The present study evaluated the effects of two interventions (viz., Yoga and Ayurveda) compared to a Wait-list Control group in institutionalized older persons. Assessments were made at baseline and after three and six months of the interventions. The assessments were of three main categories: (i) general health measures, (ii) neurological assessments, and (iii) psychological assessments. All changes referred to in this section were those which were statistically significant, detailed under the Results section.

Among the general health measures, there were changes in the pulmonary functions and the hand grip strength at three months. In the Ayurveda group, there was an increase in the minute ventilation by 39.1 percent. In the Yoga group there was an increase in the minute ventilation by 51.5 percent. The increase in minute ventilation in the Ayurveda and Yoga groups at three months would be more likely due to an increase in the tidal volume rather than an increase in the breath rate. This may be speculated as the polygraph recording of the respiratory rate showed no change in either group.

At six months, the pulmonary functions showed changes and also there were changes in anthropometric measurements. Unlike at three months, at six months the Ayurveda group did not show changes in minute ventilation, but showed an increase in maximum voluntary ventilation by 22.6 percent. This possibly showed greater voluntary effort in this group at the six monthly assessments. The Yoga group showed an increase in forced vital capacity by 31.8 percent and continued to show an increase in minute ventilation (34.8 percent). This suggested that lung volumes and capacities improved in the Yoga group after six months. The Wait-list control group showed a
decrease in the forced vital capacity by 35.6 percent which may suggest that in the absence of interventions, respiratory function deteriorated though the magnitude of change needs to be understood. Also, while the hand grip strength did not change at six months, the mid-arm circumference which is taken to be an indicator of muscle mass, decreased by 1.8 percent at the end of six months.

With respect to changes in the Yoga group, there was an increase in FVC and minute ventilation. In an earlier study, an increase in the lung capacity following Yoga practice was attributed to an increased development of respiratory musculature (Bhole, 1967). The group who received the Ayurveda intervention showed an increase in minute ventilation and Maximum Voluntary Ventilation at the end of six months. The underlying mechanisms cannot be speculated upon as the physiological effects of the individual components as well as of the combination used in the Ayurveda preparation have not been studied. In contrast to the Yoga and Ayurveda groups, the Wait-list control group showed a decrease in mid-arm circumference which indicates muscle mass and hand grip strength which indicated muscle endurance. Also, there was a reduction in the vital capacity. These findings suggest that in the absence of an intervention, the Wait-list Control group actually showed deterioration in functioning.

*In summary, the two interventions i.e., Yoga and Ayurveda showed a positive impact on the general health measures (pulmonary functions) while the no intervention control group showed deterioration in functioning.*
With respect to the neurological assessments, at three months there were no changes in autonomic and respiratory variables in the two intervention groups, while in contrast, the Wait-list Control group showed an increase in galvanic skin conductance by 41.8 percent, suggesting an increase in sympathetic sudomotor activity. This is important as it is already known that in the aged, there is a shift in the sympatho-parasympathetic balance towards sympathetic dominance (Mathias, 2003).

The Wechsler memory scale was used to assess different aspects of memory. As described in the introduction, memory may be categorized based on the “systems” and on the “process”. The results will be discussed considering both views. At three months, the Yoga group showed an improvement in scores for current information suggesting improvement in semantic memory. There was also an increase in the short term primary memory based on the digit span forward test (a 40.7 percent increase). The short term working memory also appeared to have improved, based on an increase in the digit span backward score. The Ayurveda and Wait-list Control group both showed an increase in the digit span forward score, which suggested an improvement in short term primary memory. Since the magnitude of change in this measurement was similar for all three groups, the improvement in short term primary memory may be merely due to a re-test effect.

At six months, there were significant changes in the autonomic and respiratory variables. These changes were suggestive of reduced sympathetic activity based on a decrease in galvanic skin conductance, in heart rate, in the low frequency component of the heart rate variability spectrum and an increase in the high frequency/low frequency ratio suggesting a shift in the sympatho-vagal balance towards vagal
dominance. The decrease in the respiratory rate in the Yoga group suggested that psychophysiological arousal was also lower. These findings are especially important as older persons have been described to have a higher sympathetic tone (Mathias, 2003).

Other important indicators of neurological functions which were studied were the gait and balance. Both of them improved significantly after six months of Yoga. The gait was also assessed in a test called “timed-up-and-go test”. Since short steps are indicative of a poor gait (Rubenstein & Trueblood, 2004), the number of steps taken to cover a fixed distance were noted at the beginning and end of six months. Following six months of both Yoga and Ayurveda, there was a decrease in the number of steps, though the magnitude of change was more after Yoga than after Ayurveda (an average of 6.23 steps reduction versus an average of 4.25 steps reduction respectively).

With respect to the scores in the Wechsler memory scale, the Yoga group performed better at six months in the test for current information (indicative of semantic memory), digit span forward (indicative of short term primary memory), digit span backward (indicative of short term working memory), and paired associate learning for pairs which are easy to associate (indicative of episodic memory). In contrast, in the Wait-list Control group there was a decrease in the scores for paired associate learning of pairs which were difficult to associate. This may suggest a deterioration of episodic memory in the Wait-list Control group, especially when it was difficult to establish associations between pairs.
Following Yoga there was a decrease in heart rate, respiratory rate, galvanic skin conductance and in the power of the Low Frequency band of the Heart Rate Variability (HRV) spectrum while the High Frequency band of HRV increased. These changes suggested an increase in cardiac vagal and decrease in cardiac sympathetic discharge (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). The gait, ability to balance and mobility all improved following Yoga. While the exact basis is not known the improvement may be related to factors such as better visuo-motor coordination (Malathi & Parulkar, 1989), postural re-adjustment (Dhume & Dhume, 1991) and improved proprioception (Naveen, & Telles, 2003). The semantic memory, primary and working short-term memory and episodic memory have improved since reduced anxiety facilitates remembering (Ax, 1953). It is possible that the anxiety reducing effect of Yoga practice was the basis of these changes. Also, the practice of Yoga has already been shown to induce “a state of alertful rest” and reduced distractibility (Wallace, Benson, & Wilson, 1971).

The absence of change in the Ayurveda group may be related to the fact that the number of participants at six months was reduced to twelve, versus eighteen in the yoga group and twenty in the control group. Hence the present study shows that compliance with taking an herbal preparation has specific difficulties.

The Wait-list Control group showed an increase in skin conductance suggestive of increased sudomotor sympathetic activity and possibly of physiological activation. Finally this group showed a decrease in the scores of episodic memory.
These findings once again suggest that in the absence of an intervention, the Wait-list Control group actually showed deterioration in functioning.

*In summary, Yoga practice has brought about changes suggestive of reduced physiological activation and improved gait, balance and mobility and different components of memory. The Ayurveda group showed no significant changes with respect to the neurological variables except mobility while the Wait-list Control group showed signs of physiological activation, reduced memory scores and hand grip strength (suggestive of reduced muscular endurance).*

The psychological assessments were two: depression scores and the self rated quality of sleep. At three months, the Yoga group showed a decrease in the geriatric depression scores. There was also a decrease in the time taken to fall asleep (by an average of 7.5 minutes) and in the number of awakenings each night. In contrast, in the Yoga group there was an increase in the number of hours slept each night (0.45 hours).

At six months also, the Yoga group showed a decrease in depression scores, time taken to fall asleep (10.56 minutes), and number of awakenings each night. The Yoga group showed an increase in number of hours slept each night (1.29 hours), and in the subjective feeling of being rested in the morning. These results suggest that Yoga practice improves subjective feelings of psychological wellbeing both at three and at six months. Neither of the other two groups showed a change in the two variables indicative of psychological status.

The changes in mood with a decrease in scores indicating depression following Yoga may be related to multiple factors. For example, physical activity is
known to increase endorphin secretion (Hall & Brody, 1999), while guided relaxation was shown to reduce the secretion of hormones related to stress. Since Yoga incorporates both physical activity and relaxation, these factors may have contributed to the positive affect following Yoga. The Yoga group showed improvements in several aspects of their self rated quality of sleep such as a decrease in time taken to fall asleep, an increase in the number of hours slept each night, an increase in the feeling of being rested in the morning. Once again these benefits may be attributed to increase in physical activity and relaxation associated with Yoga.

The changes in general health measures viz., lung functions and grip strength and anthropometric measurements which occurred in the present older population were seen previously in volunteers of an younger age group following Yoga training. For example, sports teachers (group average age 34.7 ± 5.9 years) who had already been involved in various physical activities for approximately nine years, showed an improvement in vital capacity after three months of Yoga training (Telles, Nagarathna, Nagendra, & Desiraju, 1993). Apart from this, the beneficial effects of Yoga practice in improving lung functions have been shown in army personnel (Ray, Sinha, Tomer, Pathak, Dasgupta, & Selvamurthy, 2001) and in bronchial asthma patients (Goyeche, Abo, & Ikemi, 1982; Nagarathna & Nagendra, 1985). The hand grip strength was shown to be significantly higher in children after ten days of Yoga training and in adults after a one month Yoga training program (Dash & Telles, 2001). Yoga practice was also shown to improve the hand grip strength in sports teachers (Telles, Nagarathna, Nagendra, & Desiraju, 1993) and patients with rheumatoid arthritis (Haslock, Monro, Nagarathna, Nagendra, & Raghuram, 1994;
Changes in lung functions following Ayurveda per se have not been documented. Ayurvedic preparations typically consist of a combination of substances (Sharma & Dash, 1998). However, there have been a number of reports on the pulmonary benefits of specific herbal substances such as Tulsi (Ocimum Sanctum) (Prakash & Gupta, 2005). These references are large in number and have not been cited here as this report examined the effects of a preparation which consisted of a number of traditionally described substances, not of any one, alone.

With respect to the neurological measures, studies on the effects of Yoga practice on autonomic and respiratory variables have been well documented. An early study described the psychophysiological effects of transcendental meditation (TM) as producing a wakeful hypometabolic state, characterized by an increase in heart rate and skin resistance, and in EEG alpha and decreased breath rate and oxygen consumption (Wallace, 1970; Wallace, Benson, & Wilson, 1971). More recently, a combination of Yoga practices have been showed to have comparable effects in sports teachers (Telles, Nagarahna, Nagendra, & Desiraju, 1993), community home girls (Telles, Narendran, Raghuraj, Nagarahna, & Nagendra, 1997), children with impaired vision (Telles & Srinivas, 1999). In all these cases there were signs of reduced sympathetic activity in different subdivisions (e.g., sudomotor sympathetic, vasomotor sympathetic and cardiac sympathetic).

Balance is an important variable and is disturbed in various conditions apart from aging. For example, certain cases of mental retardation are associated with poor balance. Experienced meditators when assessed on a balance board showed better performance compared to a group who received dextroamphetamine (Dhume &
Dhume, 1991). The memory scores of university students were found to improve following the practice of TM (Kember, 1985). A single study reported the effects of four Yoga breathing practices on verbal and spatial memory task scores (Naveen, Nagarathna, Nagendra, & Telles, 1997). The results suggested that yoga breathing through a particular nostril increases spatial task scores rather than verbal scores, and no lateralized effect was seen.

The decrease in depression scores following yoga of the present study is in line with previous reports of an improved sense of wellbeing following yoga shown by Ray and colleagues (2001), as well as another report in which a specific Yoga practice called Sudarshan Kriya Yoga (SKY) which includes high frequency breathing was given to persons with diagnosed depression and the effects were compared with those of a conventional anti-depressant (i.e., imipramine) and with electroconvulsive therapy (Janakiramaiah, Gangadhar, Naga Venkatesha Murthy, Harish, Subbukrishna, & Vedamurthachar, 2000). It was found that SKY produced lesser benefits than electroconvulsive therapy but could be considered as a potential alternative to drugs in melancholia, as a first line of treatment.

In a study on exercise-effects, since Yoga practice has several aspects, namely physical activity, relaxation, awareness of breathing and detached observation, a 10-week exercise program was more effective than health education talks in reducing depression in older adults with depressive disorder (Mather et al., 2002). These results suggested the importance of older adults with depressive disorder, taking part in group exercise activities.
With regard to the effects of Yoga on sleep, the improvement in sleep following yoga seen here is in line with earlier reports that yoga is one among other complementary therapies, which are useful in the management of insomnia (Lang, Huntley, & Ernst, 2001). The practice of yoga has been shown to reduce signs of physiological arousal in normal volunteers based on measurements of autonomic and respiratory variables and oxygen consumption (Telles, Reddy, & Nagendra, 2000; Vempati & Telles, 2002), as well as a decrease in plasma catecholamine levels (Udupa, Singh, & Yadav, 1973). A similar benefit of reduced physiological arousal following yoga was also seen in persons with higher than usual arousal to begin with, related to their social circumstances (Telles, Narendran, Raghuraj, Nagarathna, & Nagendra, 1997) or to physical impediments (Telles & Srinivas, 1999).

*In summary Yoga training has brought about a state of positive affect and improved the quality and quantity of sleep (self rated). The Ayurveda and Wait-list Control groups showed no influence on the psychological variables.*
In conclusion this is the first trial in which Yoga and Ayurveda have been evaluated as separate interventions for older persons. There have been significant benefits following the introduction of Yoga as a part of routine of these older persons. The improvements were in diverse areas such as pulmonary functions, autonomic status, gait and balance, different aspects of memory, the affect or mental state and quality of sleep.

However, it is essential to keep in mind that the study was conducted on older persons who were institutionalized and who had no adequate income. This would make the present group different from older people in their own houses and who have control over their finances. This also suggests areas for future research mentioned under the next section (i.e., an appraisal of the thesis)
OVERVIEW

A critical review of the work done has been made with an objective of understanding the limitations of the study as well as to get insights into ideas for future research.

LIMITATIONS OF THE STUDY

(i) The study was conducted on older persons who were residing in an old age home. This population was preferred for two main reasons: (i) their living conditions were uniform, and (ii) since they were residing in the home, it could be expected that there would be a lower rate of dropouts. However, the fact that the study was conducted on institutionalized older persons who also had inadequate finances, raises a question about whether the findings would be applicable to older persons in general. For example, ‘older persons in general’ could include older persons living in a family or a community setting and older persons living in an institution but with adequate financial resources.

(ii) While the first point was a limitation of the study, the second point describes the weakness of the study. This weakness was that there was a high number of dropouts in the Ayurveda group which was believed to be due to the subjects erroneous concept of undesirable effects of the preparation as well as individual factors. However, it is necessary to emphasize that every attempt was made to convince the volunteers that the preparation had none of the adverse effects which were reported, but in spite of it dropouts did occur. This serves to highlight possible difficulties in administering a herbal preparation, especially to older
persons who may have their own concepts and fears related to the intake of any medicine or remedy.

**STRENGTHS**

This study is the first randomized control trial which has evaluated both Yoga and Ayurveda compared with a Wait-list Control group in older persons taking into account a wide range of variables such as (i) measures for general health, (ii) neurological status and (iii) psychological functioning. Also, the assessments were made after three and six months of the respective interventions, allowing for a longitudinal follow-up and evaluation of progression in any changes seen. The other strength of the study is that participation of the subjects in the interventions was closely supervised.

**POSSIBLE AREAS OF FUTURE RESEARCH**

As mentioned above, the present randomized control trial evaluated Yoga and Ayurveda for the promotion of positive health in older persons, who were (i) living in an old age home and (ii) had inadequate financial resources. Hence, while the trial did demonstrate several benefits with Yoga practices and some benefits with the Ayurveda preparation, it would be desirable to evaluate these interventions in older persons in different settings, e.g., living at home or as part of a community or without inadequate finances. It may also be interesting to understand the mechanisms involved in the improvements in some of the measures studied, e.g., a whole night
polysomnography study would give essential further information, substantiating the improvement in self-rated quality of sleep in the aged population studied here.