CHAPTER VIII

DISCUSSION

8.1 Summary

This was a two weeks long crossover randomized two armed control study on 80 patients with chronic low back pain. Results showed significant (p< 0.01, Repeated Measures ANOVA) improvements within yoga group on all variables with significant group time interactions and between group differences after 7 days except a few physiological variables. Most of the variables showed significant differences within groups after 14 days but not between groups. There was non significant difference between groups (YC post verses CY post) on 14th day on all variables. Discussions on each of these variables presented below includes effect of one and two weeks’ intervention, comparisons with normative values where available and comparisons with earlier one arm study of two weeks and other studies.

8.2 Crossover design

The crossover design of this study although appeared to be novel as it matches with the double blind crossover design of drug trials, it has a major limitation for yoga study because (i) it cannot be double blind since it is an interventional study and (ii) it has spill over effect. The spill over effect could be abated by planning an ideal design of giving a wash out period between the two interventions. This was not possible due to practical difficulties. Although this was not an ideal situation of a double blind crossover control design the study has a clear message with remarkable differences in the results in the 2nd week after the crossover pointing to the supremacy of yoga in many of the variables. An earlier study (Pradhan B, 2009) in the same setting using the same intervention in CLBP patients (with same selection criteria as the present study) has shown that a continuous
yoga schedule for 14 days (without crossover) can have continuing improvement similar to the results of yoga intervention found in this study. A comparative presentation of these differences in some variables (wherever data available) between the 2 studies are discussed below.

8.3. Discussion on each variable

8.3.1 Disability

ODI: In the YC group, there was significant reduction in disability by 49% which did not change significantly after shifting to the control intervention in the 2nd week. This indicates the carry over effect of yoga from the first week to second week. In the CY group there was a non-significant improvement in the 1st week followed by 42% improvement in the 2nd week when they shifted to the yoga intervention. The overall change at the end of 2nd week was significant within both groups but did not differ significantly between groups.

Vini yoga was used in CLBP (Sherman et al., 2005) on an out patient basis which has shown about 37% reduction at 6th week, 60% at 12 weeks and 62% at the end of 26 weeks as assessed by Roland Morris Disability Scale. In another study using Iyengar yoga (Williams et al., 2005) a 77% reduction in functional disability was found after 12 weeks. The present study has shown 49% reduction within 1 week.

8.3.2 Pain

Assessment of pain was done by 2 measures i.e., NRS and. Section 1 of ODI. In the YC group, there was significant reduction in pain by 49% in NRS and 60% in Sec 1 of ODI which did not change significantly after shifting to the control intervention in the 2nd week. In the CY group there was a non significant improvement in the 1st week followed by 38% in NRS and 57% in ODI (section 1) improvement in the 2nd week when they
shifted to the yoga intervention. The overall change at the end of 2 weeks in both the groups did not differ significantly.

The improvement observed in pain intensity in the current study was 46% which is comparable to the percentage in earlier studies: 55% in Pradhan’s study (Pradhan, et al., 2008) which was a similar residential program for 2 weeks as assessed on VAS, 70% in the study by Williams et al (2003) in an out-patient program for 3 months and 14% (Groessl et al. 2008) after 10 weeks of yoga in Veterans Administration (VA) patients with chronic back pain. This would have resulted in reversal of the biochemical processes and opened up the connective tissue plasticity (Langevin, et al 2007).

8.3.3 Flexibility

8.3.3.1 Goniometric measures

Spinal flexion (SF), Spinal extension (SE), Right lateral flexion (RLF) and left lateral flexion (LLF): In the YC group, there was significant improvement in spinal flexibility in SF by 28.3%, SE by 51.52%, RLF by 26.36% and LLF by 39.15% which did not change significantly after shifting to the control intervention in the 2nd week pointing to the spill over effect of yoga. In the CY group there was a non significant improvement in the 1st week followed by significant improvement in all the variables in the 2nd week. The overall change at the end of 2 weeks in both the groups was significant within groups but did not differ significantly between groups.

8.3.3.2 SAR

In the YC group, there was significant improvement in SAR scores by 50% which changed significantly after shifting to the control intervention in the 2nd week. In the CY group there was a 3.7% improvement in the 1st week followed by 40% improvement in
the 2\textsuperscript{nd} week. The overall change at the end of 2 weeks in both the groups was significant within groups with non significant difference between groups.

These results are similar to Galantino’s Iyengar yoga study of three months which showed 64 % improvement. The two week’s results of Pradhan’s study shows a 34.29% improvement.

8.3.3.3 SLR

In the YC group, there was significant improvement in SLRR and SLRL scores by 31.14% and 28.38% which did not change significantly after shifting to the control intervention in the 2\textsuperscript{nd} week. In the CY group there was a 19% and 21% improvement in the 1\textsuperscript{st} week followed by 15% and 15% improvement in the 2\textsuperscript{nd} week when they shifted to the yoga intervention. The overall change at the end of 2 weeks in both the groups was significant within groups with non significant difference between groups.

Comparisons:

SLRR 38% in YC and 36 % in CY groups after two weeks in present study and 36% after two week’s of yoga in Pradhan’s study.

SLRL 35 % in YC and 40 % in CY groups after two weeks in present study and 37% after two week’s of yoga in Pradhan’s study.

Thus the results of Iyengar yoga showed significant reduction in pain and functional disability, after 16 and 32 weeks of yoga (3 classes per week), with no significant improvement in the degree of spinal flexibility. The present study although of only 7 days’ duration showed significant changes not only in pain and disability but also in the objective measures of spinal flexibility.
8.3.4 Stress, anxiety and depression

8.3.4.1 Stress

The scores on PSS showed that baseline stress levels were higher (18.80 ± 6.22) than the normative mean value (14.1) for normal adult Indians. Baseline PSS scores correlated negatively with QOL and positively with BDI. PSS was not used as an outcome measure as this questionnaire is designed for one month follow up and the present study was for only two weeks.

8.3.4.2 STAI

In the YC group, there was significant reduction in state and trait anxiety by 20.4% and 16 % which did not change significantly after shifting to the control intervention in the 2\textsuperscript{nd} week. In the CY group there was a non significant improvement in the 1\textsuperscript{st} week followed by 19 % and 8 % improvement in the 2\textsuperscript{nd} week when they shifted to the yoga intervention. The overall change at the end of 2 weeks in both the groups was significant but did not differ between groups.

The consistency of reduction in state anxiety during the yoga intervention, (20% in week 1, 19% in week 2) with non-significant changes during the physical exercise intervention corroborates earlier studies on yoga in other chronic stress-related conditions (Gupta et al 2006). In trait anxiety tests, subjects are asked to indicate how they felt ‘most of the time’ during the preceding week i.e. before they came for the intervention on the first day, during the first week’s intervention on the 7\textsuperscript{th} day, and during the second week’s intervention on the 14\textsuperscript{th} day. These results, showing that the Yoga intervention consistently produced significant improvements both weeks, may seem paradoxical. Trait anxiety was designed as a robust construct to measure slow underlying anxiety changes over weeks and months. In this context, the validity of ascribing changes to a one week
intervention period may sound questionable. However, in a previous short term (9 day) yoga study (3-4 hours/day in an outpatient setup) Gupta et al (2006) observed reductions in trait anxiety in patients with chronic disease. Thus, the improvement in trait anxiety in the present study, of 16% by the YC group the first week, and of 8% by the CY group the second week, with significant group*time interactions, and differences between groups, may be considered evidence for the yoga intervention’s power to reduce deep-rooted stress.

It is commonplace among those who teach and practice yoga that even a 30 minute, carefully practiced session of asanas and pranayama transforms how they feel internally. That a week of intensive programs of this kind, morning, noon and night, should have effects even on deep and apparently inerasable levels of anxiety, does not seem so implausible. The significance of this transformation may be compared to that of well substantiated changes in the emotionality variable as a result of regular Transcendental Meditation practice, something in which EPI author, HA Eysenck, himself took great interest when it was discovered (Abrams 1990). Both emotionality and Trait anxiety are considered long term, stable properties of the personality. In both cases, deep Yoga-based programs have indicated that they may not be as permanent as was originally supposed.

Two earlier randomized control studies of yoga for back pain, (Sherman et al., 2005, Williams et al., 2005) have also found reduction in pain and increased spinal mobility. However, that significant reductions in scores on state and trait anxiety, and depression scales, can also be produced in such a short intensive inpatient yoga program, seems to be a unique finding of this study. These results may stem from the fact that IAYT incorporates many stress-management components (see the list of various relaxation and meditation techniques included in the Intervention.
8.3.4.3 BDI

In the YC group, there was significant reduction in BDI scores by 47% which did not change significantly after shifting to the control intervention in the 2nd week. In the CY group there was a 20% improvement in the 1st week followed by 50% improvement in the 2nd week when they shifted to the yoga intervention. The overall change at the end of 2 weeks in both the groups was significant but there was no change between groups.

There was a positive correlation between BDI and PAS at r=0.4 (p<0.01) in change scores of yoga group and not the control group. There were significant correlations in change scores after the intervention between BDI and trait anxiety in both groups.

Comparisons

Feyer, et al., (2000) showed that a history of pre-existing psychological distress influenced recurrent episodes of LBP. Yoga intervention for 10 weeks showed favorable changes in Energy/ fatigue (32%), Depression (27%), Physical Health Scale (5%) and Mental Health Scale (12%) in patients with CLBP (Groessl et al., 2008). They showed that increased levels of psychological distress (as measured by the GHQ) preceded the occurrence of new episodes of pain by only short intervening periods, implying a role for acute distress in the onset of the disorder. In the study, by Pradhan et al there were significant decreases in anxiety and insomnia (AI) symptoms by 59%, and severe depression (SD) by 45% in GHQ after two weeks of intervention in CLBP patients. Sharma R et al. (2008) in a study which included both healthy volunteers and patients found a remarkable improvement in the subjective well-being scores.

Although no other RCT yoga study has found significant improvements on psychological components of CLBP (Galantino et al, 2004), a number of non-yoga studies of cognitive behavioural therapy (CBT), pharmacotherapy, aerobics, physical therapies etc. have
observed that improvement in pain and disability in CLBP patients may be accompanied
by reduction in anxiety and depression (Koldas et al., 2008). Goubert et al. (2005)
observed correlations between somatic and physical function subscales of BDI with
dysfunctional cognitions related to CLBP. These were a reflection of how their chronic
lower back pain was interfering with their daily life.

Thus, yoga seems to provide the feeling of wellness that could both be the cause and the
effect of the improvement in pain and flexibility.

8.3.5 QOL

In the present study, all subjects reported corresponding improvements in sleep, sense of
well being and confidence after the program. In the YC group, there was significant
improvement in the scores of WHOQOL Bref on all domains i.e. 28 % in physical, 16 %
in psychological, 10.17% in social and 8.8 % in environmental domains which changed
significantly after shifting to the control intervention in the 2\textsuperscript{nd} week. In the CY group
there was a non significant improvement in the 1\textsuperscript{st} week followed by a significant
improvement in the 2\textsuperscript{nd} week when they shifted to the yoga intervention. The overall
change at the end of 2 weeks in both the groups was significant but did not differ
significantly between groups.

8.3.5.1 Physical Health:

The baseline scores for this domain in CLBP (present study) patients were (mean 11.9)
lower than the scores (mean 13.8) in normal volunteers (Deshpande, 2007) who used WHOQOL100. After yoga it increased to 14.5 in normal
volunteers and 15.14 in patients with CLBP pointing to the normalizing effect of yoga on
physical QOL. This domain of WHOQOLBref deals with features such as mobility,
fatigue, pain, sleep, work capacity etc. The observed improvement can be attributed to
reduction in pain and disability with improvement in spinal flexibility (Tekur et al 2008). Other studies on integrated yoga in healthy children and adults have shown better physical stamina (Raghuraj et al 1997), dexterity and eye hand coordination (Telles et al, 2006). Better quality and duration of sleep after yoga has been reported in the elderly (Manjunath et al, 2005).

8.3.5.2 Psychological Health

20% improvement in yoga group with non-significant change in control group. The baseline values were lower (CLBP mean 13.0) than normal volunteers (14.7) and increased (15.2 in CLBP) similar to normal volunteers (15.5) after yoga. The improvement seen in this domain that deals with questions relating to feelings, self esteem, spirituality, thinking, learning, memory etc. may be attributed to reduction in anxiety and depression. Several studies have shown the effect of yoga in reducing anxiety (Miclalsen et al, 2005) depression (Sharma et al, 2005) and stress (Carmody et al, 2008) with enhanced mental health as observed by improved perceptual sharpness (Telles et al, 1995), memory (Naveen et al, 1997), and better information processing at the thalamic level (Telles et al, 1993).

8.3.5.3 Social health

The mean scores changed from 13.0 to 14.8 in our group of CLBP patients and 14.8 to 15.2 in normal volunteers. This domain has questions relating to problems in interpersonal relationships, social support etc. These issues that could be the main source of stresses (contributing to spinal pain), were addressed during lectures and at a personal level in yoga counseling sessions. They were aimed at achieving an introspective cognitive change by recognizing the psychological freedom ‘to react, not to react or
change the usual pattern of reaction to situations’ highlighted in yoga texts (Nagaratna et al 2000).

8.3.5.4 Environmental Health

The mean value in this domain which was lower (12.8) than normal (14.5) improved significantly to reach normalcy (14.6) after yoga and not after physical exercises. This domain has questions that deal with problems relating to financial resources, physical safety, physical environment such as pollution, noise, climate etc. One of the definitions of yoga (Bhagavad-Gētā) says that yoga results in equanimity and balance (samatavam) that can help in better tolerance to environmental changes (ḍīta uñēa samaù-tolerance to heat or cold). Studies have shown that yoga changes the physiological responses to stressors by improving autonomic stability with better parasympathetic tone in normal adults (Telles et al 1994) and reducing sympathetic arousal with improved performance in congenitally blind children (Telles et al 1999) and community home girls (Telles et al 1997).

Yoga texts explain how the integrated yoga techniques help in improving the quality of life. Voluntary reduction in the violence and aggressiveness (Deshpande et al 2005) during emotional reactions of anxiety (Miller et al 1995) or depression (Sharma et al 2005) observed after yoga could be due to the restful awareness during all the practices in general and meditation in particular (Telles et al 1995). This mastery over the emotional surges leads to controlled and need based physiological responses to stressfully demanding situations instead of uncontrolled overtones of HPA axis (Langevin et al 2007) during chronic pain.
8.3.6 Clinical Parameters

8.3.6.1 Blood Pressure

In the YC group, there was significant reduction in B.P systolic by 3.8 % in 1st week which changed significantly after 2nd week. Diastolic B.P reduced by 3 % after 1 week with non significant change after 2 weeks. In the CY group there was a reduction in B.P systolic by 2.3 % and diastolic BP by 2 % in the 1st week followed by non significant change in the 2nd week (Table no 13, 14 and 15). Within group change at the end of 2 weeks in both the groups was significant but there was no significant between groups.

Stress management through yoga practices such as relaxation techniques (Sarang et al, 2006), prāṇāyāma (Raghuraj et al., 1998; Telles et al., 1994) and meditation (Telles et al., 1995) with effective reduction in sympathetic activation and improved autonomic stability have been seen by many earlier control studies in normal volunteers. There are also studies that have used different types of yoga and relaxation techniques in lifestyle related diseases that have shown significant improvement in autonomic variables. Autogenic training, progressive muscle relaxation, visualization and breathing exercises, chi gong and yoga are appropriate relaxation techniques which occupy a permanent place in effective antihypertensive treatment (Schwickert et al, 2006). Immediate effect of reduction in BP after single sessions of exercise, relaxation and the enhancing effect of their combination in both non-hypertensive and hypertensive subjects has been demonstrated (Santaella et al.,2006).In a study on Yoga in 13 patients with essential hypertension, aged 41–60 years, BP dropped significantly during the third week of a 4-week yoga program (1 h per day, 6 days per week), and it fell further after the program. The systolic BP dropped from 142 to 128 mm Hg by the third week and to 121 mmHg by the fourth week (Vijayalakshmi et al, 2004).
8.3.6.2 RR and PR

In the YC group, there was significant reduction in RR by 10.4 % and a non significant reduction in PR by 1.4 % which did not change significantly after shifting to the control intervention in the 2\textsuperscript{nd} week. In the CY group there was a non significant reduction of 3.2% and 5.2 % in the 1\textsuperscript{st} week followed by a significant improvement in RR by 9 % and a non significant change (0.33%) in the 2\textsuperscript{nd} week. The overall change at the end of 2 weeks was significant for RR in the yoga group. There was no significant difference between groups.

Improvement in RR and PR was observed after one week of intervention in tsunami-affected population. The intervention was given one month after the December 2004 tsunami in Andaman Island where the affected people were living in camps. After one week of yoga program a significant decrease was found in self-rated fear, anxiety, sadness, disturbed sleep and their heart and breath rate (Telles et al, 2007).

8.3.6.3 Symptoms Scores (SS) and Weight (Wt)

In the YC group, there was significant reduction in symptom scores by 34.9% and Wt by 0.63% which changed significantly after shifting to the control intervention in the 2\textsuperscript{nd} week. In the CY group there was a significant change in the 1\textsuperscript{st} week followed by significant reduction in SS by 38.2 % and Wt by 0.7 % in the 2\textsuperscript{nd} week when they shifted to the yoga intervention. The overall change at the end of 2 weeks in the yoga group was significant but there was no significant difference between groups.

The overall reduction in SS by 48% is comparable to the previous finding of 66% improvement in SS within two weeks (Pradhan, et al., 2008) and improvement in energy/fatigue by 32% (Groessl, et al., 2008). In the earlier well planned 3-armed-randomized control study on Vini yoga, back-related functions and symptom
bothersomeness were superior in the yoga group compared to the self-care book and exercise groups after 12 and 26 weeks of intervention; no objective measures were used in the study.

8.3.6.4 Medication Scores (MS)

There was no significant change in YC or CY groups in analgesic requirement. The overall change at the end of 2 weeks in the yoga group was significant but there was no significance between groups.

In the present study of 2 weeks where there was 1 week of yoga a 8.3% reduction in the medication score was found comparable to the study by Pradhan et al where there was a 25% reduction in analgesic requirement after 2 weeks of yoga intervention, which is also comparable to those reported in earlier studies using non pharmacological therapies such as 25% after yoga (Williams et al. 2003); 26% after massage therapy, 24–27% after, chiropractic and physical therapy; 18% after acupuncture (Cherkin et al., 2001). Another study found decrease in their medication by 21% after yoga intervention (Sherman et al., 2005). The lower percentage reduction in analgesic scores in this study (8%) as compared to earlier studies could be because their baseline analgesic requirement was already low (mean of not more than 1-5 tabs per day).

8.4 Distinct features of the present study

8.4.1 Features

The current study is distinct from earlier existing literature in many ways.

1) Sample size: The previous studies had lower sample size compared to current study.

2) Randomized crossover design: There are no studies on yoga with a crossover.

3) Module of yoga: Different studies have used different set of yoga practices. Greater emphasis on yoga postures (classical back bending postures) was given in Iyengar
yoga study (Williams, et al., 2005, Vidyasagar, et al., 1989) Sherman et al. (2005) used yoga postures along with relaxation and stress reduction counseling in viniyoga study; Galantino, et al., (2004) used yoga postures with diaphragmatic breathing, and meditation. IAYT intervention based on Paï ca koša concept from the traditional yoga texts was the uniqueness of the present study. IAYT has a holistic approach with multidimensional interventions at physical, mental, emotional, intellectual and spiritual levels in keeping with the WHO definition of health.

4) Residential: None of these studies were residential.

5) Duration of practices: The frequency and duration of the yoga program varied in different studies. It was of 1.5 hour class per week with 30 minutes of practice at home for 5 days for 16 weeks in Iyengars’ module (Williams et al, 2005), a 75 minute class with a 3 hours of practice at home per week for 12 weeks in viniyoga module (Sherman et al,2005), 45 min in Vidyasagar’s (1989) study and 60 min/ session in Galantino’s study (2004). The duration of practices in the present study was 6-8 hours per day for the entire period of their stay as this was a residential program.

5) Monitoring: The daily progress was monitored by a team of well-trained yoga therapists, doctors, and counselors.

6) Lifestyle: Their lifestyle including simple vegetarian wholesome diet as per their calorie requirement, non smoking, regular hours of sleep (early to bed and early to rise) etc were ensured for both groups.

7) A 49% reduction in disability and pain (60%) with a significant increase in spinal flexibility (29%) after this short term intensive yoga program is noteworthy.

8) This is the first study that has looked at the effect of yoga on psychological measures such as anxiety, depression and QOL in patients with CLBP in an RCT with significant results. Although there are no yoga studies that have looked at the
psychological aspects in CLBP with significant results, there are a few non-yogic interventional studies (using pharmacotherapy, aerobics and physical therapies) that have shown reduction of anxiety and depression along with improvement in pain and disability in patients with CLBP (Koldas Dogan et al., 2008).

8.4.2 Reasons for better results in the present study

The difference in these remarkable observations of the present study as compared to earlier ones seems to be because of:

(a) Frequency of the daily practice which was intensive and continuous under active supervision. In other studies there was a long gap between 2 sessions,

(b) Duration of integrated practices spread out over the entire day, and

(c) Holistic approach: The integrated yoga module used in this study included OM meditation, cyclic meditation, deep relaxation technique, mind sound resonance technique, yogic hymns, and devotional sessions in addition to the practices which were common between the three studies i.e. physical postures, breathing practices and lectures.

It appears from these that the cumulative effect of intensive daily practices are more effective than those spread out with longer gaps which may not be as effective.

8.5 Lessons from the crossover design

The results presented above show an interesting contrast. For the two Yoga interventions (1st and 2nd week) they comprise consistent changes on all variables, with improvements on all variables both weeks. For the two control interventions, on the other hand, there were reductions in all flexibility variables and depression. A significant worsening in the forward flexion during control intervention in the second week in those who had improved through yoga in the first week is note worthy. A typical pattern of improvement
during the yoga session which became non significant after shifting to control session or vice versa is seen in all other variables including disability, pain and state anxiety The QOL continued to improve in the second week in YC group which points to the **spill over** effect of yoga on QOL and not on pain or disability or anxiety. Thus the messages from the analysis of this crossover design are:

1. The control intervention is useful in improving spinal flexibity and depression within one week
2. Yoga is effective in all aspects within one week
3. There is no spill over effect of yoga in pain disability and state anxiety. Hence one week of yoga intervention is insufficient to for ensuring progressive improvement. This indicates that the systematic influence of the Yoga intervention requires continued, regular Yoga practice in order to be sustained; more importantly, *that it cannot be compensated for by a physical therapy intervention.*
4. The spill over effect is seen only in QOL which can be due to the overall effect of the residential facility.

**8.6 Mechanisms**

**8.6.1 Physical – changes in Annamaya kośa**

*It is known that physical exercise therapy has an important role in CLBP.* Studies have shown that exercises are helpful in chronic low back pain to return to normal daily activities and work in adults (van Tulder et al, 2000) And decreasing pain and improving functional capacity in health care professionals (Hayden et al, 2005). The three factors that may contribute to these observed improvements are stretching, relaxation and strengthening of the paraspinal muscles.
8.6.1.1 Stretching

Yoga postures although appear to be similar to many physical exercises there are several basic differences. Yogic physical practices are mainly spinal stretches that are maintained with ease and effortlessness (Sthira sukha- āsanam- Patāḷi). Since the recommendation by Patāḷi is mainly focussed on relaxed maintenance in the final posture achieved through two clear instructions of prayatna čāithilyā (conscious local relaxation of the stretched parts) and anantasamāpatti (merge the mind in a feeling of unlimited expansion), it takes away the component of isometric contraction of the muscle fibres while maintaining any stretch and provides only a passive stretch to paraspinal muscles. The isometric contraction that could add to pain is avoided. Thus yoga postures offer voluntary introspective relaxation of the parts that are stretched and they are not just isometric exercises. In a study the effects of three different procedures i.e. relaxation, visualization, and yogic stretch with yogic breathing (prāēyāma) on perceptions of physical and mental energy and on positive and negative mood states were assessed in a group of seventy one normal volunteers with age range 21-76 years (Wood, 1993). Yogic stretch and yogic breathing produced a significantly greater increase in perceptions of mental and physical energy and feelings of alertness and enthusiasm than the other two procedures. Relaxation made subjects more sleepy and sluggish immediately after the session than yogic stretch and yogic breathing. Visualization also made them more sluggish but less content than yogic breathing and more upset than relaxation after the second session. In both these interventions they were less content than yogic breathing. Thus, a thirty minutes program of yogic stretch and breathing exercises which is simple to learn and which can be practiced even by the elderly had a markedly 'invigorating' effect on perceptions of both mental and physical energy and increased high positive mood.
which reduces stress and gives pain relief. Innocuous impulses produced by stretch act by
crowding the anterior spinothalamic tract and block pain impulses from entering the
spinal cord as proposed by “Gate control theory” proposed by Melzack (1965).

**Gate control mechanism**

Part of the pain reduction observed in Yoga is probably produced by the neural impulses
from stretch proprioceptors interfering with, and blocking the impulses on the ascending
pain pathway, as hypothesized in gate control theory. Gate control theory advanced by
Melzack and Wall in 1965 focused on descending pathways from the brain to the spinal
cord that inhibit pain signaling.

### 8.6.1.2 Relaxation of paraspinal muscles

Deep relaxation of the spinal muscles achieved during safe body movements with mindful
awareness seems to be another major factor that improves flexibility and reduces pain.
This is supported by earlier observations of increased paraspinal electromyographic
(EMG) activity during pain in subjects with CLBP (Fryer et al, 2004). Padmashree et al
(2007) have shown that yoga reduces EMG activity in conditions like chronic pain
specially headache.

The component of back pain special techniques (physical practices) of IAYT included in
this program to relax the spinal muscles was the *pavanamuktāsana* (wind releasing pose)
series (Appendix 1). These stretches practiced with internal awareness may act similar to
intermittent spinal traction in reducing the spinal muscle spasm. Maintenance in the final
posture of āsanas such as *bhujangāsana* (cobra posture), *shalabhāsana* (locust posture)
etc, contributes to improved flexibility.

Sage patanjali clearly points out that the main goal of all physical postures is mastery over
the modifications of the mind (*tato dvandvā anabhīghataū* - then the duality disappears)
through the process of local relaxation of the parts that are stretched (prayatna çaitilya-let-go all effort). This deep rest and relaxation during the practices may change the basic tone of the muscles which may result in lower Basal metabolic rate (BMR) in senior yoga practitioners (Chaya et al, 2006). Chaya et al showed that the BMR was significantly lower in senior yoga practitioners than their age, sex and BMI matched controls. The BMR of the yoga group was significantly lower by 15% when compared with the non yoga group (p < 0.001) after adjustment for body weight by analysis of covariance. This shows that yoga gives deep rest which is essential for stress and pain relief.

Another vital contribution of the yoga scriptures in this context is the principle portrayed by sage Gauḍapāda who wrote the commentary to Māēoukyā upaniñad called ‘Māēoukyā kārikas of Gauḍapāda’ (Swami Lokeswarānanda, 1995) Although this technique was promoted by the sages for spiritual evolution this principle has now been made available for stress management and deep relaxation of the muscles through a specific module called cyclic meditation (CM) (Nagendra, 1997). This 30 minute practice uses several cycles of stretches in āsanas alternating with relaxation and internal awareness. This has been shown to reduce the oxygen consumption much better than relaxation alone in supine position. Thus the technique of CM and other physical postures that produced deep rest and relaxation of the back muscles would be the other mechanism involved in IAYT.

8.6.1.3 Strengthening of paraspinal muscles

Mechanical factors such as prolonged wrong postures during a sedentary lifestyle and prolonged immobilization after the pain can lead to wasting and weakness of postural muscles. This may play an important role in functional disability and chronicity of pain (Fryer, 2004). Setubandhāsana breathing (bridge posture) and Bhujaī gāsana breathing to
strengthen the para spinal muscles, and *Ekapadāsana* (straight leg raising) and *Ardhanavasana* (half boat posture) to strengthen abdominal muscles were incorporated in this module. These were repeated under supervision in the special technique sessions (Nagaratna et al, 2007). Improvement in muscle strength and dexterity after IAYT has been demonstrated in adults (Raghuraj et al 1997) and PT teachers (Telles et al, 2006).

Thus Yoga techniques provide safe body movements accompanied by mindfulness that leads to deeper relaxation and strengthening of both spinal and abdominal muscles. This may be the mechanism to explain what appears to be paradoxical that yoga improved spinal mobility while reducing pain at the same time, for in CLBP patients spinal movement is normally painful. This is in agreement with previous findings in studies of IAYT on healthy volunteers, of improved stamina and strength (Raghuraj et al., 1997), and decreased metabolism (Chaya et al., 2006).

**8.6.2 Psychological – Manomaya kosha**

**8.6.2.1 Stress reduction**

Better results observed in the present study seems to be due to the use of more of direct mind (stress) management components of the integrated yoga module which included OM meditation, cyclic meditation, deep relaxation technique, mind sound resonance technique, yogic hymns for devotional sessions and yogic counseling apart from the practices which were common between the three earlier studies on Iyengar yoga and Viniyoga i.e. physical postures, breathing practices and lectures.

Studies on different types of meditation have consistently shown increased mental alertness even while being physiologically relaxed. Om meditation that was used in this study has also been shown to provide this psycho physiological rest (Shirley Telles et al 1995). Om meditation and cyclic meditation showed reduced oxygen consumption
suggesting psycho physiological rest . Thus these yogic practices be it physical or breathing or mental, practiced independently or as a combination seem to produce better mental alertness even while being physiologically relaxed both in the sick and healthy persons that may account for the reduction in anxiety and depression (Shirley Telles et al., 1995). This physiological rest forms the basis of stress management even in CLBP patients.

8.6.2.2 Emotions management – Manomaya Kośa

We know that the factors contributing to pain experience are multiple including sensory, affective, behavioral and cognitive (Turk et al 1983). IAYT included yogic counseling (jnana yoga) sessions that were designed

(i) to cognize the sources and patterns of their emotional responses to pain,

(ii) to restore their freedom to change the responses to these situations as well as to the chronic pain, and

(iii) learn to touch the blissful bed of inner silence during all joyful moments.

Lipchik et al showed that the increased sense of personal control over pain following a pain management program of cognitive behavioral therapy (CBT) was accompanied by reduction in negativity (Lipchik et al 1993). The science of yoga and Vedānta (Nagaratna et al, 2000) has a systematic methodology to train a person to be established in the experiential knowledge of one’s true nature which is a state of unchanging state of bliss (saccidānanda). This is the major cognitive behavioral change that makes the participant stable under all demanding situations (samatvam) that manifests as improved quality of life. Studies on yoga have shown reduction in negative affect and improvement in positive affect in healthy volunteers after IAYT Yoga and exercise as a lifestyle and stress reduction intervention has shown to decrease negative affect and improve positive affect (Mutrie et al, 2007, Danhauer et al 2008, West et al 2003)
contributed to improvement in quality of life concerns in these patients. The divine hymn sessions (bhakti yoga) were meant to foster an understanding that devotion and surrender to the Divine unfolds the subtle emotions of pure love which help in moving towards positive emotional affective states and clearing the negative affect that enhance healing and pain management.

8.6.2.3 Reduction in Anxiety and depression-Manomaya kośa

The decrease in both physical and psychological symptoms i.e. pain, anxiety and depression, suggests that yoga has the ability to reverse the interlinked downward spiral of CLBP causing depression, giving rise to further back pain, and added depression resulting from that etc. Indeed, this is consistent with previous studies, in which yoga was observed to correct disturbed moods in psychiatric patients with anxiety disorders (Krisanaprakornkit et al., 2006, Nagarathna et al., 1988) and major depressive illness (Sharma et al., 2005), showing that it can benefit even pathological levels of stress. This conclusion is corroborated by further studies, in which both physical and mental symptoms improved in healthy volunteers after yoga practice: in one, improved physical well-being and vigour resulted, as well as reduced fatigue, stress and anxiety as measured by the ‘perceived stress scale’ and STAI (Michalsen et al., 2005); in others, Vempati et al., (1999), Raghuraj et al., (1998), and Telles et al., (1994) noted reduced physiological arousal in normal volunteers, while Telles et al. (1995) found improved autonomic stability. Altogether, these provide strong evidence for yoga’s stress reducing effects. Reduction in scores on anxiety and depression indicate that subjects were given a margin of safety from subsequently redeveloping pathological levels of these conditions. From the perspective of Yoga medicine, which is as much preventive as curative, this is of significance.
8.6.3 Cognitive change – intellectual – Vijnanamaya kośa

A meta-analysis of randomized controlled trials was carried out to evaluate the efficacy of psychological interventions for adults with noncancerous chronic low back pain (CLBP). Cognitive-behavioral and self-regulatory treatments were specifically found to be efficacious. The results demonstrated positive effects of psychological interventions for CLBP (Hoffman et al, 2007). Another review showed that only intensive multidisciplinary bio-psycho-social rehabilitation with a functional restoration approach improves pain and function, and less intensive interventions does not improve the clinically relevant outcomes (Guzman, 2002). Combined respondent-cognitive therapy and progressive relaxation therapy were found to be more effective on short-term pain relief (Ostelo, 2005). Basler et al 1997 observed that control over pain through CBT was associated with physical, psychological and social well being (Basler et al,. 1997).

Participants often report that their courses give them ‘space’ to recognise causes of suppressed negative emotions. Although, as yet, we have no hard data to support this, medical records show that through counselling IAYT inpatients can learn to be more objective about previously distressing situations. This seems closely allied to the cognitive behavioural perspective, which recognizes chronic pain not to be simply a neurophysiologic state. Rather, it includes sensory, affective, behavioural, and cognitive factors, which influence the way the individual cognizes the world and assigns meaning to events (Turk et al, 1983).

In this light, the present study’s IAYT program could have helped subjects realise that ‘I have the autonomy to react or not to react to a situation ’ (Nagarathna et al, 2000). Indeed, yoga texts highlight a major change in perspective: ‘happiness is an inner state, and need
not depend on external situations’ (Nagarathna 2001). Subjects with this perspective find previously difficult situations easier to handle.

8.7 Hypotheses on possible neural and molecular mechanisms

Interest in understanding the processes involved in somatization has unfolded several pathways. A recent review based on neuroimaging and other data, (Langevin H M and Sherman K J, 2007) has proposed a dynamic reversible model of pain neuro-matrix integrating the factors of neural plasticity, central sensitization and peripheral connective tissue plasticity linking the somatosensory, motor and emotional components of CLBP.

8.7.1 Neural plasticity

8.7.1.1 Central Neural plasticity in chronic pain and yoga.

Distinct structural and functional changes in brain networks in motor and sensory cortical areas including thalamic gray matter in patients with chronic pain seen in neuroimaging were specifically related to cognition and emotion (David Borsook et al., 2007) pointing to the negative effects of pain on neural plasticity. Practices such as meditation and pranayama are known to promote neural plasticity in a positive direction as seen in our studies which showed improvement in information processing at the primary thalamo-cortical level (seen as decreased latency and increased amplitude of Na waves in middle latency auditory evoked potentials) (Telles et al., 1993,1994). We hypothesize that these physiological changes after yogic meditation may correct the structural abnormalities in the gray matter observed during the chronic pain condition.

8.7.1.2 Peripheral connective tissue plasticity in chronic pain and yoga

Mechanical, emotional, behavioural and motor dysfunction in CLBP results in inflammation that promotes fibrosis due to plasticity of intramuscular and perimuscular connective tissues in addition to spasm and wasting. This may occur as a result of tissue
hypoxia, lowered Ph and release of cytokines such as TGF beta-1 (Hunt et al., 1985, Leask and Abraham, 2004) seen during chronic pain. The nociceptive sensory inputs to the nervous system from the richly innervated connective tissues can produce these profound local changes in tissues that may promote collagen synthesis and worsen the stiffness and movement impairment (Barnard, 1990, Leask and Abraham, 2004, Sporn and Roberts, 1990). These peripheral muscle abnormalities can also induce large changes in the pattern of central motor unit activation (Fryer G et al., 2004) aggravating the muscle spasm. Yoga practices that involve mild stretches on the background of mindful rest may be instrumental in reversing this connective tissue plasticity.

8.7.2 Pain pathways

8.7.2.1 Spinal cord: gate control theory Part of the pain reduction observed in Yoga is probably produced by the neural impulses from stretch proprioceptors interfering with, and blocking, impulses on the ascending pain pathway, as hypothesized in gate control theory (Melzack 1965).

8.7.2.2 Thalamus

In studies on middle latency evoked potentials during OM meditation Telles and Desiraju (1993) used ‘self-as-control’ design and the two types of sessions, meditation and non-meditation, were repeated thrice in each subject. The results of a few more studies with a similar design (Telles et al, 1994) showed significant beneficial changes in sensory relay at the level of thalamus, with more neurons being (i.e., higher amplitude of Na waves of auditory evoked potential) recruited with better facilitation of the information processing (i.e., reduced latency of Na AEMLP). These studies in normal volunteers show the possibility of functional restoration at this level in patients with CLBP after yoga.
8.7.2.3 Cortical pathways

Earlier studies on auditory evoked potential also pointed to the efficacy of yoga at cortical level. In persons who had over five years of meditation experience there were changes that pointed to better information processing at more complex brain areas corresponding to auditory association cortices (Telles & Desiraju, 1993).

8.7.2.3.1 p300 studies during yoga.

Murthy et al (1998) conducted a study with 30 patients of depression who practiced *Sudarshan Kriya Yoga* (SKY) for 3 months. In this self as control trial there was favorable response to auditory P300 ERP aptitude after 1 month and 3 months of practice of SKY.

Lou et al (1999) studied 9 young adults who were experienced yoga teachers practicing Yoganidra relaxation meditation. Global cerebral blood flow (CBF) distribution (with the 150 – H2O PET technique) and spectral EEG analysis was done in two sessions (i) during the yoganidra relaxation meditation (ii) during the resting state of normal consciousness. In meditation, differential activity was seen, with the noticeable exception of V1, in the posterior sensory and associative cortices known to participate in imagery tasks. In the resting state of normal consciousness differential activity was found in dorso-lateral and orbital frontal cortex, anterior cingulate gyri, left temporal gyri, left inferior parietal lobule, striatal and thalamic regions, pons and cerebellar vermis and hemispheres, structures thought to support an executive attentional network.

8.7.2.3.2 fMRI studies during pain

The advent of modern neuroimaging and electrophysiological techniques has enabled researchers to examine non-invasively the pain processing network. In particular, studies
using PET and fMRI have helped resolve the major components of the pain matrix which is depicted in the schematic below.

**Simple schematic of nociceptive pathways from the periphery to supraspinal regions.**

Black arrows represent transmission of pain signals supraspinally, which is integrated at several levels along the neuroaxis, and at almost every level influenced by descending fibres (grey arrows) (Jonathan et al 2005).

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**Role of mind in modulation of pain**

The relationship between reported pain intensity and the peripheral stimulus that evokes it depends on many factors such as the level of arousal, anxiety, depression, attention and expectation or anticipation. These factors are in the process of being characterized on the physiological and pharmacological levels by means of functional imaging. These ‘psychological’ factors are in turn regulated by overt and covert information as well as more general contextual cues that establish the significance of the stimulus and help...
determine an appropriate response to it. Simple manipulations with attention alter the subjective pain experience as well as the corresponding pattern of activation during painful stimulation.

**a. Distracting the mind**

The main effect of distracting subjects during pain appears to be increased activity within the medial pain system, e.g. orbitofrontal, dorso and medial prefrontal cortex and rostral cingulate cortices, and a corresponding reduction in activation in the lateral pain system, i.e. thalamus and insula (Petrovic et al. 2000; Longe et al. 2001; Bantick et al. 2002). Recent work using functional and connectivity analyses suggest that the increased activity within prefrontal and cingulated cortices during distraction decreases pain perception via the descending pain modulatory system, presumably via antinociceptive pathways (Valet et al. 2004).

**b. Anticipation of pain**

Other experimenters (e.g. Ploghaus et al. 1999; Porro et al. 2002) have investigated the effect of anticipation of an impending painful stimulus on regional brain activity. Ploghaus and colleagues performed such a study by using a novel conditioning protocol in 12 healthy volunteers, who underwent fMRI while being presented with a pseudo-random sequence of two intensities of thermal stimulation (painful hot or nonpainful warm). Colored lights signaled in advance the two kinds of thermal stimulation and subjects learned during the imaging session which color signaled pain and which signaled warmth. The high temporal resolution of fMRI was exploited to identify brain regions involved by comparing brain activation during the colored light preceding pain with activation during the colored light preceding warm stimulation. The main effects of anticipation were found to be activation of rostral anterior insula and medial prefrontal cortices during the
anticipation of pain, whilst during pain itself insula activity was more caudal, and the
prefrontal focus was replaced by activity within the anterior cingulate cortex. Ploghaus
and colleagues (Ploghaus et al. 2001) took this work further, to determine how increases
in anxiety produced an increased pain perception. They found that hippocampal formation
(entorhinal complex), was responsible for producing anxiety-induced increased pain
perception which was different from the increased pain produced by an increased
nociceptive drive. Another study (Coghill et al. 1999, 2003) investigated whether anxiety-
induced increased pain perception produced a generalized increase in brain activation.
Generally this was found not to be similar to that produced by increased nociceptive
input. Studies of attention and anticipation have demonstrated one common finding: when
subjects actively attend to their pain or anticipate an upcoming painful stimulus, activity
within the anterior insula (AI) appears to be more rostral than during pain itself.
Therefore, the AI appears to provide a neurological substrate for monitoring the state of
the body during pain, or possibly or preparing oneself in advance. The **rostral AI** has
recently been proposed as an **interoceptive brain** centre, i.e. a region that constantly
monitors the state of the body for changes in temperature, pain or other homeostatic
function (Craig, 2002). In line with this hypothesis, Critchley et al. (2004) recently
demonstrated that subjects who were better able to perceive changes in their own heart
rate were likely to have both more strongly correlated activation in right AI in response to
an interoceptive task (heart rate monitoring), and also to have increased grey matter
density within this region. These findings suggest new avenues for future research, and
highlight the importance of recognizing that structures such as the **insula** in yoga studies
that involve introspective practices.
8.7.3 HPA axis, reduction in Sympathetic arousal and HRV studies.

A stress response in normal conditions results in the release of central nervous and peripheral neurotransmitters (i.e., nor epinephrine) and adrenal hormones (i.e. cortisol); so that an efferent message is sent from the highest centers of the brain to the periphery in order to modulate the stressful event. These peripheral mediators (i.e. nor epinephrine and cortisol) can then change the immune system or pain perception. When brain derived signals increase inflammation or enhance pain perception, stress is perceived as a worsening factor (Walker JG et al 1999). IL-18 may participate in the regulation of the HPA axis or that it may have a role in mediating the CNS dependent effects on the susceptibility to or the progression of diseases. This review summarizes the evidence linking stress and IL-18 and discusses the possible implication of the neuro-immuno-modulatory action of IL-18 (Shuei Sugama et al 2007). The yoga based relaxation technique has also shown to reduce physiological signs of arousal (Vempati & Telles, 2002). Thirty five male volunteers whose ages ranged from 20 to 46 years were studied in two sessions of yoga-based guided relaxation and supine rest. Assessments of autonomic variables were made for fifteen subjects, before, during, and after the practices, whereas, oxygen consumption and breath volume were recorded for twenty five subjects before and after both types of relaxation. A significant decrease in oxygen consumption and increase in breath volume were recorded after guided relaxation. There were comparable reductions in heart rate and skin conductance during both types of relaxation. During yoga relaxation the power of the low frequency component of the heart-rate variability spectrum reduced, whereas the power of the high frequency component increased, suggesting reduced sympathetic activity. Also, subjects with a baseline ratio of LF/HF > 0.5, showed a significant decrease in the ratio after guided relaxation, while subjects with a ratio ≤ 0.5 at baseline showed no such change. These results suggested that sympathetic activity decreased after guided relaxation based on yoga, depending on the baseline levels. Further, yoga-based isometric relaxation reduced physiological signs of anxiety (Vempati et al, 1999) and yogic breathing (prāṇāyāma) reduced the low frequency band of heart
rate variability spectra (Raghuraj et al., 1998) indicating reduced sympathetic tone (Shirley Telles et al., 1994).

Yogic breathing is a unique method for balancing the autonomic nervous system (Brown et al, 2005). Research done in our institute has shown that specific prāṇāyāma practices can have relaxing effect on the sympathetic nervous system there by reducing stress levels (Telles S et al, 1994). Reduced anxiety scores, autonomic arousal and urinary VMA levels were found after the practice of integrated approach of yoga in patients with generalized anxiety disorder (Nagarathna et al., 1988).

8.7.4 Changes in neurotransmitter

Another explanation for Yoga’s efficacy in pain reduction may lie in endorphin production at a cortical level, which is known to result from alternate stretch-and-relax procedures of Yoga asana practice.

Kjaer et al (2002) studied Yoga-nidra relaxation meditation where participants underwent two 11C- raclopride PET scans: one while attending to speech with eyes closed, and one during active meditation. There was increase in the release of endogenous dopamine in the ventral striatum and decreased blood flow in prefrontal, cerebellar and subcortical regions.

This RCT has shown a reduction in pain with improved spinal mobility along with improvement in anxiety and depression and quality of life in a short term intensive integrated yoga program in patients with CLBP.