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# COMPARISON OF MAXIMAL $O_2$ UPTAKE IN AMATEUR & ELITE BADMINTON PLAYERS

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## ABSTRACT

**Badminton is a racquet sport played using racquets to hit a shuttlecock across a net[1]. Competitive matches last between 40 minutes and an hour, at a high intensity; intense rallies usually go for six to eight seconds. $VO_2$ max is a measure of maximum rate of oxygen consumption measured during incremental exercise (exercise of increasing intensity), which is an important factor in elite players since people playing at different levels have different set of physiological pre-requisites for the game. Hence, our study aims to compare the maximal $O_2$ uptake in amateur and elite badminton players. Thisanalytical study was conducted in Amateur and elite badminton payers between the age group of 10 to 20 years. A total of 50 players (25 elite and 25 amateur) were included in the study.The Yo-Yo intermittent recovery test, level 1, was used for estimation of $VO_2$ max. An analysis of the data showed that elite badminton players had a significantly higher $VO_2$ max as compared to amateur players. Hence, the study concluded that $VO_2$ max consumption is higher in elite players and requires to be enhanced in amateur players for them to be able to continue their play effortlessly for a longer period of time.**

**KEYWORDS:** Badminton Players, $VO_2$ max, Maximal $O_2$ Uptake, YO-YO Test

Badminton is a racquet sport played using racquets to hit a shuttlecock across a net. Although it may be played with larger teams, the most common forms of the game are "singles" (with one player per side) and "doubles" (with two players per side). Badminton is often played as a casual outdoor activity in a yard or on a beach; formal games are played on a rectangular indoor court. Points are scored by striking the shuttlecock with the racquet and landing it within the opposing side's half of the court. (Bisi *et al.*, 2011)

To win a game, a player or pair needs to score 21 points. Points are scored by one player or pair after every rally. Competitive matches last between 40 minutes and an hour, at a high intensity; intense rallies usually go for six to eight seconds. Although a badminton match goes for less than half the time of a typical tennis match (between two hours and 45 minutes and three hours for tennis), badminton players tend to run twice as far and hit nearly twice as many shots (badminton players run around 6.4km and tennis players around 3.2km).

Maximal oxygen consumption ($VO_2$ max) is defined as the ability to transport and consume oxygen during exhausted work and is related to cardiorespiratory fitness. (Astorino *et al.*, 2005)

In the exercising human, maximal oxygen uptake ($VO_2$ max) is limited by the ability of the cardiorespiratory system to deliver oxygen to the exercising muscles. This is shown by three major lines of evidence: 1) when oxygen delivery is altered (by blood doping, hypoxia, or beta-blockade), $VO_2$ max changes accordingly; 2) the increase in $VO_2$ max with training results primarily from an increase in maximal cardiac output (not an increase in the a-v $O_2$ difference); and 3) when a small muscle mass is overly perfused during exercise, it has an extremely high capacity for consuming oxygen. Thus, $O_2$ delivery, not skeletal muscle $O_2$ extraction, is viewed as the primary limiting factor for $VO_2$ max in exercising humans. Metabolic adaptations in skeletal muscle are, however, critical for improving submaximal endurance performance. Endurance training causes an increase in mitochondrial enzyme activities, which improves performance by enhancing fat oxidation and decreasing lactic acid accumulation at a given $VO_2$. $VO_2$ max is an important variable that sets the upper limit for endurance performance (an athlete cannot operate above 100% $VO_2$ max, for extended periods) (George *et al.*,

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2009). A few studies have evaluated the physiological demands of competitive badminton players. Faccini and Dal Monte (1996) studied elite badminton players from Italy and found the mean and maximum $VO_2$ during match play to be 35±4 ml/kg/min and 51.8±5.8 ml/kg/min.

The American College of Sports Medicine (ACSM) has published several metabolic equations for the indirect estimation of $VO_2$ max while walking, running, and stepping as well as for leg and arm ergometers. (Lee *et al.*, 2011)

In the laboratory setting, the most accurate way to assess $VO_2$ max is undoubtedly via applying a maximal graded exercise test (GXT) performed to volitional exhaustion on a motorized treadmill or cycle ergometer while expired air is analysed continuously by gas analysers (Krustrup *et al.*, 2003) (Bangsbo *et al.*, 2008). This is the direct method of measuring $VO_2$ max. However, equipment costs and staff training limit direct measurement mainly to research and few clinical settings. Hence, in this study, we have used an indirect method of measuring $VO_2$ max which is the yo-yo intermittent recovery test.

There are two Yo-Yo intermittent recovery (YYIR) tests namely YYIR1 and YYIR2. These evaluate an individual′s ability to repeatedly perform intense exercise. The Yo-Yo IR level 1 (Yo-Yo IR1) test focuses on the capacity to carry out intermittent exercise leading to a maximal activation of the aerobic system, whereas Yo-Yo IR level 2 (Yo-Yo IR2) determines an individual′s ability to recover from repeated exercise with a high contribution from the anaerobic system. The Yo-Yo IR tests provide a simple and valid way to obtain important information of an individual′s capacity to perform repeated intense exercise and to examine changes in performance.

In this study, amateur players are the players who have been practicing badminton for less than 1 year and elite players are the ones who are playing at competitive levels like district, state or national level. Now as we know, $VO_2$ max is a measure of maximum rate of oxygen consumption measured during incremental exercise (exercise of increasing intensity), which is an important factor in elite players since people playing at different levels have different set of physiological pre-requisites for the game (Lieshout, 2002). Hence this study was done to see what the amateur players lack and to provide them the knowledge about the same.

The present study thus aimed to compare maximal $O_2$ uptake ($VO_2$ max) in amateur and elite badminton players.

## MATERIALS AND METHODS

This comparative study was carried out in Navi Mumbai Sports Association and various other sports associations of Navi Mumbai and Mumbai. A total of 50 badminton players (25 elite and 25 amateur) between the age group of 10 to 20 years were included in the study.

**Study Design**: Comparative/ Analytical study.

**Study Location**: Navi Mumbai Sports Association, Various other sports associations of Navi Mumbai and Mumba

**Study Duration**: 6 months.

**Sample size**: 25 amateur and 25 elite badminton players

**Survey method**: **Convenient sampling**

**Inclusion Criteria**

1. For amateur players: Candidates who have been practicing badminton for less than 1 year.
2. For elite players: Candidates who have been participating at district, state or national level.

**Exclusion Criteria**

1. Individuals with cardiorespiratory issue
2. Individuals with musculoskeletal injury.
3. Individuals unwilling to participate in the survey

**Procedure Methodology**

Prior consent was taken of all the subjects of this study and for those who were minors (below the age of 18), an assent form was given to the parent or the guardian. An assessment was conducted among athletes from the age group of 10 to 20. Convenient sampling was done for the same. It was made sure that the athletes are not suffering from any cardiopulmonary disease or recent musculoskeletal injury. The study duration was 6 months.

An ethical clearance was obtained from the institution. The demographic details of each athlete were noted. A brief detail of their level of activity was asked.

The Yo-Yo intermittent recovery test consists of repeated 2 - 20-m runs, back and forth between the starting, turning, and finishing line at a progressively increased speed controlled by audio bleeps from a speaker (BangsboSport.com, Copenhagen, Denmark). Between each running bout, the subjects have a 10-s active rest period, consisting of 2 - 5 m of jogging. When the subjects twice have failed to reach the finishing line in time, the distance covered is recorded and the test results are notes. The test may be performed at two different levels with differing speed profiles (level 1 and 2). In the present study, we have used the Yo-Yo intermittent recovery test, level 1, which consist of 4 running bouts at 10–13 km/h (0–160 m) and another 7 runs at 13.5–14 km/h (160–440 m), thereafter it continues with stepwise 0.5 km/h speed increments after every 8 running bouts (i.e., after 760, 1080, 1400, 1720 m, etc.) until exhaustion.

The test was performed on level ground, marked by cones, having a width of 2 m and a length of 20 m. Another cone placed 5 m behind the finishing line marked the running distance during the active recovery period. All subjects were familiarized to the test by at showing them a video of YYIRT1.

The formula by Bangsbo *et al.*, (2008) for calculating $VO_2$ max being:

Yo-yo Intermittent Recovery Test 1:

$V0^2$ max (ml/kg/min) = IR1 distance (metres) × 0.0084 + 36.4

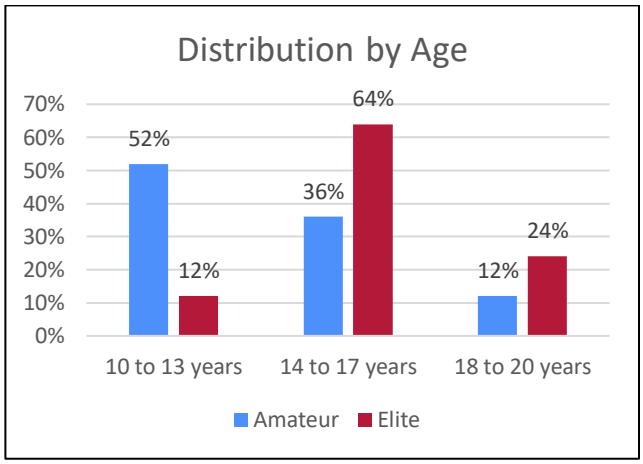
**Statistical Analysis**

All statistical analysis was done using IBM SPSS version 22.0. A paired sample t test was done on the values of $VO_2$ max obtained from amateur and elite badminton players. The level $P < 0.05$ was considered as the cutoff value or significance.

## RESULTS AND DISCUSSION

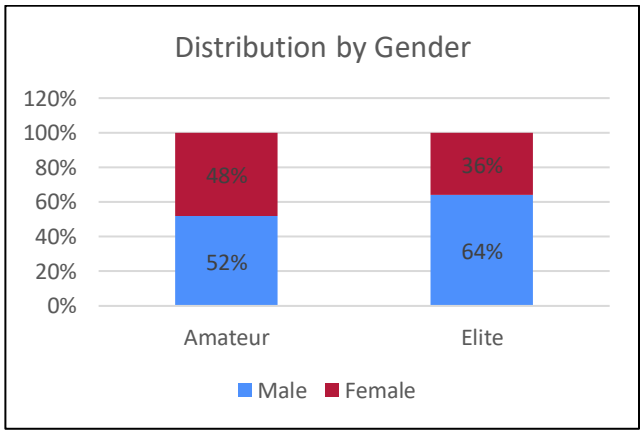
**Table 1:**

| | Amateur | Elite |
|---|---|---|
| 10 to 13 years | 52% | 12% |
| 14 to 17 years | 36% | 64% |
| 18 to 20 years | 12% | 24% |




**Graph 1:**

Inference: As per the graph, 52% of amateur players belong to the category of 10 to 13 years of age whereas 12% elite players belong to the same. Similarly, 36% amateur players are fall into the category of 14 to 17 years of age whereas 64% of elite players fall into the same. Lastly, 12% of amateur players belong to the category of 18 to 20 years of age whereas 24% of elite players belong to the same. (Table 1)

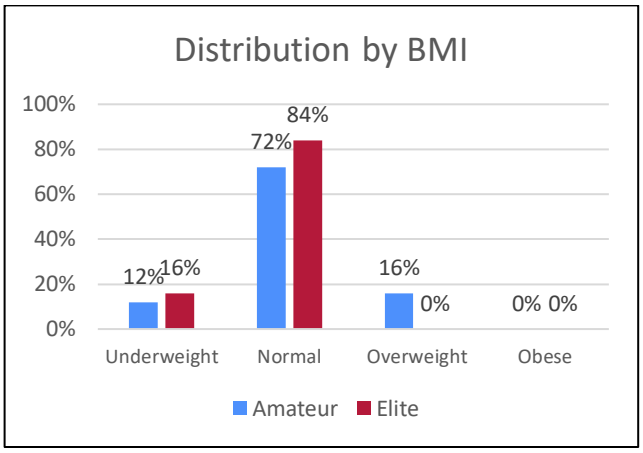



**Graph 2:**

**Table 2:**

| | Amateur | Elite |
|---|---|---|
| Male | 52% | 64% |
| Female | 48% | 36% |

Inference: Herein, we can see that there are 48% females and 52% males among amateur athletes and 36% females and 64% males among elite athletes. (Table 2)

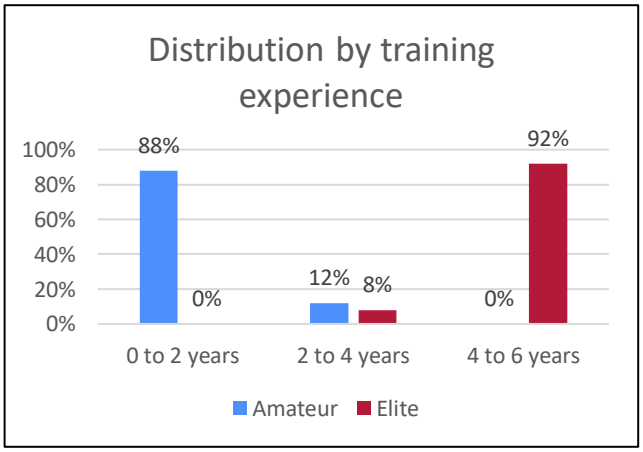



**Graph 3:**

**Table 3:**

| | Amateur | Elite |
|---|---|---|
| Underweight | 12% | 16% |
| Normal | 72% | 84% |
| Overweight | 16% | 0% |
| Obese | 0% | 0% |

Inference: This graph shows that out of the amateur players, 12% are underweight, 72% have normal BMI and 16% are overweight. Similarly, out of the elite players, 16% are underweight, 84% have normal BMI and none are overweight. (Table 3)

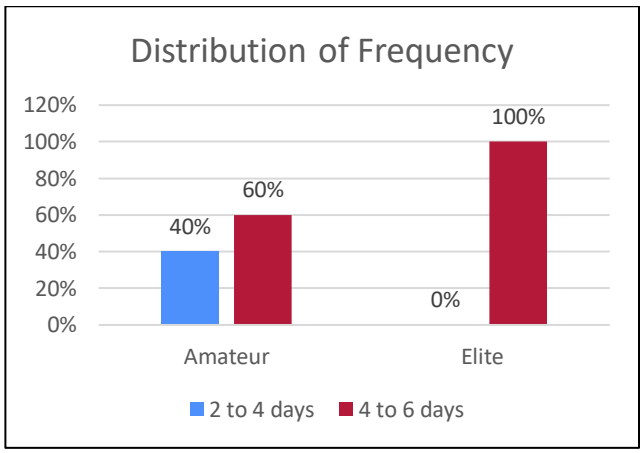



**Graph 4:**

**Table 4:**

| | Amateur | Elite |
|---|---|---|
| 0 to 2 years | 88% | 0% |
| 2 to 4 years | 12% | 8% |
| 4 to 6 years | 0% | 92% |

Inference: This graph shows that 88% of amateur players have been training for 0 to 2 years and 12% of them have trained for 2 to 4 years and none have trained for more than that. Similarly, 8% of elite players have been practicing since 2 to 4 years and 92% of them have been training for 4 to 6 years but none have trained for less than 2 years. (Table 4)

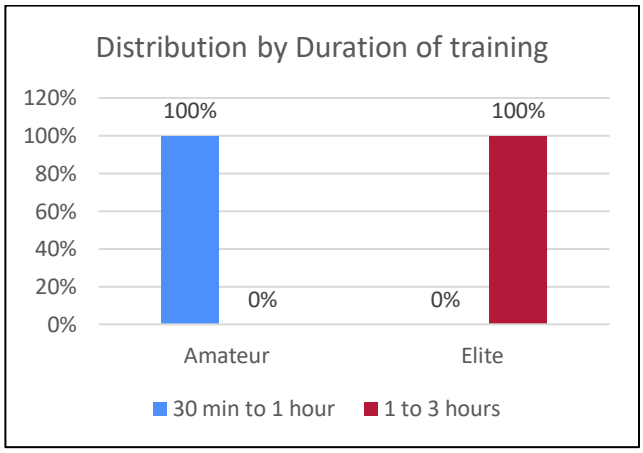



**Graph 5:**

**Table 5:**

| | Amateur | Elite |
|---|---|---|
| 2 to 4 days | 40% | 0% |
| 4 to 6 days | 60% | 100% |

Inference:As per the graph, 40% of amateur players practice for 2 to 4 days and 60% practice for 4 to 6 days. Whereas, all of the elite players practice for 4 to 6 days. (Table 5)

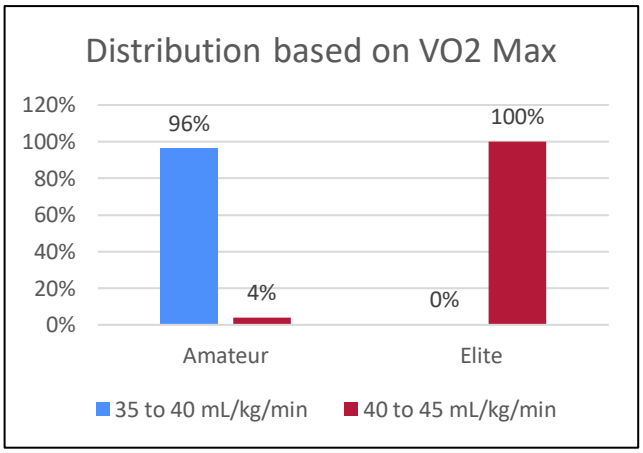



**Graph 6:**

**Table 6:**

| | Amateur | Elite |
|---|---|---|
| 30 min to 1 hour | 100% | 0% |
| 1 to 3 hours | 0% | 100% |

Inference:As per this graph, all the amateur players practice for half an hour upto 1 hour. Whereas, all of the elite players practice for a minimum of 1 hour lasting upto 3 hours. (Table 6)




**Graph 7:**

**Table 7:**

| | Amateur | Elite |
|---|---|---|
| 35 to 40 mL/kg/min | 96% | 0% |
| 40 to 45 mL/kg/min | 4% | 100% |

Inference: This graph depicts distribution of players depending on $VO_2$ max. As seen, 96% of amateur players have 35 to 40 ml/kg/min of $VO_2$ max and 4% of them have 40 to 45 ml/kg/min of $VO_2$ max. Whereas, all of the elite players have a $VO_2$ max ranging between 40 to 45 ml/kg/min. (Table 7)

## DISCUSSION

Assessment of $VO_2$ max was performed on 25 amateur badminton players and 25 elite badminton players between 10 to 20 years of age. It was a comparative study wherein the subjects were made to run between 2 cones placed 20 metres apart whilst consecutively walking for a distance of 5 meters with a cone placed 5 meters behind the starting cone.

The subjects were taken from Navi Mumbai Sports Association, Vashi and various other sports associations of Navi Mumbai and Mumbai. All statistical analysis was done using IBM SPSS version 22.0. A paired sample t test was done on the values of $VO_2$ max obtained from amateur and elite badminton players. A p value of 0.000 was obtained which was considered highly significant.

As per Graph 1, 52% of amateur players between the class interval of 10 to 13 years of age whereas 12% elite players belong to the same. Similarly, 36% amateur players between the class interval of 14 to 17 years of age whereas 64% of elite players fall into the same. Lastly, 12% of amateur players between the class interval of 18 to 20 years of age whereas 24% of elite players belong to the same. This is due to the fact that elite players need to acquire skills that come to them after years of training. Hence, majority of elite players belong to an older age group.

Graph 2 shows that there are 48% females and 52% males among amateur athletes and 36% females and 64% males among elite athletes.

According to Graph 3, out of the amateur players, 12% are underweight, 72% have normal BMI and 16% are overweight. Similarly, out of the elite players, 16% are underweight, 84% have normal BMI and none are overweight. This could be cumulative of a varied number of factors including the type of training they do, the hours they train for, days they practice for or the diet they maintain. According to a study, to gain an advantage in badminton play, the athlete must have a tall, lean and muscular stature with low body fat percentage (Lieshout, 2002). Herein, as we can see, the elite players have a lower BMI giving them an advantage.

According to Graph 4, 88% of amateur players have been training for 0 to 2 years and 12% of them have trained for 2 to 4 years and none have trained for more than that. Similarly, 8% of elite players have been practicing since 2 to 4 years and 92% of them have been training for 4 to 6 years but none have trained for less than 2 years. This is majorly because they require prolonged training experience before they can play the sport at competitive levels.

As per Graph 5, As per the graph, 40% of amateur players practice for 2 to 4 days and 60% practice for 4 to 6 days. Whereas, 100% of the elite players practice for 4 to 6

days. This is possibly due to the fact that the elite players require more regularity and more frequency when it comes to their training sessions since they are playing on a competitive level.

Graph 6 shows that 100% of the amateur players practice for half an hour upto 1 hour. Whereas, 100 % of the elite players practice for a minimum of 1-hour lasting upto 3 hours. Whereas, all of the elite players practice for 4 to 6 days. This is possibly due to the fact that the elite players have a regime of an elaborate warm up before each training session and an extensive cool down session post training. That being there, the training of the elite players is more intensive as compared to the amateur players.

Graph number 7 depicts distribution of players depending on their $VO_2$ max consumption. As seen, 96% of amateur players have 35 to 40 ml/kg/min of $VO_2$ max and 4% of them have 40 to 45 ml/kg/min of $VO_2$ max. Whereas, all of the elite players have a $VO_2$ max ranging between 40 to 45 ml/kg/min. The evidence available on physiological demands of badminton play suggests that it is a predominantly intermittent aerobic activity with a modest contribution from the anaerobic system; This proves that $VO_2$ max is an important aspect to be considered during badminton play. (Jorgen *et al.*, 2012)

As we have seen in the earlier graphs, elite players train for a longer duration when compared to amateur players. Also, elite players have more frequent training sessions as compared to amateur players. According to a study done by Astrand and Rodahl in 1986, physical training is the most crucial determining factor in $VO_2$ max (Glass and Gregory, 2007). Coherently, a study done by Fringer M. N. and Stull G. A. states that endurance training constituting continuous type of exercise can improve the $VO_2$ max in young adults (Astrand and Rodahl, 1986). Another study states that the players acquire training intensities of 80 to 95% of their maximum aerobic capacity, when training session is for a long duration (30 to 40 minutes) (Fringer and Stull, 1974). Hence, we understand that we need to device a longer duration of training session to enhance the $VO_2$ max of amateur players.

An article by D Brown, DA Weigland, EM Winter which was done on physiological characteristics of senior and junior squash players states that the $VO_2$ max of senior players is higher as compared to junior players (Morgan and Pollock, 1977). Hence as in this article we have obtained a difference in the age range of elite and amateur players, majority of amateur players belonging to a younger age group and majority of elite players belonging to an older age group, we understand that age and level of practise are major determining factors in the consumption of $VO_2$ max. Hence, from this study, we can establish a better training regime for the amateur players so as to increase their maximal $O_2$ uptake.

Analogously, a study done by Sergej M. Ostojic states that, elite players had significantly higher estimated $VO_2$ max values, compared to amateur players and estimated percentage of fast muscle fibers (fast twitch) were higher in elite players as compared to amateur players (Brown et al., 1998). Another study demonstrates that previous glycogen depletion of slow-twitch fibers enhances fast-twitch fiber recruitment, elevates $O_2$ cost, and causes a slow component of $VO_2$ during dynamic exercise with no blood lactate accumulation or muscular acidosis. These findings suggest that fast-twitch fiber recruitment elevates energy requirement of dynamic exercise in humans and support an important role of active fast-twitch fibers in producing the slow component of $VO_2$ (Ostojic, 2004). Hence concluding that $VO_2$ max consumption is higher in elite players and requires to be enhanced in amateur players for them to be able to continue their play effortlessly for a longer period of time.

## CONCLUSION

- $VO_2$ max in amateur badminton players was 35 to 40 ml/kg/min using yo-yo intermittent recovery test 1.
- $VO_2$ max in elite badminton players was 40 to 45 ml/kg/min using yo-yo intermittent recovery test 1.
- When $VO_2$ max of both the groups was compared using paired sample t test, the $VO_2$ max in elite badminton players was found to be significantly higher ($p=0.000$) than that in amateur badminton players.

## LIMITATIONS

- For this study, we have taken a small sample size due to limitation in the accessibility of elite players.
- Non-uniform distribution of people according to age as majority of amateur players belonged to the age category of 10 to 13 years whereas majority of elite players belonged to the age category of 14 to 17 years.
- Non-uniform distribution of study population as males were more than females in both, elite and amateur categories.

- Improper distribution of people according to BMI as majority of the candidates belonged to normal BMI

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