

A Comparison of Psychophysiological effects of Two Yoga Relaxation Techniques

By

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Abstract

Background:

Cyclic meditation (CM) is a technique which consists of cycles of yoga postures interspersed with periods of supine rest (SR). A previous study showed that following cyclic meditation compared to a comparable period of supine rest there was a greater reduction in oxygen consumption (32.1% verses 10.1%), in breath rate (3.6 cycles per minute verses 1.9 cycles per minute), and a greater increase in tidal volume (266.3 ml versus 161 ml). However in this study three issues remained unresolved, these were (i) the changes which occurred during the practice, not merely after it were not studied, (ii) the study cited above used a closed circuit Benedict – Roth apparatus which has drawbacks, i.e. it may be inaccurate and breathing through it requires effort, and (iii) the study demonstrated reduced physiological (metabolic) arousal without attempting to assess the mental state or functioning.

Aims and Objectives:

The present study was designed to compare cyclic meditation with an equal period of supine rest, with respect to: (1) oxygen consumption and related variables using an open-circuit apparatus, (2) an electrophysiological variable considered as an index of attention, viz., the P300, (3) the actual performance in a paper pencil cancellation task which requires the ability to sustain and shift attention, and (4) the heart rate variability (HRV) to get additional information about the level of arousal.

Subjects and Design:

The study was performed on 53 healthy male volunteers who were each studied in two sessions, one of cyclic meditation and the other of supine rest. Each session consisted of 'Pre' (5 minutes), 'During' (23 minutes) and 'Post' (5 minutes) states. While oxygen consumption (and related variables) and heart

rate variability were recorded throughout both types of sessions, the P300 (recorded at Fz, Cz and Pz) and the letter cancellation task were assessed in 'Pre' and 'Post' periods.

Results:

There was a significant increase in oxygen consumption during the practice of cyclic meditation when the subjects were actually practicing yoga postures, by 55.10%. However the oxygen consumption reduced to the initial values at the end of CM, and decreased still further post CM (by 19.39% less than 'pre' CM). In contrast, in the SR session, oxygen consumption reduced 7.28% 'during' supine rest and 4.83% post SR. The changes in the HRV were an increase in LF and decrease in HF and increase in LF/HF ratio during the practice of postures in CM, which returned to baseline values towards end of CM. Further, post CM there was reduction in LF, increase in HF and decrease in LF/HF ratio. In the SR session there was no significant change in HRV. There was a significant increase in the P300 amplitude and decrease in P300 latency post CM compared to pre, at all three recording sites. In the SR session the P300 amplitude showed no significant change however P300 latency reduced in the post period of SR compared to pre period. The net scores obtained in the six letter cancellation task were significantly more (suggesting improvement) in the post CM period compared to pre CM. The net scores in the post SR period were also more than pre SR period, but less in magnitude than CM.

Summary & Conclusion:

The present study compared two techniques practiced for same duration with two main aspects being considered. The techniques were (i) cyclic meditation, which included yoga postures and periods of supine rest, and (ii) supine rest alone. The two aspects considered were (i) physiological arousal, assessed by metabolic and respiratory variables and heart rate variability spectrum, and (ii) the ability to maintain sustained attention based on recording of the P300 and performance in a letter cancellation task.

With respect to physiological arousal, it was interesting to note that during the phases of cyclic meditation which involved actual practice of yoga postures there was an (anticipated) increase in oxygen consumption and correspondingly in energy expenditure. However the interesting fact is that these values returned to the 'pre' values in the fourth (last) phase of cyclic

meditation in which subjects lay supine and further decreased after the practice. While there was a decrease following supine rest, the magnitude was greater after cyclic meditation.

Taking the heart rate variability spectrum into account, a similar trend of increased arousal (based on an increase in the low frequency power values, and/or a decrease in the high frequency power values) was seen in the second phase of cyclic meditation where subjects were practicing yoga postures. There was a return to baseline in the fourth phase and a reverse trend after the practice, suggesting a decrease in sympathetic activity (as this may be correlated with the low frequency power values). In contrast the changes in heart rate variability after supine rest showed no significant difference. Along with these changes suggestive of decreased psychophysiological arousal and also of sympathetic tone following cyclic meditation, it was interesting to note that after this practice there were changes suggestive of a better ability to sustain and focus attention. These were evidenced by electrophysiological changes in a cortical event related potential (the P300) and in the actual performance in a letter cancellation task, which requires the ability to sustain, focus and shift attention. These findings are especially interesting as attentional mechanisms are considered to be always associated with an increase in sympathetic tone.

In summary, from these results a model of cyclic meditation has emerged, as a technique which can reduce psychophysiological arousal but also enhance different aspects of attention, such as the ability to sustain, focus and shift attention.

These results suggest that CM produces a hypo-metabolic physiological state along with an improvement in the ability to show selective and focused attention to target stimuli (evidenced by the changes in P300 and performance in letter cancellation task).

Reference:

- AARC Clinical Practice Guidelines for metabolic measurement using indirect calorimetry during mechanical ventilation. (1994). *Respiratory Care*, 39 (12): 1170-1175.
- Adiswarananda, Swami. (2004). *Meditation and its Practices*. Kolkata: Adaita Asharama.
- Agarwal, A.K., Kalra, R., Natu, M.V., Dadich, A.P., & Deswal. R.S. (2002).

Psychomotor performance of psychiatric inpatients under therapy: Assessment by paper and pencil tests. *Human Psychopharmacology*, 17: 91-93.

- Akishige, Y. (1968). A historical survey of the psychological studies in Zen. *Kyushu psychological studies*, V, *Bulletin of the faculty of Literature of Kyushu University*, 11: 1-56.
- Altman, D.G., Gore, S.M., Gardner, M.J., & Pocock, S.J. (1983) *Statistical guidelines for contributors to medical journals*. *British Medical Journal*, 286: 1489-1493.
- Apte, S.V. (1992). *Practical Sanskrit English Dictionary*. Delhi: Motilal Banarasidas Publishers Pvt. Ltd.
- Atreya, B.L., & Samvid. (1993). *The Vision and way of Vasistha*. Madras: Indian Heritage Trust.
- Bahadur, K.P. (1988). *The wisdom of Çaikhya*. Bangalore: Sterling Pvt. Ltd.
- Bangali, Baba. (2002). *Yoga Sutra of Patanjali with the commentary of Vyasa*. Delhi: Motilal Banarasidas Publishers Pvt. Ltd.
- Banquet, J.P. (1973). Spectral analysis of the EEG in meditation. *Electroencephalography and Clinical Neurophysiology*, 35: 143-151.
- Becker, D.E., & Shapiro, D. (1981). Physiological response to clicks during Zen, Yoga, and TM meditation. *Psychophysiology*, 18: 694 -699.
- Bera, T.K., Gore, M.M., & Oak, J.P. (1998). Recovery from stress in two different postures and in Shavasana- a yogic relaxation posture. *Indian Journal of Physiology Pharmacology*, 42(4): 473-478.
- Branson, J.D. (1990). The measurement of energy expenditure: instrumentation, practical considerations, and clinical application. *Respiratory Care*, 640-659.
- Brown. D.D., Mucci, W.G., Hetzler, R.K., & Knowlton, R.G. (1989). Cardiovascular and ventilatory responses during formalized Tai Chi Chuan exercise. *Research Quarterly for Exercise & Sport*, 60: 246-250.
- Brown, D.P. (1977). A model for the levels of concentrative meditation. *The International Journal of Clinical and Experimental Hypnosis*, 25(4): 236-273.
- Brown, D.R., Wang, Y., Ward, A., Ebbeling, C.B., Fortage. L., Puleo, E., Benson, H., & Rippe, J.M. (1995). Chronic psychological effects of exercise and exercise plus cognitive strategies. *Medicine and Science in Sports and Exercise*, 27(5): 765-775.
- Brunia, C.H.M. (1993). Waiting in readiness: gating in attention and motor preparation. *Psychophysiology*, 30: 327-339.
- Carrington, P., Collings, G.H. Jr., Benson, H., Robinson, H., Wood, L.W., Lehrer,

P.M., Woolfolk, R.L., & Cole, J.W. (1980). The use of meditation-relaxation techniques for the management of stress in a working population. *Journal Occupational Medicine*, 22(4):221-231.

- Chao, Khun, Phra, Sobhana, Dhammasudhi. (1968). *Insight Meditation*. London: The Committee for the advancement of Buddhism.
- Chinmayanada, Swami. (2002). *Katha Upaniñat*. Bombay: Central Chinmayanada Mission.
- Chinmayanada, Swami. (2002a). *Talks on Shanakar's Vivekcudmani*. Bombay: Central Chinmayanada Mission.
- Chinmayanada, Swami. (1984). *Māndukya Upaniñad*. Bombay: Sachin Publishers.
- Chinmayanada, Swami. (2001). *The Holy Geeta*. Mumbai: Central Chinmaya Mission Trust.
- Corby, J.C., Roth, W.T., Zarcone, V.P., & Kopell, B.S. (1978). Psycho-physiological correlates of the practice of Tantric yoga meditation. *Archives of General Psychiatry*, 35: 571 – 577.
- Cranson, R., Goddard, P. H., & Orme-Johnson, D. (1990). P300 under conditions of temporal uncertainty and filter attenuation: Reduced latency in long-term practitioners of TM. *Psychophysiology*, 27: S23.
- Crisan, H.G. (1984). *Pranayama in anxiety neurosis – a pilot study*. MD Dissertation submitted to the University of Heidelberg, Germany.
- Critchley, H.D., Melmed, R.N., Featherstone, E., Mathias, C.J., & Dolan, R.J. (2001). Brain activity during biofeedback relaxation: a functional neuro-imaging investigation. *Brain*, 124(5): 1003-1012.
- Das, T.K., & Jana, H. (1999). Basal oxygen consumption during different phases of menstrual cycle. *Indian Journal of Medical Research*, 94: 16-19.
- Deiber, M.P., Ibañez, V., Fischer, C., Perrin, F., & Mauguière, F. (1988). Sequential mapping favors the hypothesis of distinct generators for Na and Pa middle latency auditory evoked potentials. *Electroencephalography and Clinical Neurophysiology*, 71: 187-197.
- Dillbeck, M.C. (1977). The effect of the Transcendental Meditation technique on anxiety level. *Journal Clinical Psychology*, 33(4): 1076-1078.
- Elson, B.D., Hauri, P., & Cunis, D. (1977). Physiological changes in yoga meditation. *Psychophysiology*, 14: 52 -57.
- Engel, L., Andersen, L.B. (2000). Effects of body-mind training and relaxation stretching on persons with chronic toxic encephalopathy. *Patient Education and Counseling*, 39 (2-3):155-161.

- Falk, B. (1995). Effect of continuous and intermittent exercise on energy expenditure and on the cardio-respiratory response. *Perceptual and Motor Skills*, 80 (1): 64-66.
- Feuerstein, G. (2001). *The Yoga tradition, its history, literature, philosophy and practice*. Arizona: Hohm Press.
- Fox, E. (1993). Attentional bias in anxiety: selective or not? *Behavioral Research and Therapy*, 31(5): 487-93.
- Fredrikson, M., & Engel, B.T. (1985). Cardiovascular and electro-dermal adjustments during a vigilance task in patients with borderline and established hypertension. *Journal of Psychosomatic Research*, 29(3): 235-246.
- Gamabhiranada, Swami. (1986). *Çvetäçvatara Upaniñat with the comentary of Shankaracharya*. Calcutta: Advaita Ashram.
- Gamabhiranada, Swami. (1995). *Muèòaka Upaniñat*. Calcutta: Advaita Ashram.
- Gamabhiranada, Swami. (1998). *Öaittiréya Upaniñat*. Calcutta: Advaita Ashram.
- Ganong, W.F. (1987). *Review of Medical Physiology*. San Francisco: Prentice-Hall International Inc.
- Goyeche, J.R.M., Chihara, T., & Shimizu, H. (1972). Two concentration methods: A preliminary comparison. *Psychologia*, 15: 110-111.
- Halgren, E., Marinkovic, K., & Chauvel, P. (1998). Generators of the late cognitive potentials in auditory and visual oddball tasks. *Electroencephalography and Clinical Neurophysiology*, 106:156-164.
- Hirai, T. (1975). *Zen Meditation Therapy*. Tokyo : Japan publications.
- Jaeger Toennies Medizintechnik Mit System. (2001). *Oxycon Instruction Manual*, 4.5 version. Germany.
- Janowiak, J.J., & Hackman, R. (1994). Meditation and college students self-actualization and rated stress. *Psychological Reports*, 75(2):1007-1010.
- Jasper, H.H. (1958). The ten-twenty electrode system of the International federation. *Electroencephalography and Clinical Neurophysiology*, 10: 371-375.
- Jin, P. (1989). Changes in heart rate, noradrenaline, cortisol and mood during Tai Chi. *Journal of Psychosomatic Research*, 33:197-206.
- Jin, P. (1991). Efficacy of Tai Chi, brisk walking, meditation, and reading in reducing mental and emotional stress. *Journal of Psychosomatic Research*, 36: 361-370.
- Joseph, C., Ram Shankar, A., Kulkarni, D.D., Ramchandra, M., Narasimhalu, G., & Desiraju, T. (1987). Post meditational effects of Brahmakumaris (BK) and

Transcendental Meditation(TM) on computer – averaged event related evoked potential components recorded in the P300 cognitive paradigm. *Indian Journal of Physiology and Pharmacology*, 31: 49 (abstract).

- Judy, W.V. (1982). Energy expenditure, metabolism, temperature regulation and exercise. In E.E. Selkurt (Ed.), *Basic Physiology for Health Sciences* (2nd Ed.). Boston: Brown and company. pp. 521-522.
- Kasamatsu, A., & Hirai, T. (1966). An electroencephalographic study on the Zen meditation (zazen). *Folio psychiatry Neurology Japonica*, 20: 315-336.
- Khushu. S., Telles, S., Kumaran, S., Naveen, K.V., & Tripathi, R.P. (2000). Frontal activation during meditation based on functional magnetic resonance imaging (fMRI). *Indian Journal of Physiology and Pharmacology*, 44(5): 34.
- Kjaer, T.W., Bertelsen, C., Piccini, P., Brooks, D., Alving, J., & Lou, H.C. (2002). Increased dopamine tone during meditation-induced change of consciousness. *Brain Research Cognitive Brain Research*, 13(2): 255-259.
- Kubota, Y., Sato, W., Toichi, M., Murai, T., Okada, T., Hayashi, A., & Sengoku, A. (2001). Frontal midline theta rhythm is correlated with cardiac autonomic activities during the meditation procedure. *Brain Research Cognitive Brain Research*, 11(2): 281-287.
- Laberge, D. (1995). *Attentional processing: the brain's art of mindfulness*. Cambridge, UK: Harvard University Press.
- Laberge, D., & Brown, V. (1989). Theory of attentional operations in shape identification. *Psychological Review*, 96: 101-124.
- Lan, C., Chen, S.Y., Lai, J., & Wong, M.K. (2001). Heart rate responses and oxygen consumption during Tai Chi Chuan practice. *American Journal of Chinese Medicine*, 20(3): 400-408.
- Lehrer, P.M., Schoicket, S., Carrington, P., & Woolfolk, R.L. (1980). Psychophysiological and cognitive responses to stressful stimuli in subjects practicing progressive relaxation and clinically standardized meditation. *Behavior Research and Therapy*, 18(4): 293-303.
- Lehrer, P.M., Woolfolk, R.L., Rooney, A.J., McCann, B., & Carrington, P. (1983). Progressive relaxation and meditation. A study of psychophysiological and therapeutic differences between two techniques. *Behavior Research and Therapy*, 21(6): 651-662.
- Lezak, M.D., Riddle, M.C., & U'ren, R.C. (1986). The mental efficiency of older (65-77) diabetics. *Journal of Clinical and Experimental Neuropsychology*, 8: 149 (abstract).
- Lorig, T.S., & Schwartz, G.E. (1990). The pulmonary system. In J.T. Cacioppo,

L.G. Tassinary (Eds.), Principles of Psychophysiology. Cambridge: Cambridge University Press.

- Lou, H.C., Kjaer, T.W., Friberg, L., Wildschiodtz, G., Holm, S., & Nowak, M.A. (1999). A 150 – H₂O PET study of meditation and the resting state of normal consciousness. *Human Brain Mapping*, 7(2): 98-105.
- Madanmohan, Udupa, K., Bhavanani, A.B., Krishnamurthy, N., & Pal, G.K. (2002). Modulation of cold pressor-induced stress by shavasan in normal adult volunteers. *Indian Journal of Physiology Pharmacology*, 46(3): 307-312.
- Madhusudhan, Saraswati., Gambhiranada, Swami. (1998). *Bhagavad Gita*. Champawat, Himalaya: Advaita Ashrama.
- Malathi. A., & Damodaran, A. (1999). Stress due to exams in medical students - role of yoga. *Indian Journal Physiology Pharmacology*, 43(2): 218-224.
- Malliani, A., Pagani, M., Lombardi, F., & Cerutti, S. (1991). Cardiovascular neural regulation explore in the frequency domain. *Circulation*, 84: 482-492.
- Manjunath, N.K., & Telles, S. (2003). Effects of Sirsasana (headstand) practice on autonomic and respiratory variables. *Indian Journal of Physiology and Pharmacology*, 47 (1): 34-42.
- Matarese, L.E. (1997). Indirect Calorimetry: technical aspects. *Journal of the American Dietetic Association*, 351-359.
- Mokshadananda, Swami. (1997). *Jivan-Mukti-Viveka of Swami Vidyananda*. Calcutta: Advaita Ashrama. pp. 235-237.
- Mountcastle, V.B. (1980). *Medical Physiology (vol. 2)*. CV Mosby: St. Louis.
- Mukatibodhananda, Swami. (2001). *Hatha Yoga Pradipika*. Munger, Bihar: Yoga Publications Trust.
- Mumukhsnanda, Swami. (1998). *Teachings of Ramakrishna Pramahansa*. Champawat, Himalaya: Advaita Ashram.
- Murata, T., Takahashi, T., Hamada, T., Omori, M., Kosaka, H., Yoshida, H., & Wada, Y. (2004). Individual trait anxiety levels characterizing the properties of zen meditation. *Neuropsychobiology*, 50(2): 189-194.
- Naga Venkatesha Murthy, P. J., Janakiramaiah, N., Gangadhar, B.N., & Subbukrishna, D.K. (1998). P300 amplitude and antidepressant response to Sudarshan Kriya Yoga (SKY). *Journal of Affective Disorders*, 50: 45-48.
- Nagendra, H.R., (2001). *Mind Sound Resonance Technique*. Bangalore: Swami Vivekananda Yoga Prakashana.
- Nagendra, H.R., & Nagarathna, R.N. (2003). *New perspectives in stress management*. Bangalore: Swami Vivekananda Yoga Prakashan.
- Nagendra, H.R., & Nagarathana. R. (2001). *Promotion of Positive Health*.

Bangalore: Swami Vivekananda Yoga Prakashana.

- Nagendra, H.R., Swami, N.V.C. & Mohan, T. (2003). Patanjali Yoga Sutras.

Bangalore: Swami Vivekananda Yoga Prakashana.

- Natu, M.V., & Agarawal, A.K. (1997). Testing of stimulant effects of coffee on the psychomotor performance: an exercise in clinical pharmacology. *Indian Journal of Pharmacology*, 29: 11-14.
- Naveen, K.V., Nagendra, H.R., Nagarathna, R., & Telles, S. (1997). Yoga breathing through a particular nostril increases spatial memory scores without lateralized effects. *Psychological Reports*, 81: 555-561.
- Naveen, K.V., & Telles, S. (2003). Sensory perception during sleep and meditation: common features and differences. *Perceptual and Motor Skills*. 96: 810-811.
- Nicolet Biomedical Inc. (1998). Bravo EP Users Guide. USA.
- Nishimura, M., & Onodera, S. (2000). [Relaxative effects of supine floating on heart rate, blood pressure and cardiac autonomic nervous [correction of nerveous system activity]. *Uchu Koku Kankyo Igaku*, 37(3): 49-56
- Niskanen, J.P, Tarvainen M.P., Ranta-aho, P.O., & Karjalainen, P.A. (2004). Software for advanced HRV analysis. *Computer Methods and Programs in Biomedicine*, 76: 73-81.
- Niviqure Meditech Pvt. Ltd. (2003). Niviqure ambulatory ECG system: Instruction Manual, 4.6 version. Bangalore.
- Orme Johnson, D.W. (1973). Autonomic stability and Transcendental Meditation. *Psychometric Medicine*, 35: 341-349.
- Polich, J. (2004). Clinical application of the P300 event-related brain potential. *Physical Medicine and Rehabilitation Clinics of North America*, 15: 133-161.
- Polich, J. (1999). P300 in clinical applications. In E. Niedermeyer, F. Lopes da Silva, (Eds.). *Electroencephalography: Basic Principles, Clinical Applications and Related Fields*, (4th Ed.). Baltimore-Munich: Urban and Schwarzenberg. pp. 1073-1091.
- Prabhavananda, Swami. (2002). Patanjali Yoga Sutras. Madras: Sri Ramakrishana Math.
- Prasad, P.S.K. (1990). *Bhagavad Gita Explained to the Modern Man*. Hyderabad: Karunkar Pandarangi.
- Rai, L., & Ram, K. (1993). Energy expenditure and ventilatory responses during virasana - a yogic standing posture. *Indian Journal of Physiology and Pharmacology*, 37(1): 45-50.
- Rai, L., Ram, K., Kant, U., Madan, S.K., & Sharma, S.K. (1994). Energy

expenditure and ventilatory responses during siddhasana - a yogic seated posture. *Indian Journal of Physiology and Pharmacology*, 38(1): 29-33.

- Ramgopalachari, C. (1958). *Mahābharata*. Bombay: Bharti Vidya Bhavan.
- Ricklef, R.E., & Finch, C.E. (1995). *Aging a Natural History*. New York: Scientific American Library: A division of HPHLP.
- Rinck, M., Becker, E.S., Kellermann, J., & Roth, W.T. (2003). Selective attention in anxiety: distraction and enhancement in visual search. *Depression and Anxiety*, 18(1): 18-28.
- Sakakibara, M., Takwuchi, S., & Hayano, J. (1994). Effect of relaxation training on cardiac parasympathetic tone. *Psychophysiology*, 31: 223-228.
- Sandlund, E.S., & Norlander, T. (2000). The effects of Tai Chi Chuan relaxation and exercise on stress responses and well-being: an overview of research. *International Journal of Stress Management*, 7(2): 350-355.
- Satyananda Saraswati, Swami. (1992). *Meditations*. Munger: Bihar School of Yoga.
- Satyanarayana, M., Rajeswari, K.R., Rani, N.J., Krishna, C.S., & Rao, P.V. (1992). Effect of Santhi Kriya on certain psychophysiological parameters: a preliminary study. *Indian Journal Physiology Pharmacology*, 36(2): 88-92.
- Shephard, R.J. (1997). Exercise and relaxation in health promotion. *Sports Medicine*, 23(4): 211-217.
- Singh, A.K. (2002). *Tests, measurements and research methods in behavioral sciences*. Patna: Bharati Bhawan (Publishers and Distributors).
- Sugi, Y., & Akutsu, K. (1968). Studies on respiration and energy – metabolism during sitting in Zazen. *Research Journal of physical education*, 12: 190-206.
- Sukhanandanatha Brahmavadhut, Sri. (1992). *Shabdarthachintamani*. Jaipur: Printwell.
- Sundar, S., Agrawal, S.K., Singh, V.P., Bhattacharya, S.K., Udupa, K.N., & Vaish, S.K. (1984). Role of yoga in management of essential hypertension. *Acta Cardiology*, 39(3): 203-208.
- Prabhavananda, Swami. (2002). *Patanjali Yoga Sutras*. Madras: Sri Ramakrishana Math.
- Swahanada, Swami. (1984). *Chāndogya Upaniñat*. Madras: Sri Ramkrishana Math.
- Szabo, A., Mesko, A., Caputo, A., & Gill, E.T. (1999). Examination of exercise-induced feeling states in four modes of exercise. *International Journal of Sport Psychology*, 29: 376-379.
- Taimini, I.K. (1961). *The science of yoga*. Madras: The Theosophical Publishing

House.

- Tapayananda, Swami. (1982). *Çrémad Bhāgavat Mahāpurāëa*. Chennai: Sri Ramkrishana Math.
- Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, Heart Rate Variability: standards of measurement, physiological interpretation, and clinical use. (1996). *European Heart Journal*, 17: 354-381.
- Telles, S., & Naveen, K.V. (2004). Changes in middle latency auditory evoked potentials during meditation. *Psychological Reports*, 94: 398-400.
- Telles, S., & Desiraju, T. (1993a). Autonomic changes in Brahmakumaris raja yoga meditation. *International Journal of Psychophysiology*, 15: 147-152.
- Telles, S., & Desiraju, T. (1993). Recording of auditory middle latency evoked potentials during the practice of meditation with the syllable 'OM'. *Indian Journal of Medical Research*, 98(B): 237-239.
- Telles, S., Joshi, M., Dash, M., Raghuraj, P., Naveen, K.V., & Nagendra, H.R. (2004). An evaluation of the ability to voluntarily reduce the heart rate after a month of yoga practice. *Integrative Physiological & Behavioral Science*, 39(2): 119-125.
- Telles, S., Nagarathna, R., & Nagendra, H.R. (1995). Autonomic changes during 'OM' meditation. *Indian Journal of Physiology and Pharmacology*, 39(4): 418-420.
- Telles, S., Nagarathna, R., & Nagendra, H.R. (1998). Autonomic changes while mentally repeating two syllables – one meaningful and the other neutral. *Indian Journal of Physiology and Pharmacology*, 42(1): 57-63.
- Telles, S., Nagarathna, R., Nagendra, H.R., & Desiraju, T. (1994). Alterations in auditory middle latency evoked potentials during meditation on a meaningful syllable 'OM'. *International Journal of Neuroscience*, 76: 87-93.
- Telles, S., Reddy, S.K., & Nagendra, H.R. (2000). Oxygen consumption and respiration following two yoga relaxation techniques. *Applied Psychophysiology and Biofeedback*, 25(4): 221-227.
- Telles, S., & Vempati, R.P. (1999). Yoga based isometric relaxation versus supine rest: a study of oxygen consumption, breathe rate and volume and autonomic measures. *Journal of Indian Psychology*, 17(2): 46-52.
- Telles, S., Nagarathna, R., Nagendra, H.R. & Desiraju, T. (1994). Alterations in auditory middle latency evoked potentials during meditation on a meaningful syllable 'OM'. *International Journal of Neuroscience*, 76: 87-93.
- Thrall, D.A. (1982). *Transcendental meditation and progressive relaxation*:

their physiological effects. *Journal of Clinical Psychology*, 38(3): 522-530.

- Tpasyaananda, Swami. *Srimad Bhavadgita*. (2002). Chennai: Sri Ramkrishana Math.
- Travis, F., & Miskov, S. (1994). P300 latency and amplitude during eyes-closed rest and Transcendental Meditation practice. *Psychophysiology*, 31: S67.
- Travis, F., Tecce, J., Arenander, A., & Wallace, R.K. (2002). Patterns of EEG coherence, power, and contingent negative variation characterize the integration of transcendental and waking states. *Biological Psychology*, 61(3): 293-319.
- Usharbudh Arya, Pandit. (1986). *Yoga Sutras of Patanjali with the exposition of Vyasa*. Pennsylvania: The Himalayan International Institute.
- Vempati, R.P., & Telles, S. (2002). Yoga based relaxation reduces sympathetic activity judged from base line levels. *Psychological Reports*, 90: 487-494.
- Vivekananda, Swami. (2001). *Conquering the Internal Nature: Raja Yoga*. Champawat, Himalaya: Advaita Ashram.
- Vivekananda, Swami. (1971). *The Yogas and Other Works*, Swami Nikhilananda. (Ed.). New York: Ramkrishana-Vivekananda Center, pp. 694.
- Wallace, R.K., Benson, H., & Wilson, A.F. (1971). A wakeful hypo metabolic physiological state. *American Journal of Physiology*, 227: 795-799.
- Wallace, R.K. (1970). The physiological effects of Transcendental Meditation. *Science*, 167: 1751-1754.
- Wang, Y., Taylor, L., Pearl, M., & Chang, L. (2004). Effects of Tai chi exercise on physical and mental health of college students. *American Journal of Chinese Medicine*, 32 (2): 453-459.
- West, J.B. (1995). *Respiratory Physiology - the essentials*. Baltimore: Williams and Wilkins.
- Wewers, M.E., & Lowe, N.K. (1990). A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing and Health*, 13: 227-236.
- Wilson, A.F., Jevning, R., & Guich, S. (1987). Marked reduction of forearm carbon dioxide production during states of decreased metabolism. *Physiological Behavior*, 41(4): 347-352.
- Wood, C.J. (1993). Mood change and perceptions of vitality: a comparison of the effects of relaxation, visualization and yoga. *Royal Society Medicine*, 86(5): 254-258.
- Yadav, A., Tandon, O.P., & Vaney, N. (2002). Auditory evoked responses during different phases of menstrual cycle. *Indian Journal of Physiology and*

Pharmacology, 46(4): 449-456.

- Yan, J.H. (1995). The health and fitness benefits of Tai Chi. *The Journal of Physical Education, Recreation and Dance*, 66: 61–63.
- Yesavage, J.A., & Jacob, R. (1984). Effects of relaxation and mnemonics on memory, attention and anxiety in the elderly. *Experimental Aging Research*. 10(4): 211-214.
- Yildirim, A., Kabakci, G., Akgul, E., Tokgozoglu, L., & Oto, A. (2002). Effects of menstrual cycle on cardiac autonomic innervation as assessed by heart rate variability. *Annals of Noninvasive Electrocardiology*, 7(1): 60-63