INTRODUCTION

1.1 EXERCISE AND FITNESS

Exercise training is typically considered routine physical activity that increases functional exercise capacity for which the gold standard is maximal exercise capacity as expressed in terms of VO$_{2\text{max}}$ (Carlson, 1995). Exercise training usually also affects body composition, especially lean body mass (Schauer et al., 2009; Bandenhop et al., 2009).

Health benefits of exercise have been highlighted in many articles at different times and recommendations for physical activity have been adopted from time to time by all premier institutions active in health promotion and disease prevention (Fletcher et al., 1996; Warburton et al., 2006; Haskell et al., 2007). Endurance is one of the key components of fitness, a space it shares with others like strength, power, agility, flexibility, balance and co-ordination (Tancred, 1995).

1.2 ENDURANCE TRAINING

Regular endurance training also results in improvement in physical standards (Sloan et al., 2011). For this purpose, American College of Sports Medicen (ACSM) recommends physical activity of moderate intensity for a minimum of half an hour daily, 5 days a week, or high intensity aerobic exercise on 3 days a week lasting at least 20 min for the entire healthy adult population (Haskell et al., 2007).

1.3 EFFECTS OF ENDURANCE TRAINING

The various effects of endurance training can be divided into central effects, encompassing methods to improve delivery of oxygen, and peripheral effects, encompassing improvement of oxygen utilization by muscles (Laursen and Jenkins, 2002; Zuhl and Kravitz, 2012).

1.4 SLOW CONTINUOUS TRAINING (SCT)

Continuous training is a traditional model of endurance training encompasses continuous sustained activity for a longer distance and duration, is sub – maximal in
intensity (Katch, McArdle and Katch, 2011) and has been used since long time as the way towards improvement of aerobic power (Cregg, 2013). Zuhl and Kravitz (2012) have defined continuous aerobic training to be any of the various types of exercises which last for more than 20 minutes duration and are performed at a steady or fixed intensity throughout the duration of exercise. One of the forms of such continuous aerobic training is Slow Continuous Training (SCT) which requires training continuously for 20 – 30 min at around 70 % of maximal effort (Katch, McArdle and Katch, 2011). Due to its sub – maximal nature, the entire exercise is performed in a state of relative comfort (Katch, McArdle and Katch, 2011).

Central adaptations to SCT include lower heart rate at pre-training work rates (Green et al., 1990), increase in blood and plasma volume (hypervolaemia) (Green et al., 1990; Green et al., 1987), greater cardiac output, increases in muscle and cutaneous blood flow (Green et al., 1990; Rowell, 1993). While these central adaptations start manifesting within 3 days, the actual improvement in physical work capacity take many weeks (Green et al., 1987; Green et al., 1991; Coyle, 1999; McKenzie et al., 2000). The peripheral effects, on the other hand, include changes in the muscle fibre type, increase in muscle mitochondrial volume and number (Holloszy, 1967), increased muscle capillarity (Saltin and Gollnick, 1983; Yang et al., 1994), increased extraction of oxygen by muscles (Bebout et al., 1993; Yang et al., 1994; Saltin et al., 1976), resulting in overall increase in endurance capacity. Other adaptations of endurance training as a result of slow continuous training include drop in blood glucose and muscle glycogen utilization at similar workload (Coggan et al., 1995; Karlsson et al., 1975).

The overall effects of SCT can be summarized to include increased muscle mass of the heart, increase in cardiac output, venous return, stroke volume and heart contractility, better and more efficient disposal of metabolic wastes, increase in quantity and efficiency of oxidative enzymes, increased rate of transportation of oxygen and oxidative substrates into muscle, carbohydrate sparing and preferential utilization of fat as substrate, and increase in mitochondrial number and volume (Joyner and Coyle, 2008; Pavlik et al., 2010).
1.5 HIGH INTENSITY INTERVAL TRAINING (HIIT)

Notwithstanding the relative comfort of training with SCT, a majority of population is unable to follow this regime, mainly due to constraints of time (Booth et al., 1997). A need therefore arises of a more time efficient method of training which can provide superior results in a shorter time frame of activity, focusing both on enhancing aerobic fitness as well as improving physical performance (Hottenrott et al., 2012).

A possible solution to the above has been the practice of interval training, wherein the individual trains at a very high intensity for brief duration followed by periods of rest, with multiple repetition of the same prescribed exercise – recovery interval (Katch, McArdle and Katch, 2011; Hottenrott et al., 2012). A popular High Intensity Interval Training (HIIT) method used by athletic trainers and professional coaches was described by Cregg (2013) as consisting of 10-300 s of very high intensity interspersed with rest – either active or passive. It consumes lesser time, permits individuals to perform higher volume of high intensity efforts, and has beneficial effect on aerobic capacity (Cregg, 2013). The physiological challenges of HIIT are similar to those of SCT (Gosselin et al., 2011). In HIIT, much more time is spent in active or passive recovery than in actual exercise (Cregg, 2013).

HIIT has already been established as an effective method for improvement in VO$_{2\text{max}}$ (Whyte et al., 2010, Burgomaster et al., 2008; Helgerud et al., 2007; Perry et al., 2008; Tremblay et al., 1994; Warburton et al., 2005). Hottenrott et al. (2012) further established a dose – response relationship in HIIT in terms of peak intensity and frequency of load, and VO$_{2\text{max}}$ as response.

Many other effects of aerobic training have been documented, chief of which include delayed onset of Onset of Blood Lactate Accumulation (OBLA), decreased rate of lactate formation, increased lactate clearance, increased lactate tolerance, preferential utilization of fat as fuel, reduction in body fat, faster recovery of heart rate, lower body fat levels, psychological benefits (Katch, McArdle and Katch, 2011), improved insulin response and glucose tolerance, improvement in High Density Lipoprotein (HDL) levels, drop in Total Cholesterol (TCC) and Triglycerides (TG) (Regensteiner et al., 2009).
Considering the great difference in time required between the traditional model SCT and HIIT and its subsequent implication on performance seeking athletes and health seeking working population, it is natural to question the relative efficacy of the two models (Hottenrott et al., 2012). Åstrand and Rodahl (1986) in Textbook of Work Physiology debated the relative superiority of the two methods, and concluded that question cannot be answered conclusively (Seiler and Tønnessen, 2009). The same idea is also reflected in the recent exercise physiology books (Katch, McArdle and Katch, 2011) which feel that superiority of one method over the other has not been proved.

1.6 ENDURANCE TRAINING AND VO_{2max}

Maximal Oxygen uptake, or VO_{2max}, is the maximum amount of oxygen that can be used by a person, and is achieved in an intense exercise of endurance type (Katch et al., 2011). It is one of the most important determinants of aerobic performance and aerobic fitness (Keren et al., 1980), and has been used in most of the studies which have focused on endurance.

VO_{2max} is evaluated using a graded exercise test, where the subject is exposed to incremental exercise using volitional fatigue (Astorino et al., 2000; Buchfuhrer et al., 1983; Katch et al., 2011). Direct measurement from an incremental protocol on a treadmill or ergometer using maccurate, is limited in utility for a large scale study due to its requirement of extensive laboratory, costly equipment and considerable self motivation on part of the subject (Katch, McArdle and Katch, 2011).

The Beep test, also called 20m multistage fitness test, is a popular, inexpensive and reliable field test which gives a good estimation of VO_{2 max} in field conditions (Léger and Lambert., 1982; Ramsbottom et al., 1988; Brewer et al., 1988; Leger and Gadoury, 1989). It is simple to perform, and has the advantage of having an inbuilt element of competition when performed in a group (Léger and Lambert., 1982).

One of the primary aims of endurance training is increase in VO_{2max} improvement (Katch et al., 2011). The increase incorporates both central as well as peripheral mechanisms. Some of the observed changes after endurance training include increase in plasma volume, stroke volume, cardiac output, heart rate reserve and oxygen extraction. There is more effective blood flow and blood flow distribution on account of
improved cardiac output, redistribution of blood and increased capilarisation of muscles (Katch et al., 2011).

1.7 ENDURANCE TRAINING AND Vmax

Competition performance is considered the benchmark of any form of training (Cregg, 2013). It therefore stands to reason that final test of any endurance training is the ability to perform in a competition or simulated competition. Many researchers (Helgerud et al., 2001; Dufour et al., 2006) have focused on the performance of athletes after endurance training. By evaluating the maximum velocity (Vmax) achieved in a graded way, beep test also provides an effective measure of performance in a simulated competition by encouraging the subject to run till volitional exhaustion (Léger and Lambert., 1982; Ramsbottom et al., 1988; Brewer et al., 1988; Leger and Gadoury, 1989).

1.8 ENDURANCE TRAINING AND HEART RATE

In a resting stage as well as in fixed submaximal work rate, endurance training results in a decrease in heart rate (Katch et al., 2011). This is a result of increased stroke volume, which allows same amount of blood delivery at a lower heart rate (Katch et al., 2011). This is further helped by an increased peripheral oxygen extraction in the exercising muscle. Together, it reflects a more effective distribution of blood flow and a more effective utilization of oxygen at the level of the exercising muscle (Katch et al., 2011).

The effect of peak and recovery heart rate is mediated by the vagus nerve (Katsuji et al., 1994). Darr et al., (1988) reported that endurance trained athletes report much faster heart rate recovery following maximal exercise than non – athletes, especially in the initial phase of 120sec. Hagberg et al. (1980) reported a similar faster recovery in endurance trained individuals following submaximal load.

1.9 ENDURANCE TRAINING AND BLOOD LACTATE

Lactate is accumulated in blood when one exercises at intensity above lactate threshold (Katch et al., 2011). By means of both central and peripheral adaptation, endurance training affects lactate concentration in blood by decreasing rate of lactate
formation as well as by increasing lactate clearance (Katch et al., 2011). Thus, endurance training results in delayed onset of lactate accumulation (right shift of lactate curve and delayed onset of lactate threshold) (Acevedo and Goldfarb, 1989).

Lactate levels have been considered important tool both for evaluating the effects of endurance training and to provide effective training. Sahlin and Henriksson (1984) reported higher lactate buffering capacity in trained subjects. Farrell et al. (1979) had earlier reported that training at velocity corresponding to OBLA resulted in best gain in performance. Weston et al. (1999) found a correlation between higher time to fatigue, lower lactate accumulation and higher activity of citrate synthase. Tesch et al. (1978) found a preferentially early lactate accumulation in Fast Twitch fibres. A correlation exists between peak lactate and performance in events like 400m and 800m (Billat, 1996; Fujitsuka et al., 1982). It stands to logic that a higher peak lactate level will correspond with higher maximal exercise intensity, and hence better performance (Smith, 2008).

1.10 ENDURANCE TRAINING AND ANTHROPOMETRIC PROFILE

Endurance training results in reduction in weight and in body fat and an increase in lean mass (Katch et al., 2011). The effect of training on fat loss has been demonstrated by many researchers (Despres et al., 1991; Schwartz et al., 1991; Stiegler, 2006). Hottenrott et al. (2012) noticed decrease in body fat and weight in both SCT and HIIT, but increase in lean mass was seen only in HIIT. For weight loss and, more specifically, fat loss, the total energy expenditure is the most important factor (Grediagin et al., 1995; Slentz et al., 2004). In addition to the actual energy cost of the exercise, excess post – exercise oxygen consumption (EPOC) contributes significantly to the fat loss. Borsheim and Bahr (2003) have demonstrated increase in EPOC lasting many hours to days post exercise, depending on the maximum intensity of the exercise achieved. Interestingly, return to baseline values was faster in well trained individuals.

Direct assessment of body composition has only been done in cadavers (Katch et al., 2011), and form the basis for regression equations for indirect estimation by other means.
A convenient measure of body composition can be achieved by means of Bioelectric Impedence Assessment (BIA) (Katch et al., 2011). It works on the presumption that different body compartments offer different resistance to electric current of different characteristics, and that these differences are measurable in a reliable way to provide estimation of body composition (Katch et al., 2011). Many studies have validated this method (Lukaski et al., 1986; Segal et al., 1975; Deurenberg et al., 1991) and their use has been well established.

1.11 ENDURANCE TRAINING AND LIPID PROFILE AND GLUCOSE TOLERANCE

Lipid profile following endurance training is associated with dose response relationship when a continuous training protocol was adapted (Durstine et al., 2001). The observed changes with different types of endurance training have been decrease in total cholesterol, triglycerides and total cholesterol to HDL ratio, while HDL has been found to increase (Durstine et al., 2001; Fahlman et al., 2002; Cornelissen and Fagard, 2005). Similarly, glucose tolerance has also been shown to improve following endurance training (Seals et al., 1984; Bruce et al., 2006).

1.12 COMPARISON OF HIIT AND SCT

Comparison of HIIT and SCT has been carried out using different protocols and durations on the above parameters by different authors, as mentioned below. Mohr et al. (2014) found HIIT to cause greater decrease in Resting Heart Rate (Resting HR) in swimmers. Kilen et al. (2014) found similar values in swimmers for oxygen uptake and time performance in spite of decreased training volume. Ouerghi et al. (2014) found superior gains for HIIT in soccer players while de Araujo et al. (2012) noticed comparable effects among obese children for peak velocity and oxygen uptake. Many other studies (Gosselin et al., 2011; Støren et al., 2011; Ziemann et al., 2011) showed similar results. The relative comparability of the two methods on effects of body fat, lipid profile and glucose tolerance was also noticed in many studies (Nowak et al., 2015; Nybo et al., 2010; Stasiulis et al., 2010; Musa et al., 2009; Little et al., 2011; Ciolac et al., 2010; Babraj et al., 2009).
1.13 NEED FOR PRESENT STUDY

The studies were generally conducted on a specific subset of population, consisting of specific groups like women (Nowak et al., 2015), trained soccer players (Ouerghi et al., 2014), smokers (Koubaa et al., 2015) and diabetics (Ribeiro et al., 2012). Further to this, the sample size used till date was very small, and ranged from 8 (Gosselin et al., 2011) to 62 (Mohr et al., 2014). The only study using a large sample was conducted by Nemoto et al. (2007) on 60 men and 186 women which, however, had a mean age of participants as 63 years, and showed significantly higher in high intensity interval walking training group over 5 months of training.

There was a complete lack of studies on Indian population in literature. With this in mind a pilot study was conducted school going, non-athletic male Indian population (Upadhyay et al., 2010) which showed significantly greater improvement in $\text{VO}_{2\text{max}}$ after 6 weeks of HIIT when compared to SCT over 6 weeks of training. Based on the results of the pilot study, the present study was conceptualized for the young male population.

1.14 OBJECTIVE

This study aims to study the effect of 06 weeks of high intensity interval training of healthy adult population consisting of healthy individuals and recreational athletes and compare it with the effect after 06 weeks of slow continuous training for the following parameters

1. aerobic performance
2. anthropometric profile
3. peak lactate level
4. lipid profile and
5. glucose tolerance
1.15 HYPOTHESIS

This study works on the following hypothesis.

1. HIIT is more beneficial than SCT for improvement in aerobic performance, anthropometric profile, peak lactate level, lipid profile and glucose tolerance in healthy recreationally active male population.

2. HIIT is an effective and time saving method to improve aerobic performance, anthropometric profile, peak lactate level, lipid profile and glucose tolerance in healthy recreationally active male population.

1.16 ALTERNATE HYPOTHESIS

1. HIIT is not beneficial for improvement in aerobic performance, anthropometric profile, peak lactate level, lipid profile and glucose tolerance in healthy recreationally active male population.

2. HIIT is not an effective and time saving method to improve aerobic performance, anthropometric profile, peak lactate level, lipid profile and glucose tolerance in healthy recreationally active male population.