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## A systematic review on high intensity interval training vs moderate intensity interval training: Which one is to be most effective on aerobic and anaerobic capacity?

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### Abstract

**Background:** Best training protocol always wanted by the sports trainer to enhance sports performance, Therefore, establish a unique training method is the key factor to sports trainer.

**Aim:** In this systematic review analysis, we reviewed those studies which were investigating the effect of high intensity and moderate intensity interval training on aerobic and anaerobic capacity.

**Methods:** In this systematic review Broad Search Strategy was performed applying several online databases: Web of Science, Embase, PubMed, Google Scholar, Medline, Scopus, Europe PMCand, IndMED, PsycINFO. The obtained articles relevant to the objectives were critically analyzed.

**Results:** Almost all studies' findings suggest that high intensity interval training is most effective and superior to improve aerobic and anaerobic capacity in comparison to moderate intensity interval training.

**Conclusion:** High intensity interval training is most effective and superior to improve aerobic and anaerobic capacity.

**Keywords:** High intensity, moderate intensity, aerobic capacity, anaerobic capacity, interval training

### Introduction

Intensity or the qualitative component of work an athlete performs is another important training variable. Komi<sup>[1, 2]</sup> defined intensity in relation to power output (i.e., energy expenditure or work per unit of time), opposing force, or velocity of progression. According to this definition, the more work the athlete performs per unit of time, the higher the intensity<sup>[3, 4]</sup> Intensity is a function of neuromuscular activation, with greater intensities requiring greater neuromuscular activation<sup>[5]</sup>. The assessment of intensity is specific to the exercise and the sports. A sports person works at which intensity to be quantified on many ways. Such as (a) Maximum Heart Rate, (b) Based on Primary Energy System engaged during activity and (c) As a Percentage of Best Performance of the athlete etc. Then, the best performance would represent a maximum intensity. The intensity can be classified into six intensity zone, like Super-maximal (>100), Maximal (90-100), Heavy (80-90), Medium (70-80), Low (50-70) and Very Low (<50)<sup>[6]</sup>.

Interval training deals with low to high intensity activities, where rest period or recovery time is provided between two repetitions. Generally Interval training consists of increasing intensity workouts (low to high) that are interspersed by periods of rest<sup>[7, 8, 9, 10]</sup>. High intensity interval training (HIIT) refers to a very specific and particular type of training<sup>[11]</sup>. HIIT is repeated, extremely hard bouts of work interspersed with periods of recovery<sup>[10, 12, 13, 14]</sup>. It is a form of interval training, a cardiovascular exercise strategy alternating short periods of intense anaerobic exercise with less intense recovery periods, until too exhausted to continue<sup>[15, 16, 17, 18]</sup>. In broader sense each and every games and sports deal with aerobic and anaerobic capacity.

The maximum amount of oxygen in ml an athlete can use in one minute/kg of body weight is called VO<sub>2</sub> Max or aerobic capacity<sup>[19, 20]</sup>. Training can increase VO<sub>2</sub> Max by up to 20%. Factors affecting size and strength of heart, concentration of oxygen carriers in blood (Haemoglobin), density of capillaries and mitochondria in the muscles and activity of aerobic enzymes, proper training enhances these factors and increases aerobic capacity.

Whereas anaerobic capacity can be defined as the maximal amount of adenosine tri-phosphate re-synthesized via anaerobic metabolism (by the whole organism) during a specific mode of short-duration maximal exercise<sup>[17]</sup>. In the arena of sports, by nature many games need aerobic capacity more and many games need anaerobic capacity more, whereas many games

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which need both aerobic and anaerobic capacity at a same level. Indeed, numerous studies are widely published in various individual and team sports [21, 22] associated with HIIT, MIIT, Aerobic and Anaerobic Capacity. Therefore, in line with this approach being used in different sports, the aim of this systematic review is to find out which training: High Intensity Interval Training (HIIT) or Moderate Intensity Interval Training (MIIT) [23] is most likely to be effective on aerobic and anaerobic capacity.

## Methods

### Stage 1

#### Inclusion-exclusion criteria

##### Inclusion criteria

- Research articles relating to HIIT and MIIT.
- Outcome variables must be aerobic and anaerobic capacity.
- Research articles considered all age group, gender and not limited by geographical location.
- Research articles limited by English language only.
- Sources of information including primary research studies, reviews, systematic reviews.

##### Exclusion criteria

- Opinions, magazine and newspaper articles.
- Research articles excluded other than English language.
- Meta-analyses articles were excluded.

### Stage 2

#### Identify the Research Question(s)

Following a preliminary literature search and discussions between the author groups, the following research question was developed to reflect the population, context and content of the review [24].

- Which training between High Intensity Interval Training (HIIT) and Moderate Intensity Interval Training (MIIT) is most likely to be effective on aerobic and anaerobic capacity?

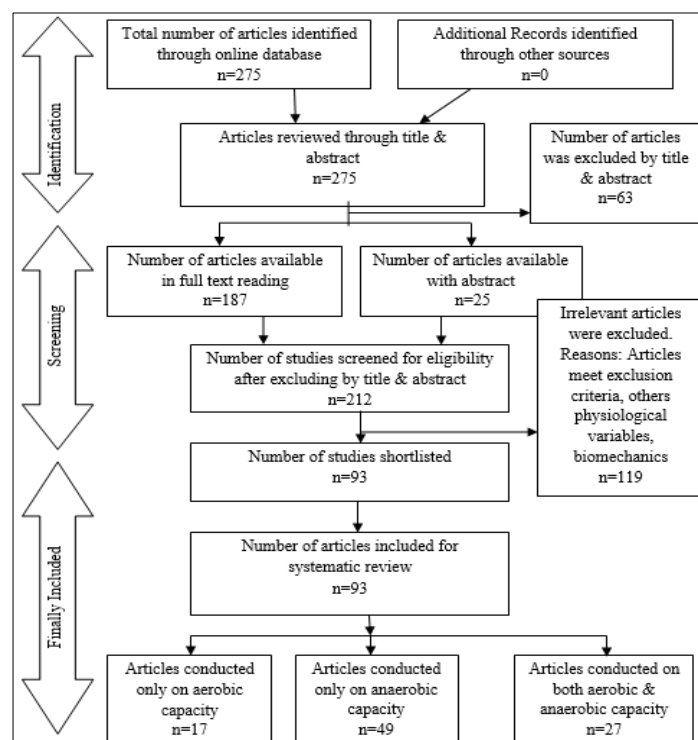
### Stage 3

### Study Search Strategy

A broad search strategy was used to avoid excluding potentialities and all the studies: effect of high and moderate intensity interval training on aerobic and anaerobic capacity were identified. The relevant articles were searched using appropriate key words and index terms by nine online research databases: Web of Science, Embase, PubMed, Google Scholar, Medline, Scopus, Europe PMCand, IndMED, PsycINFO. For articles query: HIIT on aerobic capacity, HIIT on anaerobic capacity, HIIT on aerobic and anaerobic capacity, MIIT on aerobic capacity, MIIT on anaerobic capacity, MIIT on aerobic and anaerobic capacity, HIIT and MIIT on aerobic and anaerobic capacity were used in online searchable database. Further, an effort was given to identify additional relevant studies from the reference lists of the examined articles. An attempt was made to contact with corresponding author or other subscription sources in case of unavailability of full texts. If reply was not received, then abstracts were read properly to check if they had any required information.

### Stage 4

**Eligibility criteria:** After selection of relevant articles eligibility of those articles was evaluated against the eligibility criteria by the lead author. At first reviewed the titles and abstracts of all studies and sourced the full text for all articles meeting the inclusion criteria. Those original articles of all PDF and Word Format investigating the Effect of High and Moderate Intensity Interval Training on Aerobic and Anaerobic Capacity OR Effect of High and Moderate Intensity Interval Training on Aerobic Capacity OR Effect of High and Moderate Intensity Interval Training on Anaerobic Capacity OR Effect of High Intensity Interval Training on Aerobic and Anaerobic Capacity OR Effect of Moderate Intensity Interval Training on Aerobic and Anaerobic Capacity were eligible. And those articles were not directly matched with inclusion criteria were excluded from the procedure. Lastly potentially eligible full-text articles were undertaken. The flowchart of review study selection has been shown in figure 1.



**Fig 1:** Flowchart of systematic review study selection

## Results

### Numerical analysis

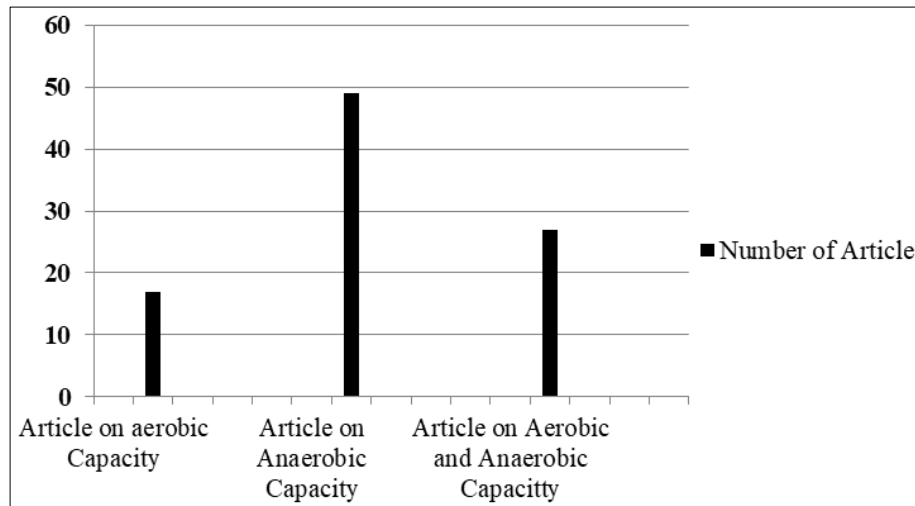
The initial search identified 275 studies, came from recognised databases. Two hundred and twelve (212) studies were remained after manually removed from the search. One hundred and nineteen studies (119) did not meet the inclusion criteria. After excluding these 119 irrelevant studies finally ninety three (93) studies were shortlisted and included for systematic review. So, overall 93 studies met inclusion criteria and were included in the analysis [24].

### Classification of studies

The relevant 93 included studies fell within three broad categories:

- Articles on aerobic capacity (n=17)
- Articles on anaerobic capacity (n=49)
- Articles on aerobic and anaerobic capacity (n=27)

A graphical presentation of classified articles has been shown below in figure 2



**Fig 2:** Graphical representation of classified articles of systematic review

### Discussion

The included studies were summarized using a narrative approach. After critically reviewing included studies, all the findings reveal that high intensity interval training (HIIT) OR maximal-intensity exercise OR short sprint interval training (SSIP) of low volume significantly enhance both aerobic and anaerobic capacity of sports persons, whereas moderate intensity interval training (MIIT) also significantly enhance aerobic capacity but not anaerobic capacity. Comparatively both high intensity interval training (HIIT) and moderate intensity interval training (MIIT) significantly improve aerobic capacity, but MIIT is not superior to HIIT. High intensity interval training (HIIT) is more effective, beneficial and superior to aerobic capacity than moderate intensity interval training (MIIT). Same thing also happened in case of anaerobic capacity; especially it is only significantly improved by high intensity interval training (HIIT), not moderate intensity interval training (MIIT). HIIT is most effective and beneficial to anaerobic capacity. High intensity interval training had a beneficial effect on aerobic capacity. Specifically, beneficial effects were observed on parameters of aerobic function. These findings therefore build upon recent evidence showing that either a single bout of high-intensity exercise or 7–8 weeks of low-volume high-intensity interval training have a beneficial effect on aerobic capacity in youth [25, 26].

### Why HIIT is most effective on aerobic and anaerobic capacity?

The source of energy during prolonged muscular activity initially is through aerobic process and then after aerobic metabolism [27]. Aerobic metabolism plays a vital role in human performance and is basic to all sports, if for no other reason than recovery [28]. Metabolically, the Krebs cycle and

electron transport chain are the main pathways in aerobic energy production. Aerobic metabolism produces far more ATP energy than anaerobic metabolism and uses fat, carbohydrates and proteins as fuel sources for generating ATP.[19,29] One of the most commonly measured adaptations to aerobic endurance training is an increase in maximal oxygen uptake ( $VO_2$  Max) associated with an increase in maximal cardiac output [30, 31, 32]. Aerobic endurance training can improve an athlete's aerobic power by 5% to 30%, depending, in parts, on the starting fitness level as well as genetic potential of the individual [28].

The intensity is one of the most important factors in improving and maintaining aerobic power. Short, but high-intensity bouts of interval sprints can improve maximal oxygen uptake if the interim rest period is also short. Callister and colleagues [19, 33] showed that long rest periods used with sprints improved sprint speed without significant increases in maximal aerobic power. Therefore, longer training sessions with higher amount of rest between exercise bouts result in less improvement in aerobic capacity. The use of shorter recovery periods between high-intensity training intervals has been shown in various studies to improve various skeletal muscle metabolic processes, resulting in improved endurance performance [34]. The continuous training at 70%  $vVO_{2max}$  produced a lesser increase in  $VO_{2max}$  [15, 35]. HIIT is a time efficient training method for improving aerobic capacity and maintaining indices of speed and power [36, 37, 38].

When the muscular activity is rapid and violent then the source of energy is through anaerobic mechanism [27]. Many researchers have been done on training adaptations associated with anaerobic endurance exercise. Skeletal muscle adaptations following anaerobic training occur in both structure and function, with reported, changes encompassing increases in size, fiber type transitions, and enhanced

biochemical and ultra-structural components (i.e. muscle architecture, enzyme activity, and substrate concentrations). Collectively, these adaptations result in enhanced performance characteristics that include strength, power, and muscular endurance, all of which are critical to athletic success. Muscle hypertrophy is the term given to the enlargement of muscle fiber cross-sectional area following training. Most notably, when ATP and Creatine Phosphate (CP) concentrations are repeatedly exhausted following bouts of intermittent high-intensity muscular contraction, the storage capacity of these high energy compounds is increased via a 'super compensation' effect<sup>[6, 33]</sup>.

Anaerobic training (resistance, sprint, plyometric, agility, high intensity interval training) in general elicits specific adaptations in the nervous system leading to greater recruitment, rate of firing, synchronization, and enhanced muscle function that enable increases in strength and power. Anaerobic training also has positive effects on bone, muscle and the associated connective tissue; the entire musculoskeletal system undergoes a coordinated adaptation to exercise<sup>[6, 33]</sup>. Short bouts with high intensity used in sprints giving short recovery period between two repetitions significantly increase anaerobic efficiency. That's why high intensity interval training can be warranted for those sports which require anaerobic fitness<sup>[6, 39, 40]</sup>.

High Intensity Exercise Endurance (HIEE) training tends to increase Type II muscle fiber content<sup>[41]</sup>. Because Type II muscle fiber content is related to the maximal rate of force development<sup>[42, 43]</sup> maximal force generation capacity and the ability to generate peak power outputs<sup>[44]</sup> it is easy to conclude that HIEE may be more beneficial for sports that rely on these performance factors, especially if high-velocity or high power movements are performed repetitively. Anaerobic performance is mainly determined by fiber-type proportion and glycolytic enzyme capacity of skeletal muscle, both of which are largely influenced by genetic factors; however, there is always a training potential to be considered<sup>[45]</sup>. Previous studies reported that high- or maximal- intensity training methods influenced the improvement of anaerobic performance variables in few team sport players<sup>[46, 47, 48]</sup>. Several authors report that the use of high intensity intervals can significantly increase markers of both anaerobic and aerobic exercise endurance<sup>[38, 39, 49, 50, 51]</sup>. HIEE training should not be limited to the development of anaerobic endurance, because this type of training also has the potential to improve Low Intensity Exercise Endurance<sup>[6]</sup>. The development of HIEE with the use of high intensity interval training appears to have a profound effect on aerobic activities that typically rely on LIEE<sup>[52, 53]</sup>. Laursen and Jenkins suggested that high intensity interval training or HIEE training may be warranted for athletes who have established an LIEE training base. Therefore, it may be beneficial to consider using HIEE training methods for athletes who participate in aerobic sports that require repetitive performance over a long duration of time<sup>[54]</sup>.

High-intensity interval training has been shown to be an effective method for improving endurance performance<sup>[53, 55, 56, 57, 58]</sup>. The results of the present study are in agreement with many studies demonstrating an increase in maximal oxygen consumption after HIIT<sup>[56, 59, 60, 61]</sup>. High intensity interval training may also induce up-regulation of glycolytic and oxidative enzymes, a possible mechanism influencing the improvements in  $\text{VO}_2 \text{ max}$ <sup>[49]</sup>. In addition, an increase in stroke volume following high intensity interval training<sup>[62]</sup> may

contribute to an increase in aerobic power of male handball players. Moreover, and consistent with the findings of other authors, the repetition of short bouts of exercise stress not only many of the physiological or biochemical systems used in aerobic efforts<sup>[59, 63, 64, 65]</sup>. But it also induces alterations in glycolytic enzymes, muscle buffering, and ionic regulation resulting in improved anaerobic performance<sup>[41, 66, 67, 68]</sup>.

By searching and critically reviewing the selected 93 studies it was found that HIIT (High Intensity Interval Training) was applied in 69 studies. Whereas, MIIT (Moderate Intensity Interval Training) was applied in 15 studies. Both HIIT and MIIT were applied in 9 studies. It was observed that the result of most of the studies shown significant in aerobic and anaerobic capacity due to HIIT, namely W. (2011)<sup>[69]</sup>, Czuba M. (2013)<sup>[70]</sup>, Cathal J. (2013)<sup>[36]</sup>, Chittibabu B. (2014)<sup>[13]</sup>, Ouerghi N. (2014)<sup>[71]</sup>, Jabbour G. (2015)<sup>[72]</sup>, Belegisanin B. (2017)<sup>[16]</sup>, Beyranvand F. (2017)<sup>[73]</sup>, Arazi H. *et al.* (2017)<sup>[74]</sup>. Further, it was shown that HIIT is more superior and beneficial than MIIT. MIIT also improved aerobic and anaerobic capacity, but not like HIIT. So on the basis of systematic review it can be concluded that High Intensity Interval Training (HIIT) is most likely effective training method than MIIT to enhance aerobic and aerobic capacity.

### Conflicts of Interest

The author of the present study declares that he has no conflicts of interest regarding the publication and authorship of this article.

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### Author's Contributions

Dr. Kallol Chatterjee is responsible for study administration, contributed to the conceptualization, performed data collection, drafted the manuscript, revised the manuscript, discussed the content and contributed to the writing of the manuscript.

### Conclusions

In conclusion it is concluded that high intensity interval training (HIIT) is most effective and superior to improve aerobic and anaerobic capacity in comparison to moderate intensity interval training.

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