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Effectiveness of high intensity interval training in amateur tennis players

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Abstract

Background: Training for better physical activity is important for every individual and includes various forms of interventions like strength training, endurance training, agility training, power and speed training which improve the aerobic and anaerobic capacity of the individual.

The components of these training are usually used for better performance in sports, both in professionally trained sports athletes as well as amateur athletes. The risk of injuries can be prevented by proper training interventions, in amateur as well as competitive sports performers.

Tennis is a competitive sport where, speed, agility and power of the tennis player are continuously challenged. It involves intermittent, high intensity efforts interspersed with periods of low intensity activity, during which active recovery and passive periods take place, over an extended period of time. In this situation, competitive tennis players need a mixture of fitness qualities such as speed, agility and power, combined with a well-developed aerobic fitness to achieve high levels of performance. HIIT has been found to be a time efficient training method for improving physical performance in players and is now widely adopted in team and racquet sports. This “time efficient” method is gaining acceptance among recreational athletes to improve their performance in less duration. One of the most popular high intensity interval workouts for improving strength, aerobic capacity, power and speed in sports players is the ‘Tabata Interval Workout’. It is a high intensity interval training method originally created by Japanese researcher Izumi Tabata and is one of the best cardio/metabolic conditioning workouts ever discovered because it is simple to understand and easy to apply.

Data collection and analysis: All the players’ base line data on outcome measures of Cooper 12 minute run test and 20 meter sprint time were collected. HIIT interval intervention was given on tennis court to all the participants for 3 days in a week for 6 weeks duration (18 training sessions) as per the Tabata protocol. Following this, outcome measures were re assessed. Eleven participants completed the entire 18 training sessions spread over six weeks duration. Data analysis of outcome measures was done using SPSS software version 20.0 and a one sample paired *t* was applied to evaluate the effect of HIIT on a continuous scale.

Results: There was a significant improvement in cooper 12 minutes run test and the direction of the *t*-value ($t(10)=-9.60, p <=0.001$) and 20mts Sprint Run test and the direction of the *t*-value($t(10) = 2.42, p <=0.03$)

Conclusions: there is a significant effect of High Intensity Interval Training on aerobic, and speed capacity in amateur tennis players.

Keywords: Tennis players, sports, high intensity training, amateur, physiotherapy, rehabilitation

Introduction

Background

Training for better physical activity is important for every individual and includes various forms of interventions like strength training, endurance training, agility training, power and speed training which improve the aerobic and anaerobic capacity of the individual.

The components of these training are usually used for better performance in sports, both in professionally trained sports athletes as well as amateur athletes. These forms of training result in better improvements in muscle strength, instantaneous force, muscle endurance, physical endurance and coordinated ability which is agility, balance, flexibility, quickness, acceleration and accuracy [1]. The risk of injuries can be prevented by proper training interventions, in amateur as well as competitive sports performers. Tennis is a competitive sport where, speed, agility and power of the tennis player are continuously challenged.

Performance in competitive tennis depends on both aerobic and anaerobic fitness levels of tennis players. Therefore training for the competitive tennis player focuses on improving cardio-respiratory endurance [2].

Tennis match may last for many hours which comprises of bouts of high intensity work such as stroke, quick changes of direction, short accelerations. It involves intermittent, high intensity efforts interspersed with periods of low intensity activity, during which active recovery (between points) and passive periods (between changes over breaks in play) take place, over an extended period of time (that is in some cases, more than 5 hours). In this situation, competitive tennis players need a mixture of fitness qualities such as speed, agility and power, combined with a well-developed aerobic fitness to achieve high levels of performance.

During match play, demands alternate between energy provision for bouts of high intensity work (ex- several strokes, quick change of direction, short acceleration and deceleration), via intra muscular phosphates and glycolysis, and replenishing energy sources and restoring homeostasis during the intervals in between (by oxidative metabolism). Thus, it seems that training competitive players should focus on improving their ability to repeatedly perform high intensity exercise and to recover rapidly from it. For these reasons, tennis training should include physical exercise aimed to enhance both aerobic and anaerobic fitness [3].

Interval training by contrast to continuous training is able to demonstrate higher improvements in VO₂ Max than continuous training as the duration of training is longer. Interval training regimes have shown to be effective in enhancing both aerobic and anaerobic reflecting aspects of match play. The rationale behind interval training programs is that the total accumulated time of vigorous exercise is higher than could be achieved during a single bout of continuous exercise at the same intensity until exhaustion [2, 4].

High Intensity Interval Training (HIIT) is one of the many interval training regimens which is found to be the most effective means of improving cardio-respiratory and metabolic function and, in turn, the physical performance of athlete. HIIT involves repeated short-to-long bouts of rather high-intensity exercise interspersed with recovery periods. The inclusion of sprints and all out efforts in racquet sport players has shown to be an effective practice. HIIT usually consists of sport specific training at work and rest intervals ranging from 15 seconds to 4 minutes, 90–100% velocity at the level of maximum oxygen uptake (VO₂max), heart rate (HR) values more than 90% of maximum HR (HR max) and work-to-rest ratios of 1:1–4:1 [5]. This strategy has been found to be effective in enhancing the aerobic capacity without negatively affecting strength, power, or sprint performance [6, 7]. HIIT has been found to be a time efficient training method for improving physical performance in players and is now widely adopted in team and racquet sports. This “time efficient” method is gaining acceptance among recreational athletes to improve their performance in less duration [8].

The benefits, effectiveness and physiological adaptations found during HIIT of competitive tennis players have been ascertained in the literature [8-9]. However, applicability of HIIT in amateur tennis players is not known.

Although there is currently little evidence that high intensity intermittent exercise maybe more effective in improving aerobic component than lower exercise intensities, recent results have shown that running may induce greater improvements in maximal aerobic capacity and endurance performance than moderate continuous exercise (85% of

maximal heart rate, HR) [10].

A sudden increase in volume and/ or exercise intensity over a longer period could lead to overtraining symptoms characterized by washed out feeling, tiredness, lack of energy, chronic performance decrements, biomechanical changes, muscle and joint pain as well as decreased immunity. Contrary to this assumption, a high intensity interspersed with interval training done on swimmers did not show any of the above symptoms after training periods [11].

One of the most popular high intensity interval workouts for improving strength, aerobic capacity, power and speed in sports players is the ‘Tabata Interval Workout’. It is a high intensity interval training method originally created by Japanese researcher Izumi Tabata and is one the best cardio / metabolic conditioning workouts every discovered because it is simple to understand and easy to apply.

The original Tabata Protocol consists the following: 5 minutes of warm-up, 8 intervals of 20 seconds all-out intensity exercise followed by 10 seconds of rest and a 2 minute cool-down. Tennis is characterized by quick starts and stops, several directional changes, repetitive overhead motions, and the involvement of several muscle groups during the different strokes, which alternate from brief periods of maximal intensity to longer periods of moderate and low intensity activities [12, 13, 14]. The duration of a tennis match play is often more than one hour and in some cases more than five hours [8, 14, 15], but actual playing time is ~20–40% of total match time on clay courts and ~20% on fast court surfaces [16, 17].

The tennis performance is the ability to repeat intermittently muscular force at high speed [18].

The Functional performance of any complex chain of torque transfers (i.e., serve or ground strokes in tennis) depends on several factors including technique, flexibility, muscle strength, speed, and power [19]. The ability to maintain a high technical efficiency during those phases of high-intensity, intermittent exercise is an important feature of successful contemporary tennis players [20].

The tennis specific interval training is as traditional interval based conditioning, namely the attainment of optimal exercise intensities to heavily tax the aerobic system (e.g. 90-95% maximum heart rate HR max) [21].

Both types of training can effectively improve cardiac and skeletal muscle metabolic functions, running or cycling based HITT is today considered to be one of the most effective forms of exercise for improving physical performance in athlete [22, 23].

Procedure

Ethical clearance was obtained from the institutional ethical committee of JSS medical college. Participants were recruited after a brief assessment to rule out any cardiovascular or medical problems and then the informed consent was obtained.

Eighteen tennis players who fulfilled the inclusion criteria were chosen after enumeration of amateur players in all the tennis clubs of Mysuru city. All the players’ base line data on outcome measures of Cooper 12 minute run test and 20 meter sprint time were collected. HIIT interval intervention was given on tennis court to all the participants for 3 days in a week for 6 weeks duration (18 training sessions) as per the Tabata protocol. Following this, outcome measures were re assessed.

The intervention commenced by the participants doing a warm-up and stretch for 5 minutes prior to the run. They were then instructed to run as far as possible in 12 minutes

(walking was permitted). Distance covered was recorded in yards. Participants did a cool down of 5 minutes upon completion of test.

Eleven participants completed the entire 18 training sessions spread over six weeks duration. Their post intervention outcome measures were taken and the data was analysed.

According to Tabata protocol chosen in this study, 4 minutes work out subject was done. It consisted of 20seconds pushups and 10 seconds rest; following this, another 20 seconds of skate play and 10 seconds rest. These alternate periods of workout for 20 seconds followed by 10 seconds of rest period was followed for 4 minutes. The progression on intensity was prescribed as per the Tabata protocol.

Results

Based on the mean of pre and post (Table 1)12mts Cooper Run test and the direction of the *t*-value ($t(10) = -9.60, p \leq 0.001$), (Table 2) we can conclude that there is a statistically significant improvement in the 12 minutes Cooper Run test with the intervention of HIIT programme from an Average and SD of 2106.18 ± 214.45 to 2562.91 ± 284.12 , respectively. The mean of pre and post (Table 1) 20mts Sprint Run test and the direction of the *t*-value ($t(10) = 2.42, p \leq 0.036$), (Table 2) we can conclude that there is a statistically significant improvement in time for the 20 meters Sprint Run test with the intervention of HIIT programme from an Average and SD) of 3.63 ± 0.30 to 3.19 ± 0.38 , respectively. Hence, we infer that there is a significant effect of High Intensity Interval Training on aerobic capacity, and speed in amateur tennis players.

Table 1: Mean and Standard Deviation of Run Tests

Run Test	Pre-Intervention of HIIT Mean (SD)	Post-Intervention of HIIT Mean (SD)
12 Minutes Cooper Run Test in Meters	2106.18 (214.45)	2562.91 (284.12)
20 Meter Sprint Run Test in Seconds	3.63 (0.30)	3.19 (0.38)

Table 2: One Sample Paired t Test.

Tests	Mean(SD)	SE Mean	95% Lower CL	95% Upper CL	t value	D F	P value
Pre Intervention 12 Minutes Cooper Run Test - Post Intervention 12 Minutes Cooper Run Test	-456.73(157.74)	47.56	-562.70	-350.75	-9.60	10	$\leq 0.001^*$
Pre Intervention 20 Meter Sprint Run Test - Post Intervention 20Meter Sprint Run Test	0.43 (0.60)	0.18	0.03	0.83	2.42	10	0.036*

P values are derived using the one sample paired t test; *Significant; **Highly Significant

Statistical Distribution Followed

Figure 1. Test for Normality: 12 Minutes Cooper Run Test (Pre HIIT): The dots are the distribution of the data and the

line is the normal distribution. As the dots are clustered around the normal line, and this tells the distribution is also approximately normal (Similar for figures 2-8).

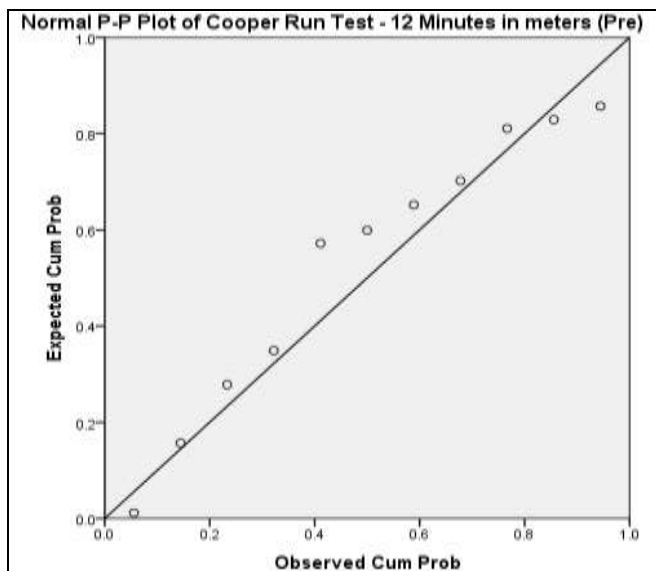


Fig 1: Test for Normality: 12 Minutes Cooper Run Test (Pre HIIT)

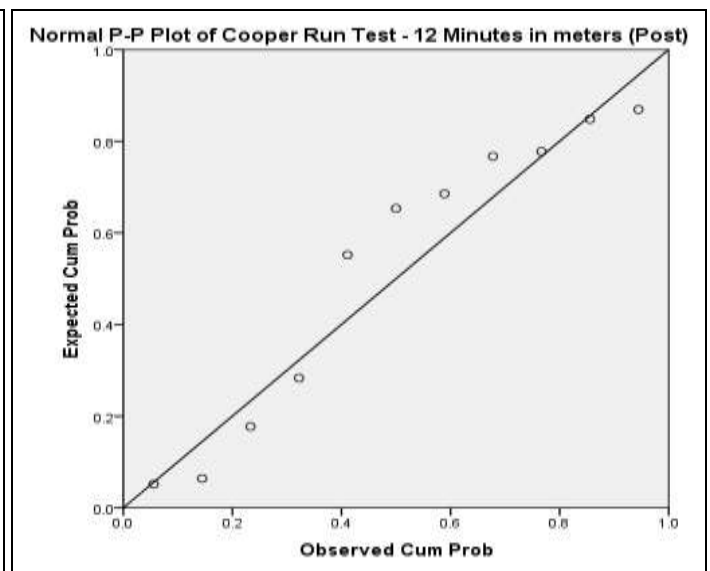


Fig 2: Test for Normality: 12 Minutes Cooper Run Test (Post HIIT)

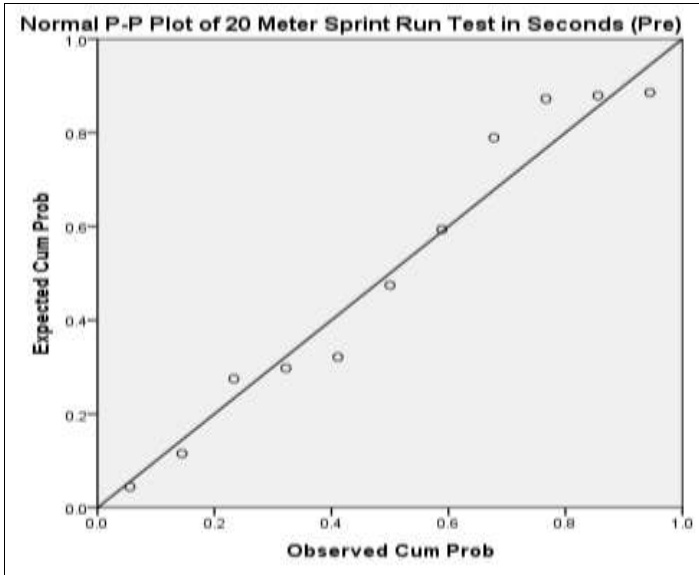


Fig 3: Test for Normality: 20 Meters Sprint Run Test (Pre HIIT)

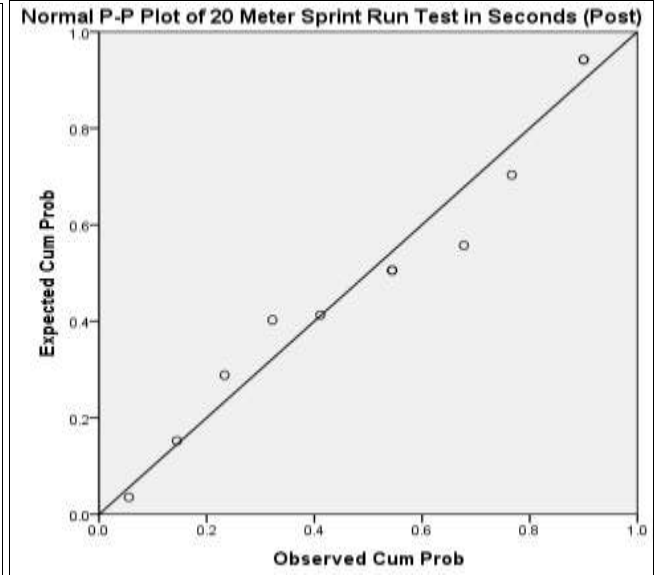


Fig 4: Test for Normality: 20 Meters Sprint Run Test (Post HIIT)

Figure 5: Test for Outliers: 12 Minutes Cooper Run Test (Pre HIIT)

The box plot shows any outliers present in the data. Here we can see there are no significant outliers for all the below

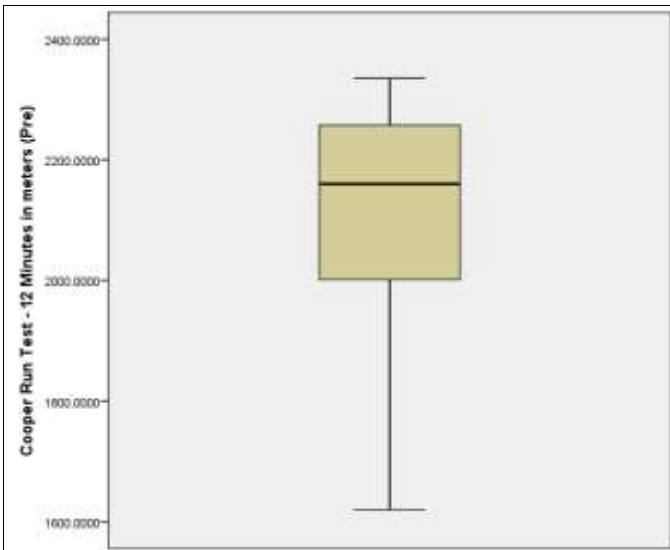


Fig 5: Test for Outliers: 12 Minutes Cooper Run Test (Pre HIIT)

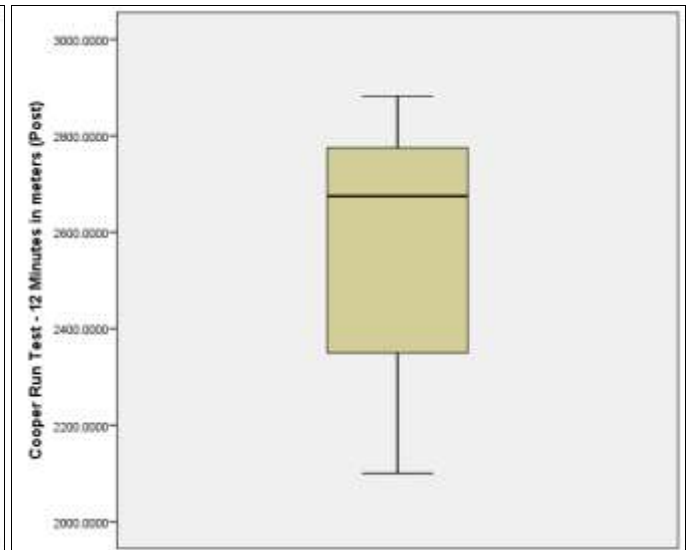


Fig 6: Test for Outliers: 12 Minutes Cooper Run Test (Post HIIT)

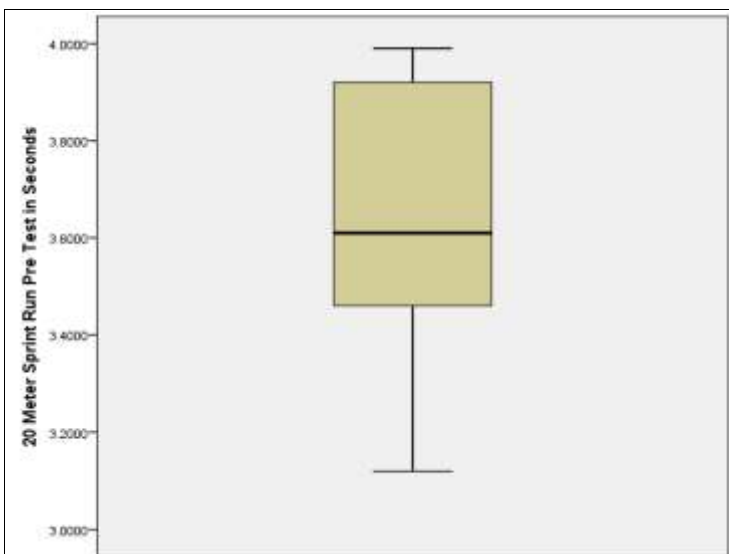


Fig 7: Test for Outliers: 20 Meters Sprint Run Test (Pre HIIT)

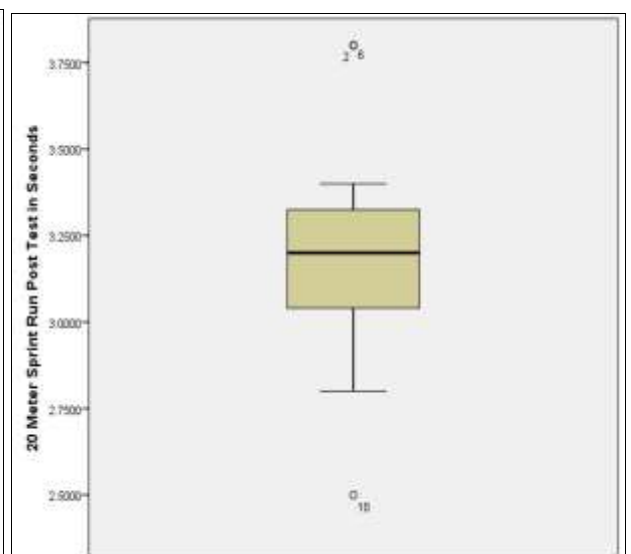


Fig 8: Test for Outliers: 20 Meters Sprint Run Test (Post HIIT)

Discussion

The objective of this study was to find the effectiveness of High Intensity Interval Training on parameters of aerobic capacity and speed in amateur tennis players. Tabata protocol was used as the intervention. Outcome measures used were Cooper 12 minute run test to check the aerobic capacity and, 20 meter sprint run test to measure the speed in amateur tennis players of Mysore city tennis clubs. Pushups and skate play were the interventions used to improve the aerobic capacity, speed and agility in the players.

A total of 11 amateur tennis players out of 18 included in the study completed the 18 training sessions, spread over 6 weeks, at thrice a week of 4 minutes duration. Level of significance was 0.05. The results showed that there was a significant improvement in the aerobic capacity of the tennis players, when compared before and after six weeks of intervention ($p=0.001$). Earlier study done on the effects of high intensity interval training showed similar improvements in aerobic capacity of the players [24,25].

High intensity interval training for a short duration increases aerobic capacity by increasing the cardio respiratory fitness of the athletes. HIIT has been proved to improve the components of strength of the muscles and Pushups have been found to increase the cardiovascular endurance [26-27]. Apart from the strength of shoulder girdle muscles

When trained with high intensity inter spread with intervals the oxidative capacity of the skeletal muscles was found to be improved [1].

Also, there is an increase in VO_{2peak} following endurance training of high intensity for short duration. Improvements in VO_{2max} could be due to an increased oxygen delivery (increase in stroke volume) and/ oxygen utilization by active muscles. As maximum heart rate remains unchanged in response to training, improvements in oxygen delivery to exercising muscles during high intensity exercising can be attributed to an increase in stroke volume. Stroke volume can increase through a higher left ventricular contractile force and/ or through an increase in cardiac filling pressure, which raises end diastolic volume and resultant stroke volume.

In addition sprint training protocol evokes changes in the capacity to produce energy via oxidative metabolism. It is also known that the aerobic contribution to sprint exercise increases, depending on the recovery between bouts, as a function of successive sprint. The relatively short recovery periods used would have imposed a considerable demand on the aerobic metabolism in meeting ATP synthesis in the latter sprint bouts; all of these factors may explain the observed increase in VO_{2max} .

Hence, time saving strategies for enhancing performance limiting factors such as endurance and strength performance are desirable.

This study showed a significant improvement in the speed of performance. This was as indicated by a decrease in the time taken to complete the 20 meters sprint run test ($p=0.03$), with the level of significance set at ($p<0.05$). Similar results were found when an skate play intervention was done up to 8-week in a study done by Cecilia Gevatl *et al* in 2012 done on 11 years athletes to know the effects of speed training programme on acceleration ability and maximum speed running.

Several studies on sprint interval training have proved to increase the aerobic and anaerobic performance with very low time commitment. It could also have induced similar improvements in cardio respiratory fitness and skeletal muscle oxidative capacity as prolonged training, and a

substantial improvement in insulin action.

Repeated short interval bouts stress the physiological/biochemical systems used in aerobic efforts, posing a considerable metabolic challenge to the skeletal muscles, as there is a large reduction in muscle glycogen and pH and increases in blood lactate as well as whole body carbohydrate and fat oxidation [28, 29, 30].

The skate play is an indicator of the agility component of speed performance. An increased agility of performance in skate play was found in this study, which is similar to earlier studies done on field sports players [31].

Hence, HIIT intervention improves the aerobic capacity and speed in amateur tennis player. Therefore, performance of the competitive players can also be improved as a result of this training intervention.

Several studies of shorter duration from 4 to 12 weeks have also resulted in improvements in the aerobic and anaerobic capacities, and speed of amateur as well as elite players [29].

Conclusions

The study showed there was significant improvement in speed and aerobic capacity in armature tennis players after 6 weeks of Tabata protocol intervention.

Clinical Implications

To improve the performance and reduce the risk of injuries the Tabata protocol can be implemented as it had shown improvements in aerobic capacity and speed which is essential for a amateur tennis players.

Research Implications

Tabata protocol used in this study showed a significant improvement in the outcome measures of Cooper 12 minute run test ($p=0.03$) and 20 meters sprint test (0.01). Hence, Tabata protocol can be implemented as a HIIT for improving the aerobic capacity, speed and agility in amateur tennis players.

Limitations

Sample size was less. Power was not checked as the intervention included is also been proved to improve the power.

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