYT) is achieved by the practice of deep relaxation at the somatic level in different postures (*asanas*), slow controlled breathing to decrease the respiratory rate (*pranayama*), and mind calming techniques such as meditation and chanting. Yoga, unlike many other alternative therapies, has been extensively evaluated but lacks a comprehensive systematic review. However, references to clinical trials in asthma (Goyeche et al., 1982; Jain et al., 1991), hypertension (Patel, 1973), pain management (Nespor, 1991), diabetes (Jain et al., 1993), and mood changes (Wood, 1993) exist. The cardiovascular effects of yoga have been particularly well researched. Transcendental meditation has been shown to decrease oxygen consumption and resting heart rate (Wallace, 1970), and to increase cutaneous vascular resistance along with a reduction in the heart rate, suggesting increased mental alertness in a physiologically relaxed state (Telles et al., 1995). In the United States, Herbert Benson, a professor at Harvard Medical School and a proponent of the relaxation response, has extensively published the effects of meditation to treat many cardiovascular ailments ranging from headache to hypertension (Roush, 1997). Beyond these clinical observations, there is a growing body of evidence suggesting that mechanical actions can have physiologic effects at the cellular level. Changes in cell shape can lead to altered gene regulation, including changes in matrix metalloproteases and adhesion molecules (Garfinkel and Schumacher, 2000). Resultant changes in cell function are just beginning to be understood.

Interestingly, the physiologic state produced by the regular practice of IAYT is the exact opposite of the fight-or-flight response that occurs during stress. The gentle stretching and improved body flexibility decreases muscular tension and stiffness, the relaxed controlled breathing reverses the shallow fast respirations, and the meditation calms the mind, and has inhibitory effects on the HPA axis which is activated during stress. In fact, many of the techniques of relaxation, internal focus, and systematic breathing currently included in childbirth classes have their roots in yoga (Collins, 1998).

At present, there are no randomized trials or recommendations from professional organizations regarding the role or safety of IAYT during pregnancy. This study was conducted to test the hypothesis that stress management in pregnancy using IAYT improves pregnancy outcomes when compared with standard obstetric management. The primary outcomes studied included gestational age at delivery, mean birth weight, mode of delivery, intrauterine growth retardation, and obstetric complications such as pregnancy-induced hypertension and intrauterine death.

METHODS

The study population comprised 335 pregnant women who registered for antenatal care at Gunasheela Surgical and Maternity Hospital, a referral center for obstetrics and gynecology in Bangalore, India. Women were enrolled in a prospective observational study between January 2000 and December 2002. Out of 3500 women screened, 1200 fit the eligibility criteria, and were divided into two groups based on their distance from the hospital: subjects in the Near group ($n = 438$) lived within 15 minutes travel from the hospital; subjects in the Far group ($n = 762$) lived further than 15 minutes travel from the hospital. Patients were presented with the study protocol and those in the Near group were encouraged to select the yoga arm of the study, to facilitate compliance, as it involved multiple visits to the hospital to learn yoga. Patients in the Far group elected the control arm as it did not involve frequent trips to the hospital. From the control group, 526 patients were matched for age, parity, body weight, and Doppler velocimetry score (DVS), but only 166 signed the informed consent. In the yoga group, only 169 patients consented to be enrolled in the study. The 360 patients in the control group and the 269 patients in the yoga group who were unwilling to take part in the study gave reasons such as: being unsure of their residence after discharge (which is related to the local cultural practice of moving between parents, in-laws, and their own homes); husbands, in-laws, or parents disliked the idea of their participation in the research; or they wanted to be in the yoga arm but were unwilling or unable to come regularly to the hospital to learn yoga. The women were from the middle to upper socioeconomic strata.

The study received ethical approval from the director and members of the governing council of the hospital. The inclusion criteria were: pregnant women between 18 and 35 years of age, irrespective of parity, with no previous yoga training, between 18 and 20 weeks gestation with a baseline DVS of umbilical and uterine vessels (Table 1). The exclusion criteria included multiple pregnancy; protracted medical illness complicating pregnancy; or a history of previous pregnancy loss due to known single gene defects, chromosomal disorders, fetal malformations, and intrauterine infections.

Yoga practices including physical postures (*asanas*), breathing techniques (*pranayama*), and meditation were practiced by the yoga group, one hour daily, from the date of entry into the study until delivery. The control group walked half an hour twice a day (standard obstetric advice) during the study period. Compliance in both groups was ensured by frequent telephone calls and strict maintenance of an activity diary.

IAYT was taught by a well-trained yoga therapist in groups of 2 to 8 pregnant women during the first week after enrollment. Subsequently, the women were asked to practice these techniques at home and were reviewed every 3 to 4 weeks during their routine antenatal visits. Yoga practices differed based on the trimester (Table 2). Care was taken to avoid practices that were contraindicated during a given gestation. The physical postures (*asanas*) of yoga were performed while standing, sitting, or lying either prone or supine on the floor, as previously described (Nagendra and Nagarathna, 2001). The exercises take each joint in the body through the full range of motion: stretching, strengthening, and balancing each body part (Nagendra and Nagarathna, 2001). Internal awareness and synchronization of *asanas* with breathing was considered critical. The breathing techniques (*pranayama*) focus on conscious prolongation of inhalation, breath retention, and exhalation. *Pranayama* includes the complete yoga breath (conscious breathing in the lower, middle, and upper portions of the lungs), interval breathing (duration of inspiration and expiration being altered), and alternate nostril breathing, as outlined previously by Iyengar et al. (1993). Meditation included techniques such as listening to one's own breath or repeating a mantra (word) to bring about a state of selfawareness and inner calm (Canter, 2003).

The women were closely monitored during their routine antenatal visits. At each visit, blood pressure was measured, and a value ≥140/90 mm Hg on 2 separate occasions 6 hours apart, or an increase of 15 mm Hg from the baseline value after the 20th week was considered PIH. At each visit, an ultrasound scan monitored fetal growth: intrauterine growth retardation (IUGR) was defined as an estimated weight <10th percentile (Singh, 2002). In addition, at each visit, Doppler ultrasound of the uterine and umbilical vessels was done to calculate the resistance index (Ott, 1990) and the total DVS.

At birth, the mode of delivery (vaginal or cesarean section), gestational age (in weeks), and birth weight (g) were

Table 1. Mean Baseline Doppler Velocimetry Scores

Blood vessel	*RI*	*Score*	*RI*	*Score*
Left uterine artery	<0.58	0	≥0.58	1
Right uterine artery	<0.58	0	≥0.58	1
Umbilical artery	<0.75	0	≥0.75	1
Persistent diastolic notch in the left uterine artery	Negative	0	Positive	1
Persistent diastolic notch in the right uterine artery	Negative	0	Positive	1

A total Doppler velocimetry score >3, of a maximum 5, is considered a predictor for fetal growth restriction. RI, resistance index.

Table 2. Yoga Practices for Pregnancy by Trimester

	Months				Months		
	1–3	*3–6*	*6–9*		*1–3*	*3–6*	*6–9*
Loosening exercises				Asanas (prone)			
Hands stretch/side stretch	Yes	Yes	Yes	Bhujanga	Yes	Yes	No
Hands in/out	Yes	Yes	Yes	Shalabha ardha	Yes	No	No
Ankle stretch	Yes	Yes	Yes	Asanas (sitting)			
Straight leg raising alternative	Yes	Yes	Yes	Pascimothana	Yes	No	No
Straight leg raising both legs	Yes	Yes	No	Ustra	Yes	Yes	No
Forward/backward bending	Yes	No	No	Sasanka	Yes	No	No
Side bending	Yes	Yes	Yes	Badha kona	No	No	Yes
Twisting	Yes	Yes	Yes	Vakra	Yes	No	No
Breathing exercises				Ardha-matsyendra	Yes	No	No
Tiger breathing	Yes	Yes	Yes	Squatting	Yes	Yes	Yes
Rabbit breathing	Yes	Yes	Yes	Upavista	Yes	Yes	Yes
Sasankasana breathing	Yes	Yes	No	Pranayama			
Asanas (standing)				Sectional breathing	Yes	Yes	Yes
Ardha-kati chakra	Yes	Yes	Yes	Nadi sudhi	Yes	Yes	Yes
Ardha chakra	Yes	Yes	Yes	Bhramari/seetali/seetkari	Yes	Yes	Yes
Padahasta	Yes	Yes	No	Relaxation techniques			
Prasarita	Yes	Yes	Yes	Instant relaxation	Yes	Yes	Yes
Asanas (supine)				Quick relaxation	Yes	Yes	Yes
Viparitakarani	Yes	Yes	No	Deep relaxation	Yes	Yes	Yes
Sarvanga	Yes	No	No	Meditation			
Matsya	Yes	No	No	OM—AAA, UUU, MMM	Yes	Yes	Yes
Pavana muktasana kriya	Yes	No	No	Mind sound resonance technique	Yes	Yes	Yes

documented. Preterm delivery was defined as <37 completed weeks of gestation.

Statistical analysis was performed using the SPSS statistical software. The study data were subject to intention-to-treat analysis with respect to all outcomes. Continuous variables were analyzed using Student's *t*-test and proportions by the Chi-square or Fischer exact test. Results were considered to be statistically significant for $p < 0.05$.

RESULTS

Maternal characteristics did not differ between the two groups (Table 3). DVS were examined at the time of enrollment to identify pregnancies at high risk for developing complications (PIH, IUGR, perinatal mortality) and were found to be similar between groups. Compared to the control group, the interventional group (IAYT) had a statisti-

Table 3. Maternal Characteristics

	Yoga group (n = 169)	*Control group (n = 166)*	p
Mean age	26.0	26.5	0.12
Mean weight at first antenatal visit (kgs)	54.37	53.14	0.27
Mean weight at last antenatal visit (kgs)	66.72	65.17	0.17
Gravida			
1	92 (54%)	80 (48%)	
2	50 (30%)	60 (36%)	
3	10 (6%)	12 (7%)	0.43
4	7 (4%)	9 (5%)	
≥5	10 (6%)	5 (3%)	
Parity			
0	120 (71%)	110 (66%)	
1	39 (23%)	45 (27%)	0.64
≥2	10 (6%)	11 (66%)	
Mean Doppler velocimetry score	2.24	2.16	0.6

There was no statistically significant difference between groups.

cally significant decrease in preterm deliveries, decreased numbers of small-for-gestational-age babies, and decreased incidence of idiopathic IUGR and IUGR associated with PIH (Table 4). The incidence of PIH and emergency cesarean sections tended to decrease, but the differences were not statistically significant. There were no adverse events related to the practice of yoga in the interventional group. Subgroup analysis done to evaluate the effect of IAYT on specific complications of pregnancy such as PIH, idiopathic IUGR, and preterm delivery did not show statistically significant differences between groups.

DISCUSSION

In this study, we evaluated the role of IAYT started at mid-gestation and continued until delivery on pregnancy outcomes. We compared this group to a matched control group who were similar in patient characteristics, but performed aerobic exercise twice a day (standard obstetric advice). The interventional group (IAYT) had a statistically significant increase in mean gestational age at delivery, decreased small-for-gestational-age babies, and decreased incidence of idiopathic IUGR and IUGR associated with PIH. The incidence of PIH and emergent cesarean sections tended to decrease but was statistically not significant.

Given the larger picture of multiple failed attempts to reduce low birth weight and prematurity in the past decade, this study provides a potential intervention that might improve pregnancy outcomes. The exact role of IAYT is unclear. Whether this represents a true causal effect or an association needs to be studied further. We speculate that its actions mediate three commonly postulated mechanisms for the transfer of maternal stress to the fetus.

The relationship between the HPA axis and the reproductive system in pregnancy is complex and intriguing. The hormones of the HPA axis primarily have strong inhibiting effects on the hypothalamo-pituitary-gonadal axis (HPG) (Chrousos, 1998). There is also evidence suggesting that the endometrium, myometrium, and ovaries are rich in receptors for corticotrophin releasing hormone (CRH) and cortisol receptors (Mulder et al., 2002). Given this functional relationship, it is not difficult to hypothesize that psychological (and physical) stress may lead to poor reproductive outcomes.

The three possible mechanisms that have been postulated to explain the transmission of maternal stress to the unborn baby are a reduction in transplacental blood flow, a placental transfer of maternal stress hormones, and stress-induced pCRH (placental CRH) released prematurely into the fetal environment. Reductions in placental blood flow have been documented by Doppler flow studies showing high resistance of the uterine arteries in women with high anxiety scores at 32 weeks gestation (Teixeira et al., 1999). Corticosteroids readily cross the placenta in many animal models, but the human fetus is protected by the placental enzyme 11β-hydroxysteroid dehydrogenase (11β-HSD), which converts the active cortisol into inactive cortisone (Seckl, 1997). Under certain circumstances of maternal hypercortisolemia (stress) the fetal levels of cortisol have been found to be linearly related to maternal levels (Gitau et al., 1998). The placenta produces pCRH between 8 and 10 weeks gestation along with hypothalamic CRH. In normal pregnancies the pCRH rises rapidly during the last 2 to 4 weeks, to facilitate parturition. Under abnormal circumstances (PIH, preterm labor, or maternal stress) the pCRH surge occurs prematurely. Premature activation of pCRH has been linked to preterm labor and delivery (Majzoub and Karalis, 1999).

Women undergoing assisted reproductive techniques (IVF) as a result of functional disorders of the HPG axis have been shown to have higher stress scores than women

Table 4. Pregnancy Outcomes

	Yoga group (n = *169*)	*Control group* (n = *166*)	p
Mean gestational age at delivery (weeks)	38	37	0.10
Mean birth weight (g)	2790	2690	0.12
Mode of delivery			
Normal vaginal delivery	90 (54%)	81 (49%)	
Elective cesarean section	38 (22%)	27 (16%)	0.08
Emergency cesarean section	39 (23%)	55 (33%)	
Intrauterine death	2 (1%)	3 (2%)	0.69
Birth weight			
<2500 g	32 (19%)	51 (31%)	0.01[a]
≥2500 g	135 (80%)	112 (67%)	0.01[a]
Pregnancy-induced hypertension (PIH)	31 (18%)	39 (23%)	0.25
Intrauterine growth retardation (IUGR)	35 (21%)	59 (36%)	0.003[a]
PIH with IUGR	6 (4%)	16 (10%)	0.025[a]
Preterm delivery	23 (14%)	48 (29%)	0.0006[a]

[a]$p < 0.05$ univariate analysis between groups. p value and significance.

undergoing the same procedure for anatomic obstructions (tubal block, malformations of the cervix or uterus) (Wasser, 1999). In other studies, it has been shown that IVF is less successful when women report stress or anxiety at the start of treatment (Demyttenaere et al., 1994; Milad et al., 1998).

Animal experiments have shown that exposure of pregnant dogs to stressful conditions (such as capture, noise, immobilization, introduction of a strange male, or crowding) often results in a smaller litter size (embryo resorption), structural malformations, growth retardation, and lower birth weight of the puppies (deCatanzaro and Macniven, 1992). More recently, many well-controlled human studies suggest a direct relationship between prenatal maternal stress and pregnancy complications. The rate of spontaneous abortions increased in women who had experienced a recent stressful life event (Neugebauer et al., 1996) and increased stress at work (Fenster et al., 1995). Structural malformations have been associated with the death of an older child during pregnancy (Hansen et al., 2000) and with marital disharmony (Nimby et al., 1999). The risk of pre-eclampsia is increased with first trimester depression and anxiety (Kurki et al., 2000) and with increased serum concentrations of pCRH between 18 and 20 weeks gestation (Hobel et al., 1999; Perkins et al., 1995). Preterm labor and preterm delivery are associated with mid-trimester stress and elevated pCRH between 15 and 20 weeks gestation (Hobel et al., 1999; Leung et al., 1999). Anxiety and depression are also documented to decrease birth weight and head circumference (Lou et al., 1994). Maternal administration of natural or synthetic corticosteroids can also induce changes associated with maternal stress, such as growth retardation (Benesova and Pavlik, 1989), structural malformations (Uno et al., 1994), and impaired growth of the lungs and the brain (Gramsbergen and Mulder, 1998; Uno et al., 1994).

IAYT is the application of yoga practices to promote health (as defined by the World Health Organization) and in disease states. Intuitively, pregnancy seems an ideal situation to test the antistress benefits of yoga. The word yoga comes from a Sanskrit root *yuj* that means to yoke, to join, and to direct and concentrate one's attention. The practice and philosophy was first described by Patanjali in the classic text *Yoga Sutras* (Lasater, 1997). The goal of this ancient tradition was to calm the restless mind and seamlessly unite the mind, body, and spirit to promote positive health, selfawareness, and spirituality. A few studies done in healthy adults have documented the effects of yoga practice, such as reduced sympathetic activity (Vempati and Telles, 2002), changes in the autonomic nervous system (Raghuraj et al., 2003), the effect of *pranayama* on oxygen consumption (Telles and Desiraju, 1991), and chanting "Om" and its effects on the autonomic nervous system (Telles et al., 1995). We hypothesize that similar mechanisms may operate in pregnant women and have effects directly on the nervous system and indirectly on the HPA axis. Though yoga developed from Indian philosophy and religion, the practice of yoga does not require spiritual beliefs or religious rituals (Myers, 1997).

Various study designs have been used to study the benefits of yoga. The three common designs are:

- Physiologic changes in healthy volunteers (heart rate, blood pressure, electroencephalogram) (Stancak et al., 1991)
- Physical and psychologic outcomes after practicing IAYT (reduction in body weight, autonomic arousal, improved somatic steadiness, muscle strength, life satisfaction scores, higher levels of well-being) (Bera and Rajapurkar, 1993; Madanmohan et al., 1992; Schell et al., 1994; Telles et al., 1993a; Telles et al., 1993b)
- Comparisons between aerobic exercises and yoga.

Blumenthal et al. (1991) compared the effects of aerobic exercise and yoga on cardiac and respiratory functioning in older adults. Aerobic exercise three times per week had significantly greater effects on cardiac and respiratory performance than did a twice weekly class consisting of yoga stretches (Blumenthal et al., 1991). A recent evidence-based systematic review (Kramer, 2002) of aerobic exercise in pregnancy concluded that aerobic exercise appears to improve or maintain physical fitness and body image. Data was insufficient to assess its risks or benefits for the mother and infant (Kramer, 2002).

CONCLUSIONS

Although there are multiple studies evaluating the benefits of yoga, this is the first study to specifically look at the effects of yoga on pregnancy outcomes. The recruited women did not have risk factors for the poor pregnancy outcomes (low birth weight or prematurity) common in developing countries, such as poor socioeconomic status, unwed status, excessive physical stress, substance abuse including smoking, multiple gestation, and chronic maternal malnutrition or disease. It is possible that greater benefits of yoga might be seen in higher stress environments. The drawbacks of the study were that it was not a randomized controlled trial, no stress scores were recorded (either pre- or post-IAYT), and the patient selection bias of self-selected groups. However, the patient selection bias was nullified to a great extent by stratifying patients according to geographical distance from the hospital. We believe (but did not measure) that patient characteristics such as motivation, health status, spiritual belief, and lifestyle were equally distributed among the two groups based on our study design. More patients were in the Far group, as this hospital is primarily a large referral hospital drawing patients from adjoining towns and villages.

In conclusion, this study is the first to examine the effects of yoga in pregnancy and its outcomes. Yoga by its

holistic approach to health appears to be safe in pregnancy and leads to improved outcomes. Future studies should evaluate the relationship between preconception stress and pregnancy stress, the role of prenatal stress and fetal programming (Barker's hypothesis) (Barker et al., 2002), and effects of IAYT on maternal indices of pregnancy outcomes. Based on this pilot study, we advocate randomized control trials to definitely demonstrate the beneficial effects of IAYT on pregnancy outcomes.

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REFERENCES

Barker DJP, Ericksson JG, Forsen T, Osmond C. Fetal origins of adult disease: Strength of effects and biological basis. Int J Epidemiol 2002;31:1235–1239.

Benesova O, Pavlik A. Perinatal treatment with glucocorticoids and the risk of maldevelopment of the brain. Neuropharmacology 1989; 28:89–97.

Bera TK, Rajapurkar MV. Body composition, cardiovascular endurance and anaerobic power of yogic practitioner. Indian J Physiol Pharmacol 1993;37:225–228.

Blumenthal JA, Emery CF, Madden DJ, Schniebolk S, Walsh-Riddle M, George LK, McKee DC, Higginbotham MB, Cobb FR, Coleman RE. Long-term effects of exercise on psychological functioning in older men and women. J Gerontol 1991;46:P352–P361.

Canter PH. The therapeutic effects of meditation. BMJ 2003;326:1049–1050.

Chrousos GP. Stressors, stress, and neuroendocrine integration of the adaptive response. The 1997 Hans Selye Memorial Lecture. Ann N Y Acad Sci 1998;851:311–335.

Collins C. Yoga: Intuition, preventive medicine, and treatment. J Obstet Gynecol Neonatal Nurs 1998;27:563–568.

deCatanzaro D, Macniven E. Psychogenic pregnancy disruptions in mammals. Neurosci Biobehav Rev 1992;16:43–53.

Demyttenaere K, Nijs P, Evers-Keibooms G, Koninckx P. Personality characteristics, psychoneuroendocrinological stress and outcome of IVF depend upon the etiology of infertility. Gynecol Endocrinol 1994;8:233–240.

Fenster L, Schaefer C, Mathur A, Hiatt RA, Pieper C, Hubbard AE. Psychologic stress in the workplace and spontaneous abortion. Am J Epidemiol 1995;142:1176–1183.

Garfinkel M, Schumacher HR Jr. Yoga. Rheum Dis Clin North Am 2000;26:125–132.

Gitau R, Cameron A, Fisk NM, Glover V. Fetal exposure to maternal cortisol. Lancet 1998;353:707–708.

Goyeche JR, Abo Y, Ikemi Y. Asthma: The yoga perspective. Part II: Yoga therapy in the treatment of asthma. J Asthma 1982; 19:189–201.

Gramsbergen A, Mulder EJH. The influence of betamethasone and dexamethasone on motor development in young rats. Pediatr Res 1998;44:105–110.

Hansen D, Lou HC, Olsen J. Serious life events and congenital malformations: A national study with complete follow-up. Lancet 2000;356:875–880.

Hobel CJ, Dunkel-Schetter C, Roesch SC, Castro LC, Arora CP. Maternal plasma corticotropin-releasing hormone associated with stress at 20 weeks' gestation in pregnancies ending in preterm delivery. Am J Obstet Gynecol 1999;180:S257–S263.

Hodnett ED, Fredericks S. Support during pregnancy for women at increased risk of low birthweight babies. Cochrane Database Syst Rev 2003;3:CD000198.

Huizink AC, Robles de Medina PG, Mulder EJ, Visser GH, Buitelaar JK. Stress during pregnancy is associated with developmental outcome in infancy. J Child Psychol Psychiatry 2003;44: 810–818.

Iyengar BKS. Light on the yoga sutras of Patanjali. London, Aquarian Press, 1993.

Jain SC, Rai L, Valecha A, Jha UK, Bhatnagar SO, Ram K. Effect of yoga training on exercise tolerance in adolescents with childhood asthma. J Asthma 1991;28:437–442.

Jain SC, Uppal A, Bhatnagar SO, Talukdar B. A study of response pattern of non-insulin dependent diabetics to yoga therapy. Diabetes Res Clin Pract 1993;19:69–74.

Kramer MS. Aerobic exercise for women during pregnancy. Cochrane Database Syst Rev 2002;2:CD000180.

Kurki T, Hiilesmaa V, Raitasalo R, Mattila H, Ylikorkala O. Depression and anxiety in early pregnancy and risk for preeclampsia. Obstet Gynecol 2000;95:487–490.

Langer A, Farnot U, Garcia C, Barros F, Victora C, Belizan JM, Villar J. The Latin American trial of psychosocial support during pregnancy: Effects on mother's wellbeing and satisfaction. Latin American Network for Perinatal and Reproductive Research (LANPER). Soc Sci Med 1996;42:1589–1597.

Lasater J. The heart of Patanjali. Yoga J 1997;137:134–144.

Leung TN, Chung TKH, Madsen G, McLean M, Chang AMZ, Smith R. Elevated mid-trimester maternal corticotrophin-releasing hormone levels in pregnancies that delivered before 34 weeks. Br J Obstet Gynaecol 1999;106:1041–1046.

Lou HC, Hansen D, Nordentoft M, Pryds O, Jensen F, Nim J, Hemmingsen R. Prenatal stressors of human life affect fetal brain development. Dev Med Child Neurol 1994;36:826–832.

Madanmohan, Thombre DP, Balakumar B, Nambinarayanan TK, Thakur S, Krishnamurthy N, Chandrabose A. Effect of yoga training on reaction time, respiratory endurance and muscle strength. Indian J Physiol Pharmacol 1992;36:229–233.

Majzoub JA, Karalis KP. Placental corticotropin-releasing hormone: Function and regulation. Am J Obstet Gynecol 1999; 180:S242–S246.

Milad MP, Klock SC, Moses S, Chatterton R. Stress and anxiety do not result in pregnancy wastage. Hum Reprod 1998;13: 2296–300.

Mulder EJ, Robles de Medina PG, Huizink AC, Van den Bergh BR, Buitelaar JK, Visser GH. Prenatal maternal stress: Effects on pregnancy and the (unborn) child. Early Hum Dev 2002; 70:3–14.

Myers E. Yoga and you. Boston: Shambhala Press, 1997.

Nagendra HR, Nagarathna R. Yoga for Promotion of Positive

Health, first edition. Bangalore: Swami Vivekananda Yoga Prakashana, 2001.
Nespor K. Pain management and yoga. Int J Psychosom 1991;38: 76–81.
Neugebauer R, Kline J, Stein Z, Shrout P, Warburton D, Susser M. Association of stressful life events with chromosomally normal spontaneous abortion. Am J Epidemiol 1996;143:588–596.
Nimby GT, Lundberg L, Sveger T, McNeil F. Maternal distress and congenital malformations: Do mothers of malformed fetuses have more problems? J Psychiatr Res 1999;33:291–301.
Ott WJ. Comparison of dynamic image and pulsed Doppler ultrasonography for the diagnosis of intrauterine growth retardation. J Clin Ultrasound 1990;18:3–7.
Patel CH. Yoga and bio-feedback in the management of hypertension. Lancet 1973;2(7837):1053–1055.
Perkins AV, Linton EA, Eben F, Simpson J, Wolff CDA, Redman CWG. Corticotrophin-releasing hormone and corticotrophin-releasing hormone binding protein in normal and pre-eclamptic human pregnancies. Br J Obstet Gynaecol 1995;102:118–122.
Raghuraj P, Telles S. Effect of yoga based and forced uninostril breathing on the autonomic nervous system. Percep Mot Skills 2003;96:79–80.
Roush W. Herbert Benson: Mind–body maverick pushes the envelope. Science 1997;276:357–359.
Schell FJ, Allolio B, Schonecke OW. Physiological and psychological effects of Hatha-Yoga exercise in healthy women. Int J Psychosom 1994;41:46–52.
Seckl JR. Glucocorticoids, feto-placental 11h-hydroxysteroid dehydrogenase type 2, and early life origins of adult disease. Steroids 1997;62:89–94.
Singh M. Intrauterine weight chart (AIIMS). In: Singh M, ed. Care of the Newborn, 5th ed. New Delhi: Sagar Publications, 2002.
Stancak A Jr, Kuna M, Novak P, Srinivasan MA, Dostalek C, Vishnudevananda S. Observations on respiratory and cardiovascular rhythmicities during yogic high frequency respiration. Physiol Res 1991;40:345–354.
Stott DH, Latchford SA. Prenatal antecedents of child health, development, and behavior. An epidemiological report of incidence and association. J Am Acad Child Psychiatry 1976;15: 161–191.
Teixeira JMA, Fisk NM, Glover V. Association between maternal anxiety in pregnancy and increased uterine artery resistance index: Cohort based study. BMJ 1999; 318:153–7.
Telles S, Nagarathna R, Nagendra HR. Autonomic changes during "OM" meditation. Indian J Physiol Pharmacol 1995, 39(4): 418–20.
Telles S, Desiraju T. Oxygen consumption during pranayamic type of very slow breathing. Indian J Med Res 1991, 94: 357–63.
Telles S, Hanumanthaiah B, Nagarathna R, Nagendra HR. Improvement in static motor performance following yogic training of school children. Percept Mot Skills 1993a;76:1264–1266.
Telles S, Nagarathna R, Nagendra HR, Desiraju T. Physiological changes in sports teachers following 3 months of training in Yoga. Indian J Med Sci 1993b;47:235–238.
Uno H, Eisele S, Sakai A, Shelton S, Baker E, DeJesus O, Holden J. Neurotoxicity of glucocorticoids in the primate brain. Horm Behav 1994;28:336–348.
Van den Bergh BRH. Maternal emotions during pregnancy and fetal and neonatal behavior. In: Nijhuis JG, ed. Fetal behavior. London, Oxford University Press, 1992:157–174.
Vempati RP, Telles S. Yoga based guided relaxation reduces sympathetic activity judged from baseline levels. Psychol Rep 2002;90:487–494.
Villar J, Farnot U, Barros F, Victora C, Langer A, Belizan JM. A randomized trial of psychosocial support during high risk pregnancies. N Engl J Med 1992;327:1266–1271.
Wallace RK. Physiological effects of transcendental meditation. Science 1970;167:1751–1754.
Wasser SK. Stress and reproductive failure: An evolutionary approach with applications to premature labor. Am J Obstet Gynecol 1999;180:S272–S274.
Weinstock M. Does prenatal stress impair coping and regulation of hypothalamic-pituitary-adrenal axis? Neurosci Biobehav Rev 1997;21:1–10.
Wood C. Mood change and perceptions of vitality: A comparison of the effects of relaxation, visualization and yoga. J R Soc Med 1993;86:254–258.

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