DISCUSSION

5.1 BACKGROUND

This research work studied and compared the effects of HIIT and SCT on various performance related and health related parameters in healthy adult population. This was done with a view to come at a final recommendation regarding their use, with relation to performance enhancement in sports and health promotion. With this vision, the study focussed on the parameters of aerobic performance (VO$_{2\text{max}}$, Vmax and recovery heart rates at 02, 03 and 05 min), peak lactate levels, anthropometric profile (weight, body mass index, body fat, lean mass and basal metabolic rate), blood lipid profile (total cholesterol, triglycerides, HDL and total cholesterol to HDL ratio) and blood glucose profile (fasting blood glucose and 2 hour post prandial glucose).

5.2 AEROBIC PERFORMANCE

238 adult healthy male volunteers participated in the study. The results show that despite much lesser total training time, HIIT shows greater improvement in VO$_{2\text{max}}$ than SCT, and has similar response to SCT in blood lactate levels, lipid profile and glucose profile. While improvement in lean mass was greater in HIIT, parameters like body fat, weight and BMI show better result with SCT, albeit with 5 times of the weekly duration of exercise.

Aerobic performance has been described in terms of VO$_{2\text{max}}$, Vmax and recovery heart rate. Both HIIT and SCT have resulted in a significant increase in the VO$_{2\text{max}}$ levels (Figure 3, Table 2). In the current study, VO$_{2\text{max}}$ showed much better improvement with HIIT after 6 weeks of training. Even after just 3 weeks of training, the improvement is higher with HIIT, which is maintained after 6 weeks of training. Figure 4 shows that the quantum of increase in difference is greater between initial phase of 0 – 3 weeks than during later phase of 3 – 6 weeks. This phenomenon points to higher increase in the early part of training which is maintained with continuation of training.

The pattern of change, both for HIIT and SCT, are similar. In both cases, there is a higher initial increase, but the slope depicting the increase in VO$_{2\text{max}}$ becomes less steep in the later phase.
For Vmax too, the pattern of increase with both HIIT and SCT remain the same. In both the cases, there is an early increase of maximal velocity (Vmax). The quantum of increase is similar across both the training methods. The slope indicating the increase is relatively less steep in the later part of training.

The heart rate pattern shows an opposite behaviour. There was decrease in resting heart rate falls with both types of training. The recovery heart rates at 02, 03 and 05 min show sequential fall after cessation of exercise. This quantum of fall is more in the earlier phase of rest. With both HIIT and SCT, the rate of fall of heart rate is increased. As with VO$_{2\text{max}}$ and Vmax, the initial phase of training (0 – 3 weeks) results in greater drop in heart rate at all the time intervals studied (2min, 3min and 5min) than the later phase (3 – 6 weeks).

Thus it is also apparent from the present study that the initial phase of training draws a greater beneficial response than the later phases. It can, therefore, be supposed that the benefit from the two modes of exercise will not be indefinite.

Another parameter of the result is that the time involved in producing the effects. While HIIT had a total exercise time of 30 min per week, the SCT group had a total exercise time which was 5 times higher at 150 min per week.

It is quite apparent that both HIIT and SCT are very effective methods for increasing the Aerobic performance in this study population. It is equally apparent that one needs to spend much less time on ground for HIIT purposes as compared to SCT.

The results appear to be along similar line to that apparent with most of the reviewed literature, as specified below. While Smith-Ryan et al. (2015) and Astorino et al. (2012) had not noticed any significant difference between the effects of HIIT and SCT with 3 weeks of training, and Dunham and Harms (2011) over 4 weeks of training, Novak et al. (2015), Kilen et al. (2014) and Ouerghi et al. (2014) had found HIIT type training to be significantly better than SCT type training over 12 weeks of training for improvement in endurance performance.

The present study demonstrates the superior effect of HIIT over SCT for improvement in aerobic performance with 6 weeks of training. Ziemann et al. (2011) had observed similar changes in recreationally active males in a similar time frame.
de Araujo et al. (2012) with 12 weeks of training in obese children and Fernandez et al. (2012) with 6 weeks of training in competitive tennis players have different results. They failed to appreciate any significant difference between the two methods of training in respect of aerobic performance.

A possible explanation of the later study could be the choice of subjects. Competitive tennis players were probably well trained before they were recruited for the study, and 6 weeks may have been insufficient for the difference to manifest. Even in the present study, there is a decreasing benefit on VO$_{2\text{max}}$ on incremental exercise, as manifested by the slope depicting difference in VO$_{2\text{max}}$ between HIIT and SCT becoming less steep in the later phase of training (Figure 4).

HIIT is compared with SCT in terms of total time spent doing the actual exercise, HIIT is far superior to SCT for performance enhancement as well as for achieving health benefits (Smith, 2008). Tabata et al. (1996) noticed that while both HIIT and SCT produced similar benefits in aerobic capacity over 6 weeks of study, HIIT improved anaerobic performance by around 28%, while no such change was observed in SCT group. Further, they realised that the aerobic effects were noticed after HIIT using one – fifteenth of the time needed for SCT. Similarly, Gibala et al. (2006) noticed similar benefits of HIIT and SCT where energy consumption in HIIT was 90% lower, in spite of actual exercise time spent in SCT being 42 times more than that of HIIT.

Laursen and Jenkins (2002) had reported significantly improved endurance performance after HIIT without any significant increase in oxidative or glycolytic enzyme activity. Laursen et al. (2005) did not find any increase in plasma volume after different modalities of HIIT, in spite of an improvement on VO$_{2\text{max}}$, anaerobic capacity and ventilator threshold, which led them to believe that the changes were brought about by peripheral and not central adaptations.

Improvements in exercise performance following endurance training are a result of both physiological (including cardio – respiratory, metabolic, ionic and neural adaptations) and psychological (perception of mood and effort, level of motivation) factors (Smith, 2008). Some short term studies on HIIT lasting upto 2 weeks
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(Burgomaster et al., 2005; Gibala et al., 2006; Little et al., 2010) did not show any improvement in VO\textsubscript{2max}. This points towards greater role of peripheral factors in the early phases of HIIT. Studies on sedentary subjects (Whyte et al., 2010), however, proved to be beneficial even in 2 weeks for improvement in VO\textsubscript{2max}.

Repeated efforts of high intensity during HIIT result in high level of oxidative metabolism as a result of increased oxygen delivery and uptake at the muscle as well as due to decrease in substrate level phosphorylation mediated by phosphocreatine hydrolysis and glycolysis (Parolin et al., 1999). This is responsible for multiple pathways of physiological and adaptations (Gibala, 2015). These include increased non-oxidative enzymatic activity of glycogen phosphorylase and phosphofructokinase, improvement in muscle buffering capacity and ionic adaptations like higher quantity and activity of sodium-potassium ATPase (Kubukeli et al., 2002; Ross and Leveritt, 2001). Some studies have also noted bidirectional shift to type IIa (I -> IIa <- IIx) muscle fibre type (Kubukeli et al., 2002; Ross and Leveritt, 2001). The later findings are however, not universal and are noted, if at all, only after long duration of HIIT. Gibala et al. 2009 have pointed that acute bout of HIIT does not activate fibre growth or hypertrophy pathways. Hypertrophy of both type I and type II fibres following HIIT, if present, are modest (Ross and Leveritt, 2001).

Adaptations in oxidative energy metabolism and exercise capacity following HIIT are very rapid and require much lower absolute load and training volumes (Burgomaster et al., 2005, 2006, 2007; Gibala et al., 2006). Increased muscle oxidative enzymes activity of citrate synthase and cytochrome oxidase can rise by 15 – 35% after 6 sessions of HIIT over 2 weeks (Burgomaster et al., 2005, 2006, 2007). While SCT can also bring about similar changes in similar time frame (Gibala et al., 2006), the total energy expenditure required in the same time period for the effects of HIIT to manifest was around 10% of the SCT intervention. In the same time frame, similar effect of increase in resting muscle glycogen content and decreased glycogen utilization was also noted (Burgomaster et al., 2006, 2007). It is known that blood glucose does not contribute greatly to short term sprint performance, as is practiced during HIIT (Juel et al., 2004). Increase in GLUT4 protein content can be a possible explanation towards higher glucose uptake during recovery and resultant higher muscle glycogen content.
that has been seen after HIIT (Burgomaster et al., 2006; Burgomaster et al., 2005; Gibala et al., 2006).

On the other hand, increase activity of \(\beta\)-hydroxyacyl- CoA dehydrogenase (HAD), fatty acid translocase (FAT/CD36) in muscle and improvement in levels of plasma membrane associated fatty acid binding protein (FABPpm) were not noted until 6 weeks of HIIT (Burgomaster et al., 2006, 2007). It is known that extramuscular lipid is a less important contributor of energy for sprint training during HIIT (Jones et al., 1980). Over several weeks, through increased activity of \(\beta\)-hydroxyacyl CoA dehydrogenase (HAD), it is likely that HIIT will result in increased capacity for skeletal muscle lipid oxidation (Parra et al., 2000; Rodas et al., 2000; Simoneau et al., 1987). A short term study on HIIT have failed to report any change in HAD (Burgomaster et al., 2006). This may explain the delayed benefits on lipid profile and body fat level as a result of HIIT noted in our study. It is possible that increase in study duration would yield a picture even more favorable towards HIIT for lipid profile and changes in body composition.

As far as central adaptations are concerned, Matsuo et al. (2014) have demonstrated an increase left ventricular mass and stroke volume after 8 weeks of HIIT. Rakobowchuk et al. (2008) reported peripheral vascular changes after 6 weeks of HIIT while Cocks et al. (2013) noticed improvement in muscle microvascularity, mitochondrial content and microvascular enzyme content after 6 weeks of HIIT.

HIIT results in increased muscle fibre recruitment during the training, particularly type II fibres (Saltin and Gollnick, 1983).

It seems that AMP-activated protein kinase (AMPK) and mitogen-activated protein kinase (MAPK) cascades are involved in the signaling pathways, resulting in upregulation of the oxidative metabolism. These promote specific coactivators like peroxisome-proliferator activated receptor \(\gamma\) coactivator (PGC)-1\(\alpha\), which is one of the master regulators for biogenesis of mitochondria and the oxidative system (Coffee and Hawley, 2007).

HIIT selectively and rapidly stimulates AMPK and MAPK signaling mechanisms and causes a multiple fold increase in PGC-1\(\alpha\) mRNA (Gibala et al., 2009;
Little et al., 2011) and activates nuclear translocation of PGC-1α (Little et al., 2011). Both these effects have also been observed in SCT (Little et al., 2010). Over a long duration of HIIT, as with SCT, increase in PGC-1α protein content is noticed (Burgomaster et al., 2008). Repeated, transient increases in mRNA subsequent to bouts of HIIT is also seen, resulting in gradual but sustained increment in mitochondrial protein and enzyme content (Perry et al., 2010).

Muscle oxidative capacity following HIIT increases rapidly. cytochrome c oxidase subunit 4 (COX4) levels are found to be increased by around 1/3rd, and muscle GLUT4 by 1/5th, within 1 wk of HIIT, and continue to be elevated even after 6 weeks of stopping the training. The monocarboxylate transporter 4 (MCT4) has been found to be elevated after 1 and 6 wk, while MCT1 is elevated only after 6 wk of HIIT. Muscular enzymes like fatty acid translocase (FAT/CD36) and plasma membrane associated fatty acid binding protein (FABPpm) are unaffected by HIIT training or stopping of training (Burgomaster et al., 2007)

A study by Perry et al. (2008) concluded that HIIT has the effects of reducing glycolysis, causing decrease in lactate accumulation, increase in time to exhaustion, and increased fat oxidation at same levels of exercise over 6 weeks of training. This also explains the effects of HIIT on anthropometric and lipid profile in the current study.

Little et al. (2010) had suggested that HIIT induced mitochondrial biogenesis in skeletal muscles in humans. They considered SIRT1, nuclear PGC-1alpha, and Tfam as possible mediators in this skeletal muscle mitochondrial biogenesis which resulted in higher muscular mitochondrial concentration and higher aerobic performance.

### 5.3 PEAK LACTATE LEVELS

The effect of peak lactate on exercise is evident in the literature. Gosselin et al. (2011) had noticed similar superiority of HIIT for improvement in peak lactate over SCT and other training forms, as had Sperlich et al. (2010). Tanisho and Hirakawa (2009) had noticed significant increase in time to fatigue after HIIT. This result is in same line as the present study.

Lactate is an important hallmark, and is closely associated with the effect of EPOC. Lactate accumulation at 60 sec mark of a maximal, all – out effort, corresponds
to the highest lactate accumulation in humans, beyond which an inhibition of high speed muscle contraction (Withers et al., 1993; Almuzaini et al., 1998). During this period, which lasts upto 3 hours following HIIT, there is a tendency to increased fat oxidation, thus resulting in greater fat loss (Jakicic et al., 1995).

Lactate acts as a fuel, a buffering agent, and a signal to induce metabolic and aerobic adaptations (Phelain et al., 1997; Gladden, 2004; Chawalbinska-Moneta et al., 1996), testosterone and human Growth Hormone (Turner et al., 1995; Takahashi et al., 1995; Kaiser et al., 1983). The combined effect of hormone and EPOC last for considerable time after bout of HIIT, being effective even beyond 3 hr post exercise, an effect which is not seen following SCT (Phelain et al., 1997).

The ability to tolerate lactate is important in all sports requiring anaerobic energy, as seen in sprints, or the spurt in speed towards the end of endurance event (Smith, 2008). HIIT is effective in producing greater amount of lactate by increased recruitment of type II fibres. Type I fibres use lactate as a fuel. MCT 1, in type I fibres, and MCT4 in type II fibres (Juel and Halestrap, 1999) help in the transport across muscle membrane. HIIT, but not SCT, has been found to be effective in increasing both MCT1 and lactate transport after 3 weeks of training (Baker et al., 1998). Intense exercise over longer duration also increases MCT4 (Pilegaard et al., 1999).

Dalleck et al. (2010) opined in favour of a dose – response relationship wherein the amount of improvement in lactate profile was dependent on the frequency with which HIIT was performed during training.

5.4 ANTHROPOMETRIC PROFILE

Tremblay et al. (1990) demonstrated the superior reduction in body fat following 15 week of HIIT compared with 20 weeks of SCT. They also demonstrated increased pathway of fat metabolism evidenced by increased activity of HADH (3-hydroxyacyl coenzyme A dehydrogenase) in HIIT. This resulted in a greater increase in lipid utilization, particularly in the period corresponding to EPOC.

In relation to anthropometric profile, both the interventions caused decrease in weight in the subjects studied. The overall weight reducing efficiency of SCT was better
than that of HIIT over 6 weeks of training. It is therefore imperative to look at components of weight for further explanation. The body fat decrease in case of SCT is superior to that of HIIT. On the other hand, both types of training cause an increase in the lean mass, with HIIT resulting in greater increase in lean mass than SCT.

Exercise causes alteration in body composition by causing preferential fat loss while enhancing exercise capacity, and there is a close correlation between improvement in exercise capacity and amount of fat loss. (Katch, McArdle and Katch, 2011). The present study upholds this concept both in improving performance and decreasing body fat while improving lean mass.

5.5 LIPID PROFILE

In the present study, both HIIT and SCT of exercise appear to be effective for improving the lipid profile. With the exception HDL, there is no significant difference between the effects of HIIT and SCT. Even in case of HDL, the study marginally favours SCT.

Increase in HDL levels have been documented with HIIT (Ebisu, 1985). HDL levels are linked to beta – endorphins, which is also associated with mood changes (Schwarz and Kindermann, 1992; Parry-Billing et al., 1992). Steady state protocols like SCT require around 1 hr of exercise time, after which there is an exponential increase in its production. HIIT, on the other hand, results in a much earlier release of beta – endorphin (Schwarz and Kindermann, 1992; Parry-Billing et al., 1992; Walsh et al., 1998).

When taken together with improvement in VO$_{2\text{max}}$, it is quite clear that HIIT provides for better improvement in athletic performance than SCT. This postulate is supported by the studies like those by Driller et al. (2010) in rowers, and Sperlich et al. (2011) in soccer players. Another study on active individuals by Astorino et al. (2012) found decrease in RPE and leg pain after HIIT for same levels of exertion.

It is known that modest increment in fitness by performing physical activity results in significant health benefits. (Hambrecht et al., 2000). The traditional method of physical activity involves prolonged duration physical activity at a steady state (Katch,
McArdle and Katch, 2011). It has the advantage of being physiologically similar to a competition setup (Cregg, 2013; Katch, McArdle and Katch, 2011). However, it leads to accumulation of metabolites like lactate, which limit the maximal intensity that can be performed. The exercise intensity is generally limited to 60 – 70% of maximal effort. Some athletes can take it up to 85% of HRmax, with greater benefits in performance (Katch, McArdle and Katch, 2011).

In general life, as well as in most sports endeavors, it is common to come across small periods of highly intense activity, interspersed with periods of lower intensity effort, relative rest or complete inactivity. Using the same approach for training will facilitate training at much higher intensities by causing much less accumulation of lactate and lower levels of fatigue (Katch, McArdle and Katch, 2011). In research, this interpretation has been supported by relationship between increased VO2max and improved repeat sprint ability in team sports (McMahon et al., 1998). At the cellular level, Little et al. (2010) had shown that HIIT induced mitochondrial biogenesis in skeletal muscles in humans. They considered SIRT1, nuclear PGC-1alpha, and Tfam as possible mediators in this skeletal muscle mitochondrial biogenesis which resulted in higher muscular mitochondrial concentration and higher aerobic performance.

5.6 GLUCOSE TOLERANCE

The study had excluded any subject with known Diabetes Mellitus. Hence, all subjects were euglycemics. Both forms show a marginal change in fasting and post prandial glucose levels. The quantum of these changes in both instances is less than 1%. However, it is statistically significant. More importantly, HIIT is seen as better in lowering of glucose levels than SCT in healthy young adults.

Metcalfe et al. (2011) had noticed better glucose and insulin response following HIIT, which was apparent 3 days after the cessation of exercise. Little et al. (2011) had also noticed similar improvement in 24 hr blood glucose concentration and 3 hr post prandial area under glucose curve following HIIT. Ciolac et al. (2010) noticed equal effect of HIIT and SCT in young normotensive women on insulin response and insulin sensitivity. Babraj et al. (2009) had also observed similar glucose lowering effect of HIIT on area under glucose curve after HIIT in young men.
Even though the level of decrease in fasting glucose levels is not much, the very fact that the decrease has been observed is very important. The study on type 2 diabetes yields similar results.

The present study point towards the fact that both forms of exercise are effective in lowering fasting blood glucose, and that HIIT provides better response using much less exercise time.

5.7 ORIGINAL CONTRIBUTION TO PRE – EXISTING KNOWLEDGE

Studies dealing with parameters in the present study have been discussed above. It is clear that the present study strives to contribute to the pre – existing knowledge on effects of HIIT and SCT on aerobic performance, anthropometric profile, peak lactate levels, lipid profile and glucose profile.

1. Aerobic Performance: Increase in aerobic performance was noted in studies mentioned above both HIIT and SCT. The present study corroborates findings of Ziemann et al., (2011), Novak et al., (2015), Kilen et al., (2014) and Ouerghi et al., (2014), and serves to further strengthen the evidence in favour of HIIT for superior gain in aerobic performance following HIIT.

2. Anthropometric profile: Studies focusing on effect of exercise on body fat and weight tended to be of longer duration (Tremblay et al., 1990). The present study suggests that effects on body weight, body fat, lean mass and BMR are evident following as early as 6 weeks of intervention. The study also establishes that HIIT provides significantly better reduction in body fat and better increase in lean mass and BMR than SCT in same time frame.

3. Peak lactate levels: It was well documented that training causes an increase in peak lactate level (Gosselin et al., 2011; Sperlich et al., 2010), resulting in increase in time to fatigue (Tanisho and Hirakawa, 2009). While the present study establishes that both HIIT and SCT will result in greater increase in peak lactate levels, no significant difference between the groups was seen.

4. Lipid profile: The present study shows that, while both HIIT and SCT result in improvement of lipid profile, the only significant difference between the two forms is in
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5. Glucose tolerance: The present study establishes that significant fall in fasting glucose in study population takes place in both HIIT and SCT groups over 6 weeks of training, and that the fall after 06 weeks of HIIT is more than that of SCT for the same duration. This is along same lines as the works of Metcalfe et al., (2011), Little et al., (2011), Ciolac et al., (2010), Babraj et al., (2009). However, no significant changes in levels of post prandial glucose were noted in either group.

6. Overall benefits: It is apparent that the present study shows superior improvement by HIIT in aerobic performance and anthropometric profile and similar effects as SCT in other parameters. These benefits are acquired over 6 weeks of training using an exercise time of 30 min/week in case of HIIT compared to 150 min/week for SCT. Thus, the study shows HIIT to be a more time efficient method of training for achieving health and performance related benefits of training and exercise.

5.8 DISTINCTION FROM SIMILAR WORKS

As has seen from the studies mentioned in Review of Literature as well as during the studies included in discussion, many researchers have sought to study individually or to compare different regimes of High Intensity Interval training and Slow Continuous Training. The present study differs from them in the following aspects.

1. Sample Size: The sample size in different studies ranged from 10 (Whyte et al., 2010) – 246 (Nemoto et al., 2007). The studies with larger sample size had very few parameters which and focused on a small subgroup of the population. It is not possible to extrapolate results from such studies to normal population. The present study had a sample size of 238 adult healthy male population. A large sample size has given us results which can be applied universally.

2. Subjects Studied: Most of the studies in question have studied either athletic populations, or subjects who are suffering from or are predisposed to specified illnesses.
The present study focuses on healthy young subjects who have neither had any specialized training for specific games, nor are suffering from any illness. Such a population is expected to be more representative of healthy common man who takes up exercise and activity for health and recreational purposes.

3. **Ethnicity:** The studies quoted have been regional, with greater emphasis on native population which has resultantley been Caucasians or Africans. It remained to be seen whether these effects would be similar in population like Indians which have not been extensively studied. The present study has studied people of Indian Nationality, but of diverse ethnicity. The results of the present study suggest that the effects of the interventions, i.e. HIIT and SCT, are universal and their effects are not dependent on ethnicity.

4. **Parameters used:** The present study has used a number of both health related as well as training related parameters with likely outcome for population which is interested in maintaining a healthy lifestyle. This has ensured a holistic view towards outcome of both forms of exercise and training, as well as has ensured comparison between the two. This has resulted in the outcome of the study being more applicable to the population. No other study has attempted to study and compare these forms of exercise on so many outcomes.

5.9 **CLINICAL RECOMMENDATION**

1. HIIT provides superior gains to SCT for improvement in aerobic performance and should be included in every program to improve cardio – vascular fitness and aerobic performance.

2. HIIT is an effective form of exercise for improvement in anthropometric, lipid and glucose profile, with benefits occurring in one – fifth of the time required for SCT, and may be used in place of SCT if time constraint is a limiting factor.

5.10 **POSSIBLE ERRORS AND EFFORTS TAKEN TO MINIMISE THEM**

1. **Population specification:** The target population specified in the study is young, healthy, recreationally active male between the age group of 18 – 30 years. In order to ensure that the correct population has been adhered to, unambiguous inclusion and exclusion criteria were defined and were strictly adhered to.
2. **Sampling error:** Ensuring a sample that is representative of the population is the biggest dilemma facing a researcher. In order to avoid any sampling error, the following steps were taken

a) A large sample size was taken.

b) The study was conducted on volunteers, with no compensations or promises to any material or financial gains. All volunteers falling in the parameter of specified inclusion or exclusion criteria were included in the study.

c) While no media publicity was carried out, adequate word of mouth coverage was given in colleges and other establishment to ensure maximum number of subjects.

3. **Observer Bias:** Observer bias was avoided by ensuring that the workers were well trained in the conduct of experiment and the tests, and that they did not have any stake in the interpretation of the outcome. There was no sponsorship for the study from any commercial company or venture.

4. **Randomisation:** Block randomisation was followed for dividing the subjects in study groups. This ensured that the study was carried out over a period of three years in small groups, and subjects who were motivated enough did not have to wait for the group to be formed. It also ensured that the effects of difference in environmental conditions were negated as different groups were studied at different time of the year.

5. **Comparability of groups:** Since the subjects volunteered in small groups and individually, cross – matching was not done prior to assignment of group. However, the presence of large number of subjects ensured that the two groups were evenly matched. This is reflected in the statistical analysis of the groups at the baseline level.

6. **Measurement error:** A possible source of errors in many studies is the validity of measurement. This was avoided by using same set of equipment for all the subjects. The equipment was periodically calibrated as per their service manuals.

5.11 **LIMITATIONS**

1. The study focussed on adult healthy male subjects only. This was done due to practical reasons involving lack of female attendants in the team.
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2. Only indicative parameters were used. The actual change in performance, morbidity and mortality were not studied. This would have required a long term follow up, which would have discouraged participation.

3. Effect of age, sex and co-existing morbidity were not studied. The study was limited to young, healthy, recreationally active males.

5.12 SCOPE FOR FUTURE RESEARCH

Considering the limitations of the present study with regard to participation of female subjects, subjects with different co-morbidities and the duration of intervention, it will be enlightening to conduct a study to test the sustainability of the changes brought about by both modes of training in the healthy population as well as in those suffering from different co-morbidities.