7. DISCUSSIONS

7.1 BMR

A consistent and significant decrease in BMR occurred in yoga practitioners, who practised an integrated approach of yoga, which includes practise of Āsanas, Prāṇāyāma, and Meditation. This addresses the physical, mental, emotional and intellectual aspects of the being. This is a form of adaptation in healthy, well-nourished men and women, which is different from the metabolic adaptation described by Shetty (Shetty 1999) in acute or chronic under-nutrition. Yoga is a state defined as "a high level of consciousness achieved through a deeply rested and relaxed body and a fully awake and relaxed mind" (Wallace et.al., 1971). Those who practise yoga have an actively calm and calmly active mind (Nagendra 1977). This is clearly demonstrated in the present study, since yoga practitioners had a lower basal metabolic rate, presumably due to metabolic efficiency, as described in yoga textbooks (Taimini 1961, Nagendra 1977, Mahesh yogi 1972) and demonstrated by yoga research (Sugi et.al., 1968, Wallace et.al., 1971, Wallace et.al., 1972).

High intensity exercise increases the BMR (William et.al., 1997), while low and moderate intensity exercise does not have much effect on the BMR (Ribeyre et.al., 2000, Sjodin et.al., 1996). It, therefore, seems likely that yoga which is a form of activity requiring energy expenditure (Rai et.al., 1994, Rai et.al., 1993) would increase the BMR. However, this study shows that yoga sānasas, when practised with Prāṇāyāma and Meditation over a period of time, actually reduces the BMR. (It is clearly mentioned in yoga scriptures that whether one practises Āsana, Prāṇāyāma, or Meditation (all lead to balance in the system, Taimini LK 1961). Yoga texts attribute this to the calm and relaxed state of mind, as yoga basically works at the mind level (Taimini 1961). It is possible that there may be a balance between sympathetic and parasympathetic activity, such that parasympathetic activity increases while sympathetic activity decreases. Breath Flow, Oxygen consumption, Carbon di-oxide
elimination and ventilation (in men) were significantly lower in yoga group, suggestive of lower sympathetic activity. The heart rate was lower in yoga women though it is not statistically significant. Studies on yogāsanas and meditation practitioners showed decreased arousal (Telles S 2000) along with a consistent EEG pattern (Vengar 1961) and increased Galvanic Skin Resistance-GSR (Orme Johnson 1973), reduced oxygen consumption (Wallace et.al., 1971) support this view.

Other studies have demonstrated that transcendental meditation, Zen meditation, OM meditation and certain Prāṇāyāma and relaxation techniques reduce O₂ consumption, CO₂ elimination, metabolic rate, heart rate, pulse rate, breath rate measured prior, during and after the meditation/relaxation techniques (Wallace et.al., 1971, Wallace et.al., 1972, Telles et.al., 2000, Vengar et.al., 1961, Bagchi et.al., 1957, Shirley et.al., 1991, Kasamatsu Telles et. al., 1966). Recordings of the EEG in TM Meditators (Jean Paul 1973) have also demonstrated that a predominant alpha wave activity (even with eyes half open) which progressively increased in amplitude and decreased in frequency during the first stage of TM followed by occasional theta wave in the second stage of meditation (Jean Paul 1973). All these studies were performed either during or after the meditation and compared to the basal values, and demonstrate the immediate effect of the practise of yogāsanas, meditation or Prāṇāyāma. The present study, while confirming the outcome (reduced BMR) of decreased arousal and a decreased sympathetic tone, further suggests that these short-term effects have long-term effects as well in terms of the BMR. In addition, the previous studies looked at either Meditation or Prāṇāyāma in isolation. The present study assessed the integrated effect of a lifestyle practise of yoga including Āsanas, Prāṇāyāma and Meditation.

The heart rate, respiratory rate and energy expenditure are sensitive to small changes in the psychological state (Telles et.al., 1995). These results are in accordance with what is said in the scriptures about the meditation/relaxation, i.e.
calming of the mind, slowing of the breath and relaxation of the muscles (Taimini 1961, Mahesh yogi 1972, Nagendra 1977) Yogis can achieve these hypo-metabolic states (other than sleep and hibernation) voluntarily. While a voluntary stoppage of the heart by a yogi has been recorded by Brosset (1946), yogic and Zen meditators could also produce similar hypo-metabolic effects for short periods of time by reducing their oxygen consumption, metabolic rate, and heart rate (Kasamatsu et.al., 1966, Sugi et.al., 1968, Bagchi et.al., 1957). A yoga practitioner confined in a sealed metal box while meditating was able to markedly reduce his $O_2$ consumption and $CO_2$ elimination (Anand et.al., 1961). The metabolic rate reflects the functioning of both the sympathetic and parasympathetic nervous system and is a major indicator of autonomic balance as studies (Orme Johnson 1973) on autonomic stability in transcendental meditators showed that the practitioners were more stable on the rate of GSR habituation, number of multiple responses, and spontaneous GSR, which are indicators of autonomic stability. This study also showed that a greater regularity of practice was associated with a greater autonomic stability These findings were in consonance with those from another study on Transcendental meditation (Gregory et.al., 1976), where a lower spontaneous skin resistance response, a lowered resting heart rate, and significantly faster rate of habituation to loud noises indicating stability in ANS, was observed. Our study is in conformity with the above observations that a lowered metabolic rate is an indicator of a stable autonomic nervous system, with greater resistance to stressors such as noise and other sensory stimulants, thereby possibly increasing metabolic efficiency.

Many earlier studies have indicated that there is no gender-based difference in BMR adjusted for body weight or fat free mass (Kanady et.al., 2001, Soars et.al., 1998, Anna Luzzi et.al., 1997). But there are also few studies that indicate that the gender differences exists even after adjusting the metabolic rate (ANCOVA) using FFM or FM. (Ferraro et.al., 1992, William Mc Ardle 1996). However, in our study, the differences in BMR persisted even after adjustment for body weight, between men
and women of the yoga group. This may be attributed to the difference in Fat mass Fat Free Mass, and FM/FFM ratio and or fat distribution (in specific sites like breast and genitals and lower body subcutaneous fat) (William Mc Ardle 1996). Also, it may be attributed to the effects of training in yoga to handle stress as women respond differently to different levels of stress (al’Absi et.al., 2003. Traustadottir et.al.., 2003). In addition the interplay of physical, psychological, environmental, hormonal and stress factors makes it more difficult to arrive at a definitive conclusion.

A further finding from this study is the concordance of predicted with measured BMR values in non-yoga practitioners. The prediction equation used was age and gender specific (FAO/WHO/UNU expert consultation 1985) and although derived from Western data-sets, is appropriate for Indian subjects. This is in agreement with earlier studies on similar subjects with normal BMI's (Anna Luzzi et.al., 1997). Importantly, the measured BMR of the yoga practising group was lower than that derived from prediction equations, for reasons that have been discussed above.

Based on these observations, it seems reasonable to propose that the decrease in BMR in the present study group of yoga practitioners was due to a decrease in sympathetic nervous system activity, decreased arousal response, and a stable nervous system. It is possible that the continued practice of such a lifestyle would bring certain changes that are more permanent in nature at the cellular level and all these changes have a direct effect on the BMR.

7.2. SLEEP STUDIES

The primary outcome of the study are, 1). The yoga training has beneficial effect on the metabolism in general as seen in the lowered metabolic rate of the yoga group before sleep, suggesting metabolic efficiency, 2). Yoga training has beneficial effect on the sleep as seen in the lowered metabolic rate after 7 hours of sleep.
This sort of hypo-metabolic states were observed by Wallace et al., (1971, 1972) in the practice of Transcendental meditation leads to hypo-metabolic states and proposed to call it the fourth state of consciousness. This state is different from sleep yet metabolically equivalent or has even lower than the sleeping metabolic rates. He observed 17% reduction in oxygen consumption during practice of transcendental meditation for 20 min, whereas after 8 hours of sleep the metabolic rate reduced by 10% (Robinson et al., 1986, Bijlani R L 2000). In the present study the yoga group showed 15% reduction in metabolic rate whereas non-yoga group showed 12% reduction. The highest reduction was seen in the men of yoga group who showed 19% reduction in the metabolic rate. This study not only endorses the views of Wallace et al., (1971, 1972) but further confirms that the short-term effects of yoga practices (Meditation is a part of the yoga) has long-term permanent expressions on metabolism leading to metabolic efficiency as evidenced by the lowered metabolic rates of the yoga group before sleep and after sleep.

Six weeks of weight training and endurance training do not have any effect on the SMR, as concluded by Van e Hen et al., (1995), Westerterp K R et al., (1994). But high intensity exercises increase the Basal metabolic rates whereas low and moderate intensity exercises does not have any effect on the Basal Metabolic Rates (Gilliant Wimberly M et al., 2001, Williamson D L 1997, Ribeyre J et al., 2000). All these exercises are mainly related to central or sympathetic activation (William Mc Ardle et al., 1996). It was therefore presumed that yoga which is activity requiring energy expenditure, as concluded by Rai L et al., (1994), Rai L et al., (1993) would increase the SMR/BMR. Whereas our study shows that Āsanas when practised with Prânâyâma and meditation over a period of time actually reduces the metabolic rate. This may be due to the possible alterations in the autonomic nervous functions leading to autonomic stability as observed by Orme Johnson (1973), who found that those practising TM showed stability in the rate of habituation, number of multiple responses, spontaneous GSR when compared to non-meditators. Silverman A J et al.,
(1961) observed low levels of sympathetic activity which have been correlated with greater resistance to stresses such as sensory deprivation, which is attributed to decreased arousal response (reduction in the sympathetic activation).

There are other yoga techniques such as Om Meditation (Telles S. 1995), Zen meditation, (Sugi Y et al., 1968) Cyclic meditation (Telles S. 2000), and certain Prānāyāmas (breathing techniques) (Telles S. 1991, Miles W R et al., 1964) wherein reduction in metabolic rate, heart rate, reduction in oxygen consumption, carbon dioxide elimination, breath rate, breath volume, pulse rate was observed. Pre-levels compared to the post-levels. Recordings on EEG by Jean Paul Banquet et al., (1973) showed predominant alpha wave activities with increased amplitude and frequency leading to few theta waves during practise of Transcendental meditation. Our study not only endorses this view but we can add further that Integrated Approach of Yoga Training (IAYT) can make these short-term changes into more permanent expressions as noticed in the changes in the metabolic rates of yoga group before and after 7 hours of sleep.

Further the quality of sleep and the metabolic rate is closely associated. Higher sleeping metabolic rate is associated with disturbed sleep (Gold Berg et al., 1988, Robert Brebbia 1965). Sleep stages 3 and 4 are associated with lowered metabolic rate than sleep stages 1 and 2 as observed by Fontvielle AM et al., (1994), Robert Brebbia et al., (1965) and Seal J L et al., (1999) in their study on overnight sleeping metabolic rate, BMR, and lowest energy expenditure sustained for 60 min during sleep, observed that overnight metabolic rate and BMR are equivalent, and there may be small decrease during sustained sleep for 60 min. Our study suggests that yoga group may have better sleep, say sustained for longer duration, than the non-yoga group. This is evident from the percentage of reduction of metabolic rate in the yoga group, which is nearly 19% in men and 8% in women when compared to 15% in men of non-yoga group and 5% in women of non-yoga group. The differences
are significant p<0.001, (Ancova, GLM, multivariate analysis, using before sleep values as covariates). The BMR, which includes the cost of arousal, represents the activation of central and sympathetic nervous system from sleep to basal levels as concluded by Fontvielle et.al., (1993) and this may be influenced by various factors including the control over the state of mind. (Nagendra et.al., 1977). Practice of yoga leads to decreased sympathetic activity as concluded by Orme Johnson (1973). Telles et.al., (2000), (1995) in their study on meditators. Orme John has further demonstrated that greater the regularity of practice of TM, greater was the increase in autonomic stability, and this is amply demonstrated by our study by the lowered metabolic rates of the yoga group both by before and after 7 hours of sleep compared to the metabolic rate of the non-yoga group, which can be attributed to the decreased sympathetic tone, and decreased arousal response in general (be it before sleep or after 6-7 hours of sleep), and greater ability to recover from stressful conditions quickly. This is evident when we look at the differences in yoga and non-yoga groups before sleep itself, which existed even after adjusting for body weight. (using Ancova).

There are contradictory reports about gender differences in the SMR/BMR, few claiming that the differences does not exist when adjusted for body weight, Fat mass or Fat Free Mass (Anna Luzzy et.al., 1997, Kanady A N et.al., 2001, Soars M J 1988), few others claiming that the gender differences does exist even after accounting for the Fat Mass, Fat Free Mass, or Lean Body Mass, or body weight. (Seal J L et.al., 1999, Ferraro R et.al., 1992). In our study the gender differences though not found in non-yoga group, existed in yoga group, suggesting that the effect of training in yoga to handle stress may have different effect on men and women, as women respond differently to levels of stress, as observed by al Absi M et.al., (2003) Traustadottir T et.al., (2003). A further detailed study on the effect of training on the gender differences along with detailed analysis of body composition (Fat mass, Fat Free Mass, Fat distribution) may be necessary to arrive at an exact reason.
Taking into view the reports that averages for SMR and RMR are very similar as concluded by Zhang K et al., (2002) with little variance in the sleep stages and metabolic rate as observed by Fonteville A M et al., (1994) and Gold Berg G R et al., (1988), and taking into view that there is no difference in averaged overnight metabolic rate and basal metabolic rate (Gold Berg G R et al., 1988), taking into view that the change in the place of sleep, connection to the equipments by electrodes, may have an effect on the quality of sleep, the study though not done during the sleep, looked at the quality of sleep in general by measuring metabolic rate just before sleep and after 7 hours of sleep (equivalent to BMR). We conclude that decreased metabolic rate of yoga group may be due to good quality of sleep which is brought about by continued practice of yoga leading to permanent expression on the metabolic rate in general bringing in metabolic efficiency which is an indicator of stable nervous system and more effective and efficient use of energy during sleep and activities.

Sleep architecture including EEG, EOG, and EMG and overnight sleep metabolic rate of yoga group and non-yoga group may throw more light on the exact differences in the quality of sleep of both the groups.

7.3. ĀSANA STUDIES

ĀSANA done WITH AWARENESS and done with COUNTS

Āsanas are basically stimulating in nature involving contraction of muscles, which in turn increases the oxygen consumption, metabolic rate and the heart rate (Ardle 1996, Bijlani 2000). Physiologically, it looms large that a combination of Āsanas and Savāsana should have greater energy consumption than just eyeing on the ground in Savāsana. It is shown by Telles et al., (2000) that judicious combination of stimulation, relaxation through a module (Cyclic Meditation) can give greater relaxation than just relaxation in Savāsana.
While the results of this study (Telles et al., 2000) is fascinating, it needs repeated confirmation by better measuring equipment which can also measure the changes during the practice. In our study, such an attempt has been made by first studying individual āsanas and later CM itself by measuring not only O₂ consumption, but also CO₂ volumes, minute ventilation, breath and heart rate.

The āsanas are done in different ways in different schools (Swami Muktibodhānanda 1993, Iyengar 1992, Swami Venkatesānanda 1984, Nagendra 2000) the differences depend mainly on the extent of stimulations and relaxation and only part of it have modifications in the āsanas themselves. There are very few studies on the energy expenditure pattern of Yoga āsanas based on the ways of performing āsanas.

Here in this study, two ways of doing the āsanas are selected. 1). Āsana done with full awareness, in a slow way with closed eyes and with instructions. 2). The Āsana done with eyes open and with counts to come to a particular position as prescribed by Vyāsa (Vivekananda Publication on YOGA, 1997). For example, Ardha Karatī Cakrasana and Ardha Cakrāsana are done with 4 counts, while Pādahastāsana is done with 8 counts.

The results in tables & figures show that doing āsanas with awareness and instructions consumed less energy in AKC and Pādahastāsana compared to doing the āsana with counts. But the same trend was not seen in Ardha cakrāsana a backward bend posture, it was the reverse. Here in AC, the subjects spent more energy in doing the āsana with awareness and instructions than with counts.

But the relaxation component for all the āsanas done in two different ways was same for all the āsanas (11-12% reduction in AKC & PH, while Ardha cakrāsana done with counts which recorded 16% reduction). This reduction is equivalent to TM meditation (Wallace et al., 1971).
Discussions

A significant reduction of 12 to 16% in the 3 Āsanas in comparison to reduction in Savāsana of about 7.5% is a proof of the hypothesis that stimulation-relaxation combine can bring down the metabolic rate to a greater extent than mere relaxation.

The key secret of Āsanas consists of a special process of stretch and relax which brings down the muscle stiffness (partial contraction of muscles needing greater energy expenditure for their maintenance). This is quite different from isometric training or weight-lifting training in which the muscles become more stiff (with increased energy consumption for their maintenance). While these results support the earlier findings of Nagendra et.al., (1986), Telles et.al., (2000) and Vempathi et.al., (1999) which is in conformity with Māndūkya Kārikā.

Rai and Ram (1993,1994) have demonstrated that Āsanas can be classified as mild/moderate physical exercises.

It is evident from the tables that there are gender differences both while performing the Āsanās & as also in recovery & post-phases of the Āsanās. Women spent more energy while performing Ardha cakrāsana with awareness wherein they increased their metabolic rate by 53%. The least exertion was while doing AKC with awareness (24% increase in metabolic rate). In general, the results further show that AKC is the least demanding Āsana on the metabolic rate compared to Pādahastāsana and Ardha cakrāsana which are more demanding with higher energy expenditure.

Among the 2 ways of doing Āsanas (WA & WC) the stimulation-relaxation done slowly, consciously with awareness show non-significant reduction in the post-Āsana compared to the pre-values in all Āanas.

Earlier results of Ganga, Sanahal (2003) also collaborate the above and Balaram finding that the reduction in MR non-significant in the 2 ways of doing the Āsanas. Only AKC has shown 12% reduction with a post value of 1238 KCal / day and 1247 which is significantly (p<.006 and p<.02 respectively) lower than ther predicted BMR (1405.51) KCal/day.
Discussions

Between āsanas there were no significant changes in pre- & post-values. However, there was statistical significance between the values during and recover. Pāda Hastāsana (done with awareness) showed maximum increase of 60.9% in EE while the least increase is in AKC with counts (28.91%).

The work of Rai et.al., (1993-94) showed that in Siddhāsana and Virāsana there was an increase of oxygen consumption (280 ml/min) and 570 ml/min. PH in our study showed 360 ml/min.

Between the values of Rai et.al., (1993-1994) and our study the VO₂ values per supine rest Śavāsana (222 and 224 ml/min respectively) there was no significant difference.

Except for the difference that there was more relaxation of 19% in women 16.9% in men after doing AKC with awareness (which is significantly below the predicted BMR and comparable with the Measured BMR of the Yoga group), and for men getting more relaxation after the Ardha Cakrāsana done in the āsana way (17% reduction), the relaxation percentage of difference was almost same for men and women. Wallace et.al., (1971) showed 17% decrease in oxygen consumption during TM, but what has been found by us is the highest reported so far (decreased metabolic rate), as it is found that sleep reduces the metabolic rate by 10%. Though we may not be able to draw any conclusion based on these differences, it is evident that women respond differently to different types of āsanas or relaxation posture. This may be due to the effect of yoga training as men and women respond differently to different types of training, and also due to the fact that their body composition, menstrual cycles, and response to stress differ (Ardle 1996, al Absi 2003, Traustadottir 2003).

Thus, the studies on āsanas done earlier and the present one are comparable.
Discussions

It can be found that women showed lower MR than men in all the (pre-during-recovery and post) values in all Āsanas. However, these differences were not found when the values were adjusted for body weight as covariate in ANCOVA.

The maximum reduction in MR of women was in AKC WA 19% and in AC AW(16.91%) for men.

7.4. RELAXATION STUDIES

IRT

Instant relaxation technique is characterized by progressive contraction of groups of muscles from toes to head followed by relaxation. Rai and Ram (1993,1994) who studied the Siddhāsana and Virāsana postures concluded that these two Āsanas are moderate in stimulation and the values of oxygen came back to their pre-levels, after coming back to the resting position. The increase of oxygen consumption in IRT (291 ml/min.) is about 24%, which is almost equivalent to VO₂ what is reported by Rai and Ram (1993,1994) for Siddhāsana (280 ml./min.).

In spite of the increase in VO₂ during IRT equivalent to a mild exercise, the post session of IRT has shown 8.2% reduction is EE which is more than relaxation obtained in Šavāsana (7.6%) though statistically non-significant. The key difference from Šavāsana and other relaxation techniques (QRT & DRT) is in the significant increase in HR & EE during (24% in comparison to 13, 11 & 7% in QRT, DRT & Šavāsana respectively), the practise and greater significant decrease in PR in post-session of IRT (8.62 in constrast to 107, 4, 6 & 7% in QRT, DRT and Šavāsana respectively).

It is also to be noted that IRT took only 1 minute for its performance while QRT, DRT & Šavāsana took 3,6 and 10 mts respectively. It is of great value to see that IRT in a minute could induce as much relaxation as Šavāsana could bring about.

These results show that IRT can be an effective cardiovascular mild exercise giving deeper rest to the heart in contrast to physical exercises which will fatigue the heart in the post-sessions.
The relaxation after IRT (8.19%) is equivalent to Śāvāsana relaxation (7.59%); the difference being in IRT some amount of energy is expended through the forceful contraction of the muscles, which has beneficial effect on the cardiovascular system (Ardle 1996), without the component of fatigue, which has great implications for the health benefits of the population.

Vempathi et al., (1999), in their study on IRT shows no significant change in the autonomic activity, showing greater significant decrease in breath frequency, but suggested reduction of arousal as seen in the reduced oxygen consumption. Increased oxygen consumption during the IRT suggests increased vasomotor tone (Delius and Kellerova, 1971). However, the pre-oxygen consumption levels of the study of Vempathi et al., (1999) correspond to very high basal levels of oxygen and hence, the comparison with this study becomes unrealistic.

Our results suggest increase in sympathetic activity during the practise of IRT, followed by decreased arousal response suggesting decreased sympathetic tone. The reduction in the oxygen consumption and EE, VE, and HR are in accordance with what is stated by Wallace et al., (1971) in their study on TM. The metabolic rate after the relaxation in IRT is comparable with the predicted BMR of the subjects (FAO/WHO/UNU 1985).

QRT, DRT

The effects of both QRT and DRT are similar. During the practice, QRT had associated with awareness, abdominal movements, slow breathing and with feeling in 3 phases. It took about 1 min. for each phase and totalled to about 3 minutes. DRT had 6 phases (See Chapter 4) taking 6 minutes.

The results in the table show a decrease of 11.57% in QRT (3 mts) and 14.9% in DRT (6 mts) compared to only 7.6% reduction in Śāvāsana (10 mts) are statistically significant. These results show the effectiveness of QRT & DRT compared to just lying supine in Śāvāsana.
Tables show the gender differences in the 3 relaxation methods. Women have shown greater reduction in EE that men in QRT, DRT and Savāsana. The maximum reduction was 18% in DRT in women. However, men showed greater reduction in IRT than women (10, 3 and 3.5%) in EE as also in other parameters except HR. But increase in HR was greater in IRT for women than men. All these significant differences become non-significant when adjusted for body weight, showing that the results found could all be attributed to the body surface area & weight.

These results of the study are in tune with the studies of TM by Wallace et.al., (1972). They showed a reduction of 16% in oxygen consumption after TM practice, which came back to the pre-values after the practice. In our study on DRT, there was 16% reduction of metabolic rate after 5 minutes of practice, while there was 11% decrease during the practice showing clearly that DRT done for 6 minutes could be almost as effective as 20 minutes of TM.

The reduction in oxygen consumption and heart rate after DRT are similar to that reported by Bera, (1998) who reports physiological relaxation after guided relaxation indicative of alertful rest.

In general and in summary all the relaxation postures i.e. IRT, QRT, and DRT reduces the metabolic rates, physiological arousal, the magnitude of changes being greater in DRT (15%) and then QRT, 11% reduction in metabolic rate, whereas IRT and Savāsana are similar in effects, with about 8% reduction.

Savāsana

The percentages of reduction in oxygen consumption, energy expenditure, and carbon di-oxide elimination are similar in all studies. The values of oxygen consumption and energy expenditure estimated in our study are consistent with the resting metabolic rates (Mc Ardle et.al., 1996, Robinsonet.al., 1986, Wallace RK et.al., 1971).
The initial differences, though not significant, found between Phase 1 of Savasana and Phase 1 of RMR (Savasana leading to lower values of the parameters) can be attributed to the pre-exercise anticipatory response as found at the onset of and during low and moderate-intensity exercising (18). Since Savasana is a relaxation posture, the feed-forward input from the neural command is not on the activation of a sympathetic nervous system rather more on the decreased sympathetic activity, and hence lower initial metabolic rate (No’ Brega AC 1993, Seals DR 1994).

There was progressive, consistent decrease in physiological parameters during Savasana. The changes consisted of decrease in oxygen consumption, carbon dioxide elimination, and energy expenditure with no significant change in RQ. The above changes are statistically significant when compared with RMR (EE p<0.003, VO₂ p< 0.004, VCO₂ p< 0.003). These results are similar to other reports. (Shirley 2000, Vempathi 2002, Bera TK 1998) on Savasana.

Wallace and Benson (1971) noted that while performing TM (Transcendental Meditation), the oxygen consumption goes down by 16% during meditation and comes back to the pre-level after meditation. We emphasize that in Savasana there is progressive reduction in oxygen consumption levels and these have low values not only until the end of Phase 3 but also continued upto 10 min after the period of Savasana, as observed by us.

BMR and RMR, the baseline levels of the energy expenditure/metabolism (McArdle et al., 1996, Robinson et al., 1986), being lowest in the 24-hour energy expenditure pattern, are approximately 1 kcal/kg body weight/hour for men. The physiological relaxation parameter during Savasana is approximately 0.9 kcal/kg body weight / hour.

Kjaer TW et al., (2002), have described Yoga Nidrā, which is similar to Savasana as characterized by decreased desire for action associated with decreased blood flow in the pre-frontal cerebellar and sub-cortical regions. In the present study, we
see that decrease in oxygen consumption, carbon di-oxide elimination and energy expenditure are similar in that regard, and are mainly due to the decreased arousal of sympathetic activity.

Smith et.al., (1996) compares the responses to different relaxation techniques, obtained by conducting surveys on large samples. The conclusions reached from this survey are that Yogāsana stretching, breathing and meditation are more associated with cognitive and behavioral responses like joyfulness, awareness etc., than are PMR, Imagery or massage. Our investigations endorse this view in that the reduction in the values of physiological parameters is associated with cognitive, somatic and behavioral responses. However, somatically anxious people are reported to respond better to progressive relaxation technique than to Agni Yoga as noted by Norton et.al., (1983). But our studies reveal good physiological relaxation in the somatic scores, consistent with the belief that Savāsana is effective in reduction of somatic anxiety as well, as observed by Bose et.al., (1987), who observed physical and mental relaxation in hyper-reactors who practised Savāsana.

There are also several reports that guided relaxation is more effective in reducing the physiological arousal than supine rest (Vempathi et.al., 1999).

Bera et.al., (1998) have assessed the oxygen consumption values in Savāsana before and after the Savāsana is performed, noted the baseline levels and compared these with corresponding values for different Āsana and relaxation techniques. However, the present report suggests deep relaxation in Savāsana by itself compared with the baseline data on resting metabolic rate. The comparison of values of energy expenditure with the average predicted values of energy expenditure shows that Savāsana is nine percent lower than that of the predicted values of BMR (FAO/WHO/UNU 1985). The energy expenditure at RMR values shows that RMR is about 3% higher compared to BMR, which is in conformity with the standard RMR estimation. Studies on sleep have shown that 6-7 hours of sleep brings down the metabolic rate.
by 10%, whereas in our study the metabolic rate is brought down by 9% in just 15 min and is below the predicted BMR levels. This is wakeful hypo-metabolic state giving deeper rest to the body and mind.

A combination of Āsana, Prāṇāyāma and Šavāsana increases physical and mental health (Ray US 2001, Vedantham P K, 1998). This combination is also reported to increase flexibility, endurance and relative maximal oxygen uptake (Chhabra MK 2001).

7.5. CYCLIC MEDITATION

Cyclic meditation is combination of Āsana and relaxation technique interspersed. The total time is for about 23 minutes, starting with IRT, followed by centering, stimulation in AKC from left to right, then relaxation in QRT, stimulation in Pādahastāsana and Ardha cakrāsana and finally relaxation in DRT.

Our study does not agree with the values of the parameters and the magnitude of change, never the less, agrees that the stimulation and relaxation does reduce the post-metabolic rate compared to the pre-levels. Also the reduction is comparable to the predicted BMR of the subjects, indicating deep relaxation. Further the study of Telles et.al., (2000) was done on only male subjects, whereas our study was done on both men and women.

Having tested the hypothesis that stimulation-relaxation combination can bring growth of an individual and reduce the energy consumption in the earlier studies on āsanas (section 6.3), we now proceed to examine the hypothesis in CM.

While Nagendra (1986) recorded 23% reduction in SMET done for 30 minutes and Telles et.al., (2000) recorded 32% reduction in CM done for 23 minutes using Benedict Roth (pre-post recordings) equipment to measure VO₂ the present study has recorded only 9.11% reduction. (see table 6.5.2.)
Discussions

A comparison of percent reduction in EE as also \( \text{VO}_2 \) values in various studies shown in table 6.6.1 and 6.6.2 places CM - a combination of \( \text{\&} \text{sanas and relaxation postures (IRT, QRT, DRT) as a technique better than \text{\&}v\text{\&}sana done for the same duration.}

The study of Telles et al., claiming a highly significant reduction of 32% due to CM is unacceptable based on the present studies as their initial values of \( \text{VO}_2 \) are too high as could be seen in the basal values of \( \text{VO}_2 \) compared in table 6.6.1 of various studies. No detailed measurements of metabolic changes have been reported in the study of Nagendra (1986) except of 23% reduction in metabolic rate (based on the changes in respiratory changes) in 30 minutes of practice of SMET.

SMET Yoga module mentioned therein (see table 6.6.1.) consisted of a sequence for IRT, 3 standing postures: AKC, PH & AC, QRT -2 sitting postures: Vajr\text{\&}sana, Ardha \text{\&}str\text{\&}sana or \text{\&}str\text{\&}sana ending with DRT. This second part of the SMET module is not contained in our present study of CM and can be the subject of future investigations.

(Wallace et al., 1972) had shown 16% decrease in \( \text{VO}_2 \) consumption during TM which involves sitting with closed eyes and meditation.

It is interesting to note that in our study, the decrease in metabolic rate after Ardha Cakr\text{\&}sana with counts was 17% for men, 19% in women after the practice of Ardhakati Cakr\text{\&}sana with counts. Though the percentage of decrease is more or almost equal to the studies of TM, the point to be noted herein that CM involves stimulation postures such as \( \text{\&} \text{sanas and the relaxation is higher after the stimulations, as stated by Nagendra (1986).}

Further no studies have stratified the results according the gender and our study shows the gender responses to this type of meditation. Women have shown 9.94% reduction in comparison to men with only 4.5% reduction which is statistically
significant when adjusted for body weight these differences did not get nullified as it happened in cases of āsanas & other relaxation techniques.

The reduction in oxygen consumption and the heart rate are associated with reduced physiological arousal (Wallace et al., 1972), and the psychological response as described by Orme Johnson (1993), who studied the autonomic functions in the transcendental meditators.

The reduction of the VO₂ found during the TM comes back to basal levels, after the practice of TM. In our study, the relaxation component continues even beyond the practice of CM.

A 21.46% increase in heart rate has been recorded during the practice of CM in this study. When compared to a 24% increase in VO₂ in IRT and 21 to 31.5% in different āsanas, CM practices have a sustained mild cardio-vascular exercise component for 23 minutes yet decreasing VO₂ in the post-practice session by about 10% which is better than supine rest. Hence, CM could be used in conditions of low cardio-respiratory reserves especially in individuals in whom heavy exercises are contra-indicated.

The importance of rest periods in between exercises was discussed by Falk (1985), who concludes that it enhances the joyfulness and improves compliance with exercise plan. Further Shepherd (1997) has described the stress reducing effects of non-competitive moderate to low intensity exercises with relaxation.

Wood C et al., (1993), in their study on mood changes and perception of vitality, found that the yoga stretching and breathing exercises which is simple to learn and which can be practised even by the elderly had a markedly “invigorating effect” on perceptions of both mental and physical energy and increased positive mood. This suggests that a combination of yoga Āsana and Prānāyāma is better in terms of these parameters when compared to relaxation, and visualization. Further this study
suggests that relaxation alone made the subjects sleepy and sluggish immediately. Hence the findings from this study are in accordance with our hypothesis that the combination of stimulations and relaxation is better, than just relaxation.

The CM which has a component of physiological and psychological, cognitive aspects, and this may be the contributory factor for increased relaxation compared to other exercises.

Further the gender differences in response to CM did exist even after adjusting for body weight keeping body weight as covariate.

This may be due to the fact that women respond differently to stress than men (al Absi 2003, Traustadottir 2003).

In conclusion, the findings support the idea that stimulation and relaxations are an effective tool for relaxation at all levels i.e. physiological, psychological, cognitive, and for stress release along with moderate energy expenditure, which is lacking in other types of relaxation techniques except the IRT.